ISSN 2278-3725

Package of Practices for Crops of Punjab

KHARIF 2025

PUNJAB AGRICULTURAL UNIVERSITY
LUDHIANA

ਸੰਚਾਰ ਕੇਂਦਰ/ Communication Centre
ਪੰਜਾਬ ਐਗਰੀਕਲਚਰਲ ਯੂਨੀਵਰਸਿਟੀ, ਲੁਧਿਆਣਾ/Punjab Agricultural University, Ludhiana, (India)

PAU PUBLICATIONS/ਪੰਜਾਬ ਐਗਰੀਕਲਚਰਲ ਯੂਨੀਵਰਸਿਟੀ ਦੀਆਂ ਪ੍ਰਕਾਸ਼ਨਾਵਾਂ

₹ 70 ₹ 70 ₹ 70 ₹ 70 ₹ 25 ₹ 40 ₹ 200 ₹ 25

₹ 50 ₹ 50 ₹ 50 ₹ 50 ₹ 30 ₹ 20 ₹ 20 ₹ 20 ₹ 25

₹ 200 ₹ 200 ₹ 200 ₹ 200 ₹ 200 ₹ 20 ₹ 20 ₹ 20 ₹ 20 ₹ 30/-

Available at PAU Book Shop, Gate no. 1

ਮੈਂਬਰ ਬਣੋ/ For Membership

	ਚੰਦੇ ਦੀ ਰਾਸ਼ੀ/ Subscription Money	
ਚੰਗੀ ਖੇਤੀ (ਪੰਜਾਬੀ ਵਿੱਚ ਮਾਸਿਕ ਪਤ੍ਰਿਕਾ)/ Progressive Farming (Monthly in English)	ਭਾਰਤ ਵਿੱਚ/ In India (Rs.)	ਵਿਦੇਸ਼ਾ ਲਈ For Abroad (US$)
ਇੱਕ ਪਰਚਾ/Single Copy	20/-	10.00
ਸਲਾਨਾ ਚੰਦਾ/For One Year	200/-	100.00
ਸਲਾਨਾ ਚੰਦਾ ਰਾਜਿਸਟਰਡ ਡਾਕ ਰਾਹੀਂ/ Annual through registered post	440/-	
ਪੰਜ ਸਾਲ ਲਈ/For Five Years	800/-	400.00
ਦਸ ਸਾਲ ਲਈ/For Ten Years	1600/-	1000.00
ਉਮਰ ਭਰ ਲਈ (30 ਸਾਲ ਲਈ)/ Life Subscription (For 30 Years)		
ਵਿਅਕਤੀਗਤ/Individual	3000/-	1500/-
ਸੰਸਥਾਵਾਂ ਲਈ/Institutional	5000/-	2000/-
ਫਸਲਾਂ ਦੀ ਕਾਸ਼ਤ ਲਈ ਸਿਫਾਰਸਾਂ (ਸਾਉਣੀ/ਹਾੜ੍ਹੀ)/ Package of Practices (Kharif/Rabi)		
ਇੱਕ ਕਾਪੀ/Single Copy	70/-	--
ਉਮਰ ਭਰ ਲਈ (30 ਸਾਲ ਲਈ)/Life Subscription (For 30 Years)		
ਵਿਅਕਤੀਗਤ/Individual	1000/-	--
ਸੰਸਥਾਵਾਂ ਲਈ/Institutional	1500/-	--
Agricultural Research Journal From 1-3-2020		
Single Copy	200/-	--
Annual	1200/-	75.00
Life Subscription (For 30 Years)		
Individual	6000/-	--
Insitutional	7500/-	--

Note(s):

- ਪੁਸਤਕਾਂ ਭੇਜਣ ਲਈ ਕੋਈ ਡਾਕ ਖ਼ਰਚਾ ਨਹੀਂ / No extra postage charges for sending books.
- ਆਨਲਾਈਨ ਪੈਸੇ ਜਮ੍ਹਾ ਕਰਾਉਣ ਦੀ ਵਿਧੀ: ਖਾਤਾ ਧਾਰਕ ਦਾ ਨਾਂ: COMPTROLLER, PAU, ਖਾਤਾ ਨੰਬਰ: 29380200000002, IFS Code: BARB0PAULUD
- ਆਨਲਾਈਨ ਪੈਸੇ ਜਮ੍ਹਾਂ ਕਰਾਉਣ ਤੋਂ ਬਾਅਦ ਰਸੀਦ 86993-04711 ਤੇ ਵਟਸਐਪ ਕਰੋ ਜਾਂ businessmanager@pau.edu ਤੇ ਈਮੇਲ ਕਰੋ।
- ਅਦਾਇਗੀ ਬੈਂਕ ਡਰਾਫ਼ਟ, ਮਨੀ ਆਰਡਰ ਜਾਂ ਲੋਕਲ ਅਦਾ ਹੋਣ ਵਾਲੇ ਚੈੱਕ ਰਾਹੀਂ/ Payment through Bank Demand Draft, Money Order or Cheque Payable Locally only.
- ਬੈਂਕ ਡਰਾਫ਼ਟ ਕੰਪਟਰੋਲਰ, ਪੀ.ਏ.ਯੂ., ਲੁਧਿਆਣਾ ਦੇ ਨਾਂ ਤੇ ਬਣਾਓ/ Bank Draft to be drawn in favour of The Comptroller, PAU, Ludhiana, India.
- ਮਨੀ ਆਰਡਰ ਬਿਜ਼ਨਸ ਮੈਨੇਜਰ, ਪੀ.ਏ.ਯੂ. ਦੇ ਨਾਂ ਤੇ ਭੇਜੋ Money Order to be send in favour of Business Manager, Commucication Centre, PAU, Ludhiana.

ਖੇਤੀ ਸੰਬੰਧੀ ਨਵੀਨਤਮ ਜਾਣਕਾਰੀ ਪ੍ਰਾਪਤ ਕਰਨ ਲਈ ਯੂਨੀਵਰਸਿਟੀ ਦੇ ਫੇਸਬੁੱਕ ਪੇਜ Punjab Agricultural University@pauldhpunjab ਅਤੇ ਯੂਟਿਊਬ ਚੈੱਨਲ Punjab Agricultural University Official Channel ਨਾਲ ਜੁੜੋ।

ਆਪਣੇ ਮੋਬਾਇਲ ਤੇ ਡਿਜ਼ੀਟਲ ਅਖਬਾਰ 'ਖੇਤੀ ਸੰਦੇਸ਼' ਵਟਸ ਐਪ ਰਾਹੀਂ ਮੁਫਤ ਪ੍ਰਾਪਤ ਕਰਨ ਲਈ 82880-57707 ਨੰ. ਨੂੰ ਆਪਣੇ ਵਟਸ ਐਪ ਗਰੁੱਪਾਂ ਵਿਚ ਸ਼ਾਮਿਲ ਕਰੋ।

ਸੰਪਰਕ ਕਰੋ/ Contact:

ਬਿਜ਼ਨਸ ਮੈਨੇਜਰ
ਸੰਚਾਰ ਕੇਂਦਰ
ਪੰਜਾਬ ਐਗਰੀਕਲਚਰਲ ਯੂਨੀਵਰਸਿਟੀ, ਲੁਧਿਆਣਾ-141004
ਫੋਨ- 0161-2401960 (475), 98884-37011
ਫੈਕਸ- 0161-2405731
ਈਮੇਲ- businessmanager@pau.edu
spa@pau.edu

Business Manager
Communication Centre
Punjab Agricultural University, Ludhiana, (India)-141004
Phone: 0161-2401960(475), 98884-37011
Fax- 0161-2405731
email- businessmanager@pau.edu
spa@pau.edu

ਹੋਰ ਕਿਤਾਬਾਂ ਦੀ ਸੂਚੀ ਲਈ ਪੀ.ਏ.ਯੂ. ਦੀ ਵੈੱਬਸਾਈਟ ਤੇ ਜਾਓ।

PACKAGE OF PRACTICES FOR CROPS OF PUNJAB

Kharif 2025

Volume 42 March 2025 No.1

PUNJAB AGRICULTURAL UNIVERSITY
LUDHIANA

The Package of Practices for the Crops of Punjab, *Kharif* 2025 contains the latest recommendations and readily-usable information provided by the specialists of various departments of PAU through the coordination of the Director of Research. These improved farming techniques for stepping up productivity of cereals, pulses, cotton, sugarcane, oilseeds, fodders and some other crops in Punjab have been discussed and finalised in the Research and Evaluation Committee. It is purposely written in a simple and easy-to-understand language because these recommendations are intended for the use of the field level extension workers and the farmers of Punjab.

Compiled and edited by

Dr Makhan Singh Bhullar

Director of Extension Education

Dr Amit Salaria

Extension Scientist (Agronomy)

IMPORTANT NOTICE

The information on performance of recommended technologies given in this book holds good only when used under optimal conditions. The performance of the technologies may vary with many reasons including weather conditions, soil health, quality and availability of irrigation water, management level, negligence, mishandling of recommendations etc. **The Punjab Agricultural University, Ludhiana accepts no legal responsibility in this regard.**

Advertisements given are not necessarily the recommendations of the Punjab Agricultural University, Ludhiana

Price per copy	Rs. 70.00
Subscription for life	Rs. 1000.00
Subscription for *Kharif* and *Rabi* for the Institutions forever	Rs. 1500.00

Printed and Published by

Dr Tejinder Singh Riar, Additional Director Communication,

Punjab Agricultural University Ludhiana

adcomm@pau.edu

Regd. No. 4233/84

CONTENTS

NEW RECOMMENDATIONS

CROP VARIETIES

PR 132* (Rice): It is a high-yielding, nitrogen use efficient variety with an average plant height of 113 cm. It matures in 111 days after transplanting and its average paddy yield is 31.5 quintals per acre.

PMH 17* (Maize): It is a dual purpose single cross hybrid suitable for grain and silage. It matures in 96 days and its average grain yield is 25.0 quintals per acre.

CIM Unnati* (Mentha): It is high yielding variety of menthol mint (*Mentha arvensis* L.) with high oil content of 0.81-0.83%. Its average herb yield is 113 quintals per acre.

PRODUCTION TECHNIQUES

Rice: In coarse-textured soils, apply organic manures (FYM/Poultry manure/ Pressmud/Rice straw compost) in addition to the recommended dose of nitrogen for obtaining higher yield and ameliorating micronutrient deficiencies.

For uniform ripening, permissible moisture content in grains, higher yield and quality, the transplanting of PR 126 should not be done beyond 15th July.

Direct Seeded Basmati Rice: Reduce the dose of urea to 18 kg urea per acre after green manuring with sunnhemp and 36 kg urea per acre if summer moong residue has been incorporated.

Sugarcane: In potash-deficient soils, apply 50 kg per acre of muriate of potash to plant crop (at the time of planting) and ratoon crop (with first hoeing).

Multiple Cropping: Summer *moong*-DSBR-Wheat cropping system is recommended for higher yield and economic returns.

Apply 2.5 tonnes per acre of crop residue mulch to each crop in *kharif* maize-potato-spring maize cropping system under surface/sub surface drip irrigation for higher yield and water saving.

Management of poor quality irrigation water: Yellow gypsum can be used as an effective alternative to mined gypsum to reduce the adverse effects of sodic water irrigation.

PROTECTION TECHNIQUES

Rice: Spray 300 ml per acre of Viola 10 SC (flupyrimin) for the control of planthoppers.

Spray 200 g per acre of Ayaan 48 WG (kresoxim methyl 40% + hexaconazole 8%) or 600 g per acre of Avancer Glow 75 WG (azoxystrobin 8.3% + mancozeb 66.7%) for management of sheath blight in rice.

*Subject to the approval by SAVC

Rice and Basmati Rice: Spray 400 g per acre of Supremo 50 SP (thiocyclam hydrogen oxalate) for control of rice stem borer and leaf folder in rice and basmati rice.

Basmati Rice: To manage foot rot, treat seeds with *Trichoderma asperellum* 2% WP, PAU strain @ 15 g per kg seed and dip seedlings @15 g *Trichoderma asperellum* 2% WP, PAU strain per litre of water for 6 hrs before transplanting.

Direct Seeded Rice: Spray 1.0 litre per acre of PEPE 25 SE (penoxsulam 1% + pendimethalin 24%) as pre-emergence herbicide for weed control in DSR.

Spray 500 ml per acre of Novlect 12 EC (florpyrauxifen-benzyl 2.13% + cyhalofop-butyl 10.64%) for control of weeds at 20-25 days after sowing in DSR.

Cotton: Spray 170 ml per acre of Delegate 11.7 SC (spinetoram) for management of pink bollworm.

To protect early sown cotton from pink bollworm, start the first spray when 10-20% plants start producing squares. Subsequently, sprays should be done when 5% damage is observed in flowers and green bolls.

Spring sugarcane: Spray 1200 g per acre of Triskele/Trishuk (2,4-D sodium salt 44% + metribuzin 35% + pyrazosulfuron ethyl 1%) WDG or 1000 g per acre of Sindica (2,4-D sodium salt 48 % + metribuzin 32% + chlorimuron ethyl 0.8%) WDG at 3-5 leaf stage of weeds for effective weed control.

Spray 150 ml per acre of Citigen 18.5 SC (chlorantraniliprole*) for management of early shoot borer in sugarcane.

Spray 150 ml per acre of Coragen 18.5 SC (Chlorantraniliprole*) for management of top borer in sugarcane.

Rodent management in Direct Seeded Rice: Burrow baiting after sowing followed by burrow/crop baiting at the dough stage with zinc phosphide or bromadiolone is recommended for rodent management.

FARM MACHINERY

Mat-type paddy nursery cutter: PAU nursery cutter is recommended for cutting of mat-type paddy nursery.

Details of above recommendations are provided under different chapters in this book.

List of Pesticides Restricted or Banned in the Country

a. Pesticides restricted for use		
1.	Aluminium phosphide	It is to be sold only to government undertakings/ organisations and to be used under strict supervision of government experts or Pest Control Operators.
2.	Captafol	The use of captafol as foliar spray is banned. It shall be used as seed dresser.
3.	Cypermethrin	Cypermethrin 3% Smoke Generator is to be used only through Pest Control Operators and not allowed to be used by General Public.
4.	Dazomet	The use of Dazomet is not permitted on tea.
5.	DDT	Restricted for use in public health only.
6.	Fenitrothion	The use of fenitrothion is banned on Agriculture except for locust control in scheduled deseart area and public health
7.	Methyl bromide	Restriction for its sale and use is similar to that of Aluminium phosphide.
8.	Monocrotophos	Banned for use in vegetables.
9.	Trifluralin	Restricted for use in wheat only.

b. Pesticides banned for use in agriculture in India			
1.	Aldicarb	14.	Dieldrin
2.	Aldrin	15.	Endrin
3.	Benomyl	16.	Ethyl Mercury Chloride
4.	Benzene Hexachloride	17.	Ethyl Parathion
5.	Calcium Cyanide	18.	Ethylene Dibromide
6.	Carbaryl	19.	Fenarimol
7.	Chlorbenzilate	20.	Fenthion
8.	Chlordane	21.	Heptachlor
9.	Chlorofenvinphos	22.	Lindane (Gamma-HCH)
10.	Copper Acetoarsenite	23.	Linuron
11.	DDT	24.	Maleic Hydrazide
12.	Diazinon	25.	Menazon
13.	Dibromochloropropane (DBCB)	26.	Methoxy Ethyl Mercury Chloride

27.	Methyl Parathion	35.	Sodium Cyanide
28.	Metoxuron	36.	Sodium Methane Arsonate
29.	Nicotine Sulphate	37.	Tetradifon
30.	Nitrofen	38.	Thiometon
31.	Paraquat Dimethyl Sulphate	39.	Toxaphene
32.	Pentachlorophenol (PCP)	40.	Trichloro acetic acid (TCA)
33.	Pentochloro Nitrobenzene (PCNB)	41.	Tridemorph
34.	Phenyl Mercury Acetate (PMA)		

c. Pesticide formulations banned for use			
1.	Carbofuran 50% SP	3.	Methomyl 12.5% L
2.	Methomyl 24% L	4.	Phosphamidan 85% L

CAUTION

Chemicals used to control insects, diseases and weeds are poisons for human beings. Farmers are cautioned to use these poisons carefully to avoid any effect on human health.

- Volume of spray material to be used for controlling different insects and diseases of various crops is based on the usage of shoulder-mounted knapsack sprayer having "fixed type hollow cone nozzle." Spray volume may vary when other types of sprayers/nozzles are used for this purpose.
- It should, however, be ensured that the actual amount of pesticides recommended in the "Package of Practices" should not be reduced. For proper control of weeds, it is always necessary to use flood jet or flat fan spray nozzles.

IMPORTANT NOTE

The chemicals **bearing star (*),** recommended for the control of weeds, insect-pests and diseases, belong to green chemistry with short persistence.

1. CEREALS

RICE

Rice crop occupied 31.79 lakh hectares in Punjab with total paddy production of 214.26 lakh tonnes (143.56 lakh tonnes of rice) during 2023-24. The average yield of paddy was 67.40 quintals per hectare (27.28 quintals per acre).

Important Hints

- To save water and for ease in management of paddy straw, grow PAU recommended short duration varieties.
- Avoid cultivation of Pusa 44, *Peeli* Pusa, *Dogar* Pusa as these require 15-20 per cent more water and demand atleast two extra sprays of pesticides, thereby lowering the net profit.
- Restrict to timely sowing of nursery (20 May-20 June) and timely transplanting (20 June-10 July) schedule for better grain quality, water saving and low build-up of stem borers.
- For higher yield and better grain quality from PR 126, transplant 25-30 days old nursery.
- Adopt direct seeding of rice in *tar-wattar* field from 1 June onwards for higher savings in irrigation water.
- Apply fertilizers as per soil test. Omit phosphorus application in rice following wheat that received recommended dose of phosphatic fertilizer. Use nitrogen judiciously based on Leaf Colour Chart (LCC). Excessive use of nitrogen fertilizer encourages multiplication of insect pests and diseases.
- Avoid planting of PR 131 variety in sub-mountainous areas.
- **To obtain higher yield of PR 132, apply 25% less nitrogenous fertilizers than other varieties**
- To control false smut disease, initiate the spray of recommended fungicides at boot stage of the crop.
- Plant hoppers feed at the base of rice plants and are often overlooked. Their damage is noticed only when the crop is hopper burnt. Hence, regular monitoring of the insect population is necessary.
- Use of synthetic pyrethroids leads to increase in the population of rice planthoppers. Hence, these insecticides should not be used for the control of rice insect-pests.
- Stop irrigation about a fortnight before maturity.
- Harvesting should be done at proper maturity and variety-wise. Avoid harvesting during night.

Climatic Requirements

Rice is best suited to regions of high temperature, high humidity, prolonged sunshine and assured water-supply. In Punjab, high productivity of rice can be expected if the maximum temperature remains within 34-40, 33-35 and 32-35°C, minimum temperature within 23-28, 25-27 and 20-25°C and the bright sunshine ranges between 7-11, 6-10 and 7-10 hours/day during vegetative, flowering and grain development stages, respectively.

Soil Type

Rice can grow well on soils with low permeability and over a wide range of soil reaction viz. pH 5 to 9. Generally, the loamy soils are the best for rice cultivation.

Rotations

Rice-Wheat / Berseem / Linseed / Gram / Barley, Rice-Wheat / Summer Moong/Green manuring, Rice-Celery, Rice-Potato/Peas-Celery, Rice-Potato-Potato/Summer Moong/ Sunflower/Celery/Wheat/Cucurbits, Rice-*Toria*-Sunflower, Rice-Gram-Summer Moong, Rice-*Gobhi Sarson*-Summer Moong, DSR-Potato-Mentha/Onion, DSR-Wheat-Summer moong/Green manuring.

Improved Varieties/Hybrids

PR 132 (Subject to the approval by SAVC): It is a high yielding, medium duration, nitrogen use efficient variety. It performs best at 75% (25% lower) of the recommended nitrogen dose. **Higher nitrogen dose pose the risk of lodging in this variety.** Its average plant height is 113 cm and matures in about 111 days after transplanting. It possesses long slender, clear, translucent grains with high total and head rice recoveries. It is resistant to six of the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab state. Its average paddy yield is 31.5 quintals per acre.

PR 131 (2022): It is a high yielding, medium maturing and lodging tolerant variety. Its average plant height is 111 cm and matures in about 110 days after transplanting. It possesses long slender translucent grains with high total and head rice recoveries. It is resistant to all the ten pathotypes of bacterial blight pathogen prevalent in the Punjab state. Its average yield is 31.0 quintals per acre.

PR 130 (2022): It is a high yielding, mid early and lodging tolerant variety. Its average plant height is 108 cm and it matures in about 105 days after transplanting. It possesses long slender translucent and lustrous grains with high total and head rice recoveries. It is resistant to all the ten pathotypes of bacterial blight pathogen prevalent in the Punjab state. Its average yield is 30.0 quintals per acre.

PR 129 (2020): It is an improved version of PAU 201. It possesses long slender clear translucent grains. Its' average plant height is 105 cm and matures in about 108 days after transplanting. It is resistant to all the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab state. Its' average paddy yield is 30.0 quintals per acre.

PR 128 (2020): It is also an improved version of PAU 201. It possesses long slender clear translucent grains. Its' average plant height is 110 cm and matures in about 111 days

after transplanting. It is resistant to all the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab state. Its' average paddy yield is 30.5 quintals per acre.

HKR 47 (2020): It is a mid-early maturing variety. It takes about 104 days to mature after transplanting with an average plant height of 117 cm. It possesses long slender, clear translucent grains. It is susceptible to all the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab state and is prone to lodging. Its' average paddy yield is 29.5 quintals per acre.

PR 127 (2018): It is a medium maturing rice variety with an average height of 104 cm. It matures in about 107 days after transplanting. It possesses long slender, clear translucent grains with high total and head rice recoveries. It is resistant to all the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab state. Its' average paddy yield is 30.0 quintals per acre. Do not grow this variety in alkali soils and under brackish water.

PR 126 (2017): It is an early maturing rice variety. It's average plant height is 102 cm and matures in about 93 days after transplanting. It possesses long slender, clear translucent grains. It is resistant to seven of the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab state. Its' average paddy yield is 30.0 quintals per acre. Transplant 25-30 days old nursery.

PR 122 (2013): Its' average plant height is 108 cm and matures in 117 days after transplanting. It possesses long slender translucent grains. It is resistant to all the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab state. Its' average paddy yield is 31.5 quintals per acre.

PR 121 (2013): It is a short statured, stiff strawed lodging tolerant variety with dark green and erect leaves. It attains height of about 98 cm and matures in 110 days after transplanting. Its' grains are long slender, translucent with good cooking quality. It is resistant to all the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab state. Its' average paddy yield is 30.5 quintals per acre.

PR 114 (1999): It has narrow, dark green erect leaves. It attains an average height of about 102 cm and matures in about 115 days after transplanting. It possesses extra long, clear translucent grains. It is resistant to five of the ten pathotypes of bacterial blight pathogen presently prevalent in Punjab state. Its' average yield is 27.5 quintals of paddy per acre.

PR 113 (1998): Its' average plant height is about 105 cm. Its' grains are bold and heavy. It matures in about 112 days after transplanting. It is resistant to eight of the ten pathotypes of bacterial leaf blight pathogen presently prevalent in Punjab state. Its' average paddy yield is 28.0 quintals per acre.

Do not grow these varieties

Pusa 44/*Peeli* Pusa/*Dogar Pusa*: These long duration varieties consume 15-20 per cent more water than PR varieties, have more straw load and are susceptible to all the prevalent pathotypes of bacterial blight in the State. Due to severe outbreak of insect-pest and diseases, these demand atleast two extra sprays of pesticides thereby lowering the net profit.

Agronomic Practices

Transplanted Rice

Nursery Raising: The time and method of sowing are important for getting healthy seedlings.

I. For Conventional Transplanting

Time of Nursery Sowing: 20 May- 20 June is the optimum time of sowing:

PR 132, PR 131, PR 129, PR 128, PR 122, PR 121, PR 114, PR 113	May 20-25
PR 127, PR 130, HKR 47	May 25-31
PR 126	May 25-June 20

Seed Rate and Seed Treatment: Dip the seed in suitable lots in water contained in a tub/ bucket. Stir the seed and remove immature grains which float at the top. The heavy seeds will settle down at the bottom. Eight kg of heavy seed is sufficient for transplanting an acre. Heavy seed ensures healthy, sturdy and uniform seedlings. Treat the seed with Sprint 75 WS (carbendazim + mancozeb) by making slurry of 3 g fungicide formulation in 10-12 mL water for one kg seed (24 g fungicide in 80-100 mL water for 8 kg seed) before sowing.

Land Preparation, Fertilizers and Method of Sowing: Mix 12 to 15 tonnes of well-rotten farmyard manure or compost per acre in the soil. Irrigate the field to permit the germination of weeds. Plough the field twice after about a week to kill germinated weeds.

Spread the treated seeds in 7-8 cm thick layer over wet gunny bags and cover them with wet gunny bags. Keep the layer of seeds moist by sprinkling water on it periodically. The seeds sprout in about 24 to 36 hours.

Apply 26 kg urea, 60 kg single superphosphate and 40 kg zinc sulphate heptahydrate (21% Zn) or 25.5 kg zinc sulphate monohydrate (33% Zn) per acre at sowing. Sow 8 kg seed by broadcasting on an area of 160 square meter (6.5 *marlas*) to raise nursery for one acre. To check the damage from birds, broadcast a thin layer of well-decomposed farmyard manure immediately after broadcasting rice seed. Keep the soil moist by irrigating the field frequently. Apply another dose of 26 kg urea per acre about a fortnight after sowing so as to get the seedlings ready for transplanting in 25-30 days. However, under forced circumstances, if nursery of about 45 days or above is to be transplanted, apply another dose of 26 kg urea after 4 weeks of sowing. In case, any insect attack or disease appears in the nursery, adopt the recommended plant protection measures. Irrigate the nursery regularly. The seedlings are ready when they are 20-25 cm tall or with 6 to 7 leaves.

- **Sow nursery of various varieties as per recommended schedule.**
- **Transplant 25-30 days nursery of PR 126.**
- **Level the fields with laser land leveller before direct sowing or transplanting of rice.**
- **Keep water standing in paddy field only for 2 weeks and thereafter apply irrigation 2 days after the ponded water has infiltrated into soil.**

If the seedlings in the nursery show the yellowing of new leaves, spray them three times with 0.5-1% ferrous sulphate solution (0.5-1.0 kg ferrous sulphate dissolved in 100 litres of water per acre) at weekly intervals. If the leaves turn rusty brown after becoming yellow, give a spray of 0.5% zinc sulphate heptahydrate solution (500 g zinc sulphate heptahydrate dissolved in 100 litres of water) or 0.3% zinc sulphate monohydrate solution (300 g zinc sulphate monohydrate dissolved in 100 litres of water per acre).

Weed Control: *Swank* and some other annual grasses are the main problems in rice nursery. These weeds can be controlled by applying 1200 mL per acre Butachlor 50 EC mixed with 60 kg of sand after 7 days of broadcasting seed or 500 mL per acre of Sofit 37.5 EC (pretilachlor + safener readymix) as sand mix, 3 days after sowing or 100 mL per acre of Nominee Gold/Taarak/Wash out/Macho 10 SC (bispyribac) as spray in 150 litres of water at 15- 20 days after sowing.

II. For Rice Transplanter - Mat-type nursery

Select a location having fertile soil, assured irrigation and minimum transportation distance of location to the field. There should be no stones or other hard material in the soil. The field should be preferably laser leveled and 20 metres away from tubewell and trees. Prepare the field at proper moisture. Spread polythene sheet 50-60 gauge, 90 cm wide having 1-2 mm dia perforations over it. Polythene sheets weighing 270 g spread to a length of about 15 meters (for about 150 mats) is sufficient for preparing seedlings for one acre.

Place one or more iron frames over the polythene sheet having compartments of size 45x21x2 cm for engine operated transplanter and 58x28x2 cm for self propelled transplanter. Number and size of compartments vary according to machine specifications. Fill the soil from both sides of the frames uniformly upto the top surface.

Spread 50-60 g of pre-germinated seed evenly in each compartment to achieve uniform density of 2 or 3 seeds per sq cm in the mat. For uniform seed distribution, use drum type nursery sowing seeder. The length of nursery sowing seeder is to be equal to width of frame and has openings of 1 cm diameter on full length of the roller. About 10-12 kg seed is sufficient to sow about 150 mats required for transplanting in one acre. Cover the seeds by a thin layer of soil and sprinkle water by hand sprayer for proper setting of the soil. Lift frames and put these at the next place and repeat the above procedure for sowing the required number of seedling mats. Two persons can sow seedlings for 3-4 acres in a day.

After sowing, irrigate the field on same day, but the flow of water for first 2-3 irrigations should be very mild and level should be uniform so that there is no damage to newly formed mats. Care must be taken that the seedling mats should be always wet. Spray the fertilizer after an interval of about 10 days with 200 g urea dissolve in 15 litre water to150 mats. The seedling mats will be ready after 25-30 days of sowing. Drain water from the nursery field a few hours before uprooting of nursery. Give a cut with a sharp blade/knife along the nursery boundaries of the mat. The uprooted nursery mats are ready for transport to the field.

Tractor operated seeder for mat type paddy nursery: The tractor operated seeder for mat type paddy nursery can be used to lay a 1.0 m wide perforated polythene sheet (50-60

gauge) over 1.0 m wide soil bed with simultaneous uniform seed placement over the soil bed for raising Mat type nursery for mechanical paddy transplanters. Use PAU nursery cutter for cutting of mat type paddy nursery (Annexure V)

Operations before Transplanting

Organic Manures/*Prali Char*: Apply 6 tonnes of farmyard manure or 6 tonnes of press mud or 2.5 tonnes of poultry manure or 2.4 tonnes of dried gobar gas plant slurry or 2.0 tonnes *prali char* (details of *prali char* are given under Management of Paddy Straw) per acre before preparatory tillage for transplanting of rice.

Green manuring: Since organic manures are not available in required quantities, green manuring with *dhaincha*/cowpea/sunnhemp is a very practicable alternative. After harvesting wheat or any other preceding crop, apply pre-sowing irrigation (*rauni*) and sow 20 kg per acre of *dhaincha* seed pre-soaked in water for 8 hours or 12 kg per acre of cowpea (20 kg if bold seed is used) or 20 kg per acre of sunnhemp up to the first week of May. Apply 75 kg superphosphate per acre to *dhaincha*/cowpea/sunnhemp in soils testing low in phosphorus and omit application of phosphorus to the succeeding rice crop. Bury 6 to 8 weeks old *dhaincha*/cowpea/sunnhemp one day before transplanting of paddy. *Dhaincha* should be prefered in *kallar* and recently reclaimed soils. This practice results in saving of 25 kg of N (55 kg urea) per acre. If the moong crop after picking of pods has been incorporated one day before transplanting then reduce fertilizer N dose by one-third. Green manuring with *dhaincha* also ameliorates iron deficiency in rice.

Rice straw incorporation/retention: Continuous incorporation/retention of rice straw improves soil health and rice yield. Whenever, the soil organic carbon content come under high (as per soil test report) category or after 8 years, reduces urea by 20 kg per acre in rice.

Land Preparation: Use laser land leveler for precision land leveling before puddling to enhance the efficiency of water and other farm inputs. Repair all bunds. Obtain a fine well levelled puddled field to reduce water loss through percolation, to maintain good seedling vigour and to control weeds.

Transplanting

Dates of Transplanting: Time of transplanting is a single factor which influences rice yield substantially. For getting maximum yield of rice and for the timely vacation of the field for sowing wheat and other crops, transplant rice seedlings from 20 June to 10 July.

Under late transplanting conditions, prefer transplanting of PR 126. However, for uniform ripening, permissible moisture content in grains, higher yield and quality, the transplanting of PR 126 should not be done beyond 15th July.

Age of Seedlings at Transplanting: Use 30-35 days old seedlings for medium duration varieties. However, for short duration variety (PR 126), seedlings of 25-30 days should be used. Transplanting of aged seedlings results in reduction of yield and quality.

Uprooting of Seedlings: Irrigate the nursery before uprooting. Wash the seedlings in water to remove mud.

Seedling Inoculation: Mix half kg packet of *Azospirillum* biofertilizer with 100 litre of water. Dip the root of rice nursery seedlings for one acre in this solution for 45 minutes and transplant immediately. The bio-fertilizer culture is available with the PAU Seed Shop at Gate No. 1, *Krishi Vigyan Kendras* and Farm Advisory Service Centres in different districts.

Method of Transplanting

a. Flat puddled transplanting: Transplant seedlings in lines at 20 x 15 cm (33 hills/sq m) for normal transplanting of all varieties and for late transplanting of PR126. Transplant seedlings in lines at 15 x 15 cm (44 hills/sq m) for the late transplanting of other varieties. Put 2 seedlings per hill. The seedlings should be transplanted upright and about 2-3 cm deep. This practice ensures good establishment of seedlings and early tillering, which are essential for good tiller development and synchronous flowering.

b. Ridge or Bed transplanting without puddling: In heavy textured soils, rice can be transplanted on ridges or beds to save irrigation water. After field preparation, apply basal dose of fertilizer and prepare ridges or beds with ridger or wheat bed planter. Irrigate the furrows and immediately transplant seedlings on the middle of the slopes (both sides) of 60 cm spaced ridges keeping plant to plant spacing of 10 cm or on 67.5 cm spaced beds keeping plant to plant spacing of 9 cm.

During the first 15 days after transplanting, apply irrigation on daily basis. Thereafter, apply irrigation in furrows only two days after the ponded water has infiltrated into the soil. Every care should be taken that field does not develop cracks in the furrows.

For controlling weeds, spray 120 mL per acre Nominee Gold/ Wash out/Taarak/Macho 10 SC (bispyribac) in 150 litres of water at 20-25 days of transplanting. Hand pulling of weeds can be done, if needed. Follow other cultural practices as recommended for flat puddled transplanted rice.

c. Mechanical transplanting: Mat type nursery should be transplanted with mechanical paddy transplanter or remotely controlled 2-wheel paddy transplanter at spacing of 30x12 cm.

Weed Control

Interculture with a Paddy Weeder (Annexure V), 15 days after transplanting and again after a fortnight. Where a paddy weeder cannot be run, hand weeding may be done.

Chemical weed control: The control of weeds with herbicides is both efficient and economical.

1. Control of weeds with pre-emergence and early post-emergence: Use of any of the following pre-emergence and early post-emergence herbicides provides effective control of *swank* and moderate control of other weeds.

i. **Pre-emergence (within 2 to 3 days of transplanting):** Any of the herbicide listed in the table below may be applied by mixing with 60 kg of sand per acre in standing water within 2 to 3 days of transplanting. These herbicides are highly effective against swank and provide moderate control of other weeds.

Brands (Herbicide)	Dose per acre	Remarks
Machete/Delchlor/Rasayanchlor/Exachlor/Punch/ Hiltachlor/ Thunder/Teer/Capchlor/Trapp/ Milchlor/ Narmadachlor/Fychlor/Arochlor/Megachlor/Butachlor-Sunbeam /Markchlor/Paklor /Banweed/Butacid/ Jaibutachlor 50 EC (butachlor)	1200 mL	
Fast-mix 50 EW (butachlor)	1200 mL	
Arozin 18 EC (anilofos)	850 mL	For control of kanki, Arozin/Anilogaurd/Libra/ Control H-30/Jaifos/ Pestoanilofos/Markanil/ Haragro-anilfos/Padigard have an edge over other herbicides.
Arozin/Aniloguard/Libra/Control H-30 /Pestoanilofos/ Markanil/Jaifos/Haragro-anilfos/Padigard 30 EC (anilofos)	500 mL	
Stomp 30 EC (pendimethalin)	1000 to 1200 mL	In case of Stomp, use lower dose on light textured soils and higher dose on medium to heavy textured soils.
Rifit/Eraze/Markpretila/ Revenge/Mif Pretila/Sokusai 50 EC (pretilachlor*)	600 mL	
Rifit Plus 37 EW (pretilachlor*)	750 mL	
Sathi 10 WP (pyrazosulfuron ethyl)	60 g	
Use hand gloves while applying these herbicides.		

ii. **Early post-emergence (within 10-12 days of transplanting):** Early post-emergence spray of 40 mL per acre Granite 240 SC (penoxsulam*) at 10-12 days of transplanting in 150 litres of water, particularly in fields where continuous standing of water is a problem, provides effective control of grass weeds including *swank*, paddy *mothas* and broadleaf weeds in transplanted rice. Do not spray the herbicide in the standing water and irrigation may be applied one day after spray.

2. Control of weeds with post-emergence herbicides (within 20-25 days of transplanting): Depending on the weed flora present in the field, any of the herbicide listed in the table below may be applied at 20-25 days of transplanting, by dissolving in 150 litres of water per acre, when weed plants are at 2-4 leaf stages. Do not spray the herbicide in standing water and irrigation may be applied one day after spray.

Name of herbicide	Dose per acre	Target weed flora
Nominee Gold/Wash out/Macho/Taarak 10 SC (bispyribac sodium)	100 mL	*Swank,* paddy *mothas*
Ricestar 6.7 EC (fenoxaprop-p-ethyl)	400 mL	*Chini gha* (*Leptochloa*)*, kanki*
Algrip 20 WG (metsulfuron*)	30 gram	*Paddy mothas*, broadleaf weeds *(ghrilla, sanni etc)*
Sunrice 15 WG (ethoxysulfuron)	50 gram	
Londex 60 DF (bensulfuron methyl)	40 gram	
Almix 20 WP (metsulfuron methyl 10% +chlorimuron ethyl 10%)	8 gram	*Paddy mothas, gandi wala motha,* broadleaf weeds

Novixid 3.25 OD (florpyrauxifen-benzyl 1.31%+ penoxsulam 2.1%)	500 mL	*Swank,* paddy *mothas* (*chhatri wala motha, dodiyan wala motha, ghuien*), broadleaf weeds
Eketsu 43 WG (bispyribac sodium 38 % + chlorimuron ethyl 2.5% + metsulfuron methyl 2.5%)	40 g	*Swank, paddy mothas, gandi wala motha,* broadleaf weeds

- Use different group of recommended herbicides in rotation to avoid the problem of herbicide resistance in weeds.
- Delay in application of herbicides results in poor control of weeds.

Fertilizer Application

Apply organic manures, bio-fertilizer along with chemical fertilizers for higher crop yield and maintenance of soil health.

a) Organic manures/*Prali Char:* As described earlier apply farmyard manure or pressmud or poultry manure or gobar gas plant slurry or *prali char* or incorporate green manure before transplanting of rice. Where organic manures are used, reduce the dose of urea as under:

Organic manure	**Dose (t/acre)**	**Fertilizer saving**
Farmyard manure	6	16 kg Nitrogen (35 kg urea)
Pressmud	6	25 kg Nitrogen (55 kg urea)
Poultry manure	2.5	25 kg Nitrogen (55 kg urea)
Gobar gas slurry	2.4	16 kg Nitrogen (35 kg urea)
Prali Char	2.0	16 kg Nitrogen (35 kg urea)
Green manure	-	25 kg Nitrogen (55 kg urea)
Summer moong crop residue incorporation	-	16 kg Nitrogen (35 kg urea)

Note

* In addition to saving of nitrogen, application of *prali char* @ 2.0 t/acre increase the crop yield by 10%.

* In coarse textured soils, apply organic manures (6 tonnes FYM/2.5 tonnes Poultry manure/6 tonnes Pressmud/2.5 tonnes Rice straw compost, per acre) or green manure or summer moong residue in addition to recommended dose of nitrogen (50 kg N/acre) for obtaining higher yield and ameliorating micronutrient deficiencies in rice-wheat cropping system

b) Bio-fertilizer: Treat the nursery roots with one packet of recommended bio-fertilizer before transplanting.

c) Chemical Fertilizers: Apply fertilizer on soil test basis (See Chapter on 'Soil Testing'). However, in the absence of soil test, apply the fertilizers as under:

Variety	*Nutrients (kg per acre)			Fertilizers (kg per acre)			
	N	P_2O_5	K_2O	Neem coated urea	DAP	or single superphosphate	Muriate of potash
PR 132	31.5	12	12	67.5	27	75	20
All other varieties	42	12	12	90	27	75	20

* These nutrients can also be supplied from the other fertilizers available in the market (Annexure VII) To reduce sterility in paddy, apply foliar spray of 1.5% potassium nitrate (3 kg potassium nitrate in 200 litre of water per acre) at boot stage.

Note:

- Skip phosphorus application to rice if recommended dose of phosphorus had been applied to the preceding wheat crop.
- Apply phosphorus and potassium fertilizers only when the soil test shows deficiency of these nutrients (See Chaper on 'Soil Testing').
- Apply the whole of phosphorus and potassium as per soil test before the puddling. Phosphorus can be top dressed up to 21 days after transplanting.
- When 27 kg DAP is used in deficient soil, reduce the urea dose by 10 kg.
- Apply nitrogen fertilizer in 3 equal splits to all recommended varieties. The first split should be applied upto 7 days of transplanting and second split at 21 days of transplanting. The third split to short duration (PR 126) should be applied at 35 days of transplanting while for other varieties, it should be applied at 42 days of transplanting.
- Apply the second and the third split of nitrogen when water is not standing in the field. Irrigate on the third day of the application of fertilizer.
- If the paddy transplanted after applying 6 tonne per acre of fish pond sediments in field, apply 25% less dose of recommended fertilizers.

PAU-Leaf Colour Chart (PAU-LCC) for need based Urea application

- Apply basal dose of 25 kg urea per acre.
- Start matching colour of the first fully exposed leaf from the top with the LCC at 7 day intervals after 14 days of transplanting.
- Whenever the greenness of 6 or more out of 10 leaves is lighter than LCC shade 4 apply 25 kg urea per acre.
- No urea should be applied if colour of leaves is equal to or darker than LCC shade 4.
- Use of LCC should be discontinued after initiation of flowering and no more urea should be applied.

Note: Need based nitrogen management using LCC holds good for all the prevalent rice varieties grown in all type of soils. The use of LCC is highly beneficial for optimum fertilizer nitrogen use when fields are amended with organic manures. Always

- **Never over fertilize PR 132 to avoid lodging.**
- **Prefer to use organic/green manures and reduce dose of chemical fertilizer accordingly.**
- **Skip phosphorus application if recommended dose of phosphorus had been applied to the preceeding wheat crop.**
- **Use PAU-Leaf Colour Chart for need based nitrogen application.**
- **Excessive use of nitrogenous fertilizers particularly during flowering causes sterility and consequently heavy reduction in yield.**
- **To manage iron deficiency apply foliar sprays of 1% ferrous sulphate solution.**

match colour of the leaf with LCC under shade of the body. The leaves selected for measuring leaf greenness should be free of insect-pest incidence. There should not be water stress to the crop and nutrients other than nitrogen should be supplied as per recommendations. The LCC can be purchased from PAU Seed Shop at Gate No. 1, Krishi Vigyan Kendras and Farm Advisory Service Centres in different districts.

Zinc Deficiency: The symptoms of zinc deficiency appear 2-3 weeks after transplanting (**Plate No. 1**, **page 197**). The lower leaves become rusty brown near the base and ultimately dry up. The seedlings with zinc deficiency remain stunted and tillerless. To control this malady, apply 25 kg of zinc sulphate heptahydrate (21%) or 16 kg zinc sulphate monohydrate (33%) per acre at puddling in case previous crop in this field had shown the symptoms of zinc deficiency. Where the deficiency is noticed in the growing crop, apply this quantity of zinc sulphate as soon as possible.

In highly deteriorated soils, the symptoms of zinc deficiency sometimes appear in patches even after the application of the recommended dose of zinc sulphate. In that event, broadcast 10 kg of zinc sulphate heptahydrate or 6.5 kg zinc sulphate monohydrate per acre mixed with an equal quantity of dry soil on the affected patches.

Iron Deficiency: Under scarcity of water, chlorosis among seedlings appears in the youngest leaf about three weeks after transplanting (**Plate No. 2, page 197)**. Plants die and often the crop fails completely. Start giving copious irrigations as soon as chlorosis appears and give 2 or 3 sprays of one per cent ferrous sulphate solution at weekly intervals (1 kg of ferrous sulphate in 100 litres of water per acre).

Irrigation and Drainage: Keep the water standing continuously in the crop for two weeks only after transplanting so that the seedlings get properly established. Afterwards, apply irrigation two days after the ponded water has infiltrated into the soil**.** To save irrigation water, irrigate with tensiometer installed at 15-20 cm soil depth at soil matric tension of 150$\pm$20 cm or when water level in tensiometer enters yellow strip. Every care should be taken that field does not develop cracks. In this way, irrigation water can be saved without causing any reduction in yield. The depth of standing water should not exceed 10 cm. Drain away excess water before interculturing or weeding and irrigate the field after these operations. Stop irrigation about a fortnight before maturity to facilitate easy harvesting and the timely sowing of the succeeding *rabi* crop.

Harvesting and Threshing: Harvest the crop just when the ears are nearly ripened and straw has turned yellow. If harvesting is delayed till the crop is dead ripe, the shattering of grains occurs. The milling quality of the grains is also affected. Combines are successfully used for harvesting paddy. Operate the combine at proper speed. Prefer combines fitted with a PAU Super S.M.S. (Straw Management System) for chopping and even distribution of straw. After harvesting of paddy with such combines, wheat can directly be sown with the help of Happy Seeder without burning of paddy straw. Tractor-drawn vertical conveyor reaper windrower can also be used for harvesting paddy. Multi-crop threshers can also be used for threshing paddy (Annexure V).

Production of Pure Seed: Select a good plot of the standing crop and rogue it thoroughly so that it is made free from all admixtures and diseased plants. Harvest and thresh this plot separately. Dry the produce well and store separately in disinfested bins.

Marketing and Storage

Marketing of the farm produce is an important function as income of the farmer to some extent depends upon it. As per specified norms, the moisture content in paddy should not be more than 17 per cent at the time of its marketing. The farmer has to pay only **unloading and cleaning charges** of the produce. The farmers are advised to get **'J' form** from the commission agent. The produce kept for home use should be dried thoroughly in the sun for about a week and stored in bins or kept in a heap inside the room. The optimum moisture content for storage is 12 per cent.

Management of Paddy Straw

In Punjab, about 220 lakh tonnes paddy straw is produced annually and a large portion of the straw is being burnt by the farmers. The straw contains a significant amount of essential plant nutrients. One tonne of paddy burning causes loss of 400 kg organic carbon, 5.5 kg of N, 2.3 kg of P, 25 kg of K and 1.2 kg of S. The burning of residue causes complete loss of nitrogen and sulphur. Due to burning of paddy straw poisonous gases like carbon dioxide, carbon monoxide, methane and nitric oxide are produced which are harmful for human and animal health. To avoid burning of straw, the following techniques are recommended:

1. In-situ management of paddy straw

a. Wheat sowing with Happy Seeder: Happy Seeder is recommended to sow wheat in combine harvested paddy field without any straw burning. It is a PTO driven machine operated by 45 HP tractor and it covers about 0.75-0.80 acre per hour. The loose straw needs to be spread uniformly in the field for the proper working of Happy Seeder. It can be done manually or harvest the paddy by combine harvester fitted with PAU super straw management system (SMS). After the harvesting of paddy with combine fitted with Super SMS, wheat can be sown with Happy Seeder or Spatial Zero Till Drill, without straw burning. The paddy straw acts as mulch which adversely affects the weed population.

In case the paddy is harvested with a combine without SMS system, use PAU Straw Cutter cum Spreader for chopping and spreading of paddy straw. After chopping of straw, sow wheat with PAU Happy Seeder (fitted with press wheels).

b. Wheat sowing with Super Seeder: Harvest paddy with combine harvester fitted with the PAU Super SMS for sowing wheat with Super Seeder in combine harvested paddy field without any straw burning. It is a PTO driven machine operated by 55 HP or above tractor and it covers about 4.5-5.5 acre per day.

c. Wheat sowing with PAU Smart Seeder: Harvest paddy with combine harvester fitted with the PAU Super SMS for sowing wheat with PAU Smart Seeder in combine harvested paddy field without any straw burning. It is a PTO driven machine operated by 45 HP or above tractor and it covers about 7-8 acre per day.

d. Surface seeding : Surface seeding-cum-mulching: It is a low-cost and easy technique for *in-situ* paddy residue management for timely sown wheat. It does not require much costly machinery, provides complete mulching and weed infestation is also less.

In this method, wheat seed and basal fertilizer are uniformly broadcasted in a combine harvested paddy field. It is followed by one pass of cutter-cum-spreader which cut the whole paddy straw (at 4-5 inch above soil surface). It is followed by irrigation to initiate germination of wheat. For sowing one acre, 45 kg wheat seed (treated with recommended pesticides) and 55 kg DAP as basal fertilizer are used.

Use 'PAU Surface Seeder' for sowing of wheat. It consists of seed & fertilizer box attachment, with fluted roller metering system, mounted on to a cutter-cum-spreader. It is a low cost machine which sow wheat seed and apply basal fertilizer in a combine harvested paddy field and cut the whole straw simultaneously. It is followed by irrigation. Alternatively, combine harvester fitted with seeding attachment which sow wheat and apply basal fertilizer at the time of paddy harvest, can be used. It is followed by a single operation of cutter-cum-spreader and irrigation.

e. Incorporation: Chop the straw and stubbles with Paddy Straw Chopper cum Spreader after combine harvesting of paddy. The chopped straw can be mixed in to the soil with rotary tillers after applying a light irrigation. The field comes in wattar condition in 2-3 weeks depending on type of soil. Sow wheat seed with zero till drill or with conventional drill. **Grow short duration rice varieties for increasing window period for straw management.**

2. Management after removal of paddy straw

Use Straw baler for baling the paddy straw after combine harvesting. It collects the loose straw or complete straw after chopping the standing stubbles with stubble shaver. These bales can be used for different purposes as follows:

a. Power generation: Eleven biomass power plants have been established in Punjab for the generation of electricity from paddy straw bales. Heat produced by burning paddy straw is used to run steam turbine which further generates electricity.

b. Paddy straw based bio-gas plant: Paddy straw can be used in a specially designed biogas plant for bio gas production. This biogas plant is filled one time with 16 quintal chopped paddy straw along with 4-5 quintal cattle dung and it provides 3-4 m^3 biogas daily for 3 months.

c. Paddy straw geyser: A geyser has been developed by the University for heating water by using paddy straw bales. In this geyser about 100 litres of water can be heated to 45-50^{0}C in 3-4 hours. The water once filled in the geyser remains hot for up to 24 hours or even more.

d. Phospo-compost: Phopho-compost can be prepared from the paddy straw. (see details in Orgrnic Farming Chapter)

e. *Prali Char*: *Prali Char* is a carbon rich porous product obtained after the partial combustion of rice straw at low temperatures in the presence of little or no oxygen. It can be prepared in a pyramid or dome type kiln, made up of bricks and clay. To prepare 8 quintals of *Prali Char* from 12 quintals of rice straw, the height of this dome should be 14 ft with 10 ft diameter. Two windows each at the top and at the bottom of the kiln are

provided for loading of paddy straw. Six vents of 2 inch diameter in the upper portion and eight vents are provided at three heights on the remaining portion of the structure. Fill the kiln with rice straw up to top. Seal the lower loading window and ignite the straw from the top loading window and immediately seal it with clay.

The partial combustion of rice straw will start from the top and proceeds towards the bottom. The emission of thin blue smoke from the vents indicates that the process of *Prali Char* formation is complete in this zone. To facilitate the combustion in the next zone, seal the vents located in the upper portion of the dome and likewise proceed to seal the vents of the middle and lower zone, respectively. The whole process usually takes about 10-12 hours. To seal the cracks developed during combustion and to cool the kiln, pour a diluted mixture of clay and water on the outer surface of the kiln. Normally it takes about two days to cool, however it can be cooled by sprinkling water for removing the *Prali Char* on the same day. On an average, it contains 30-36 % carbon, 0.5-0.6 % nitrogen, 0.16-0.22 % phosphorus and 1.6- 2.2 % potassium. Its' application to rice and wheat @ 2.0 t/acre saves 16 kg N (35 kg urea), increases crop productivity and improves soil health.

Besides, paddy straw can also be used as mulch material in different crops, mushroom cultivation and as animals bedding.

Plant Protection

A. Insect Pests

Rice stem borers: The larvae of these insects bore into the stem and cause damage from July to October. The affected young plants show dead-hearts (yellowing and drying of central shoot) whereas the old ones produce empty earheads which turn white and stand erect (**Plate No. 3, page 197**).

The fields showing more than **5% dead hearts (Economic Threshold Level, ETL)** should be sprayed with 60 mL Coragen 18.5 SC (chlorantraniliprole*) or 20 mL Fame 480 SC (flubendiamide* 39.35%) or 50 g Takumi 20 WG (flubendiamide* 20%) or 400 g Supremo 50 SP (thiocyclam hydrogen oxalate) or 170 g Mortar 75 SG (cartap hydrochloride) or 1 litre Coroban/ Dursban/Lethal/Chlorguard/Durmet/Classic/ Force 20 EC (chlorpyriphos) or 80 mL neem based bio-pesticide, Ecotin (azadirachtin 5%) in 100 litres of water per acre. Further application of any of these insecticides may be repeated as and when damage reaches economic threshold level. Prefer Ecotin at pest initiation stage.

- **For need based insecticides application, spray the crop at Economic Threshold Level (ETL) of insect-pests as under:**

- Stem borers: 5% dead hearts

- Leaf folder: 10% leaf damage

- Planthoppers: Minimum 5 planthoppers per hill

Leaf folder: The larvae fold the leaves, eat out the green tissue and produce whitestreaks (**Plate No. 4, page 197**). The damage is highest during August-October. When the leaf damage reaches **10% (ETL),** adopt the following control measures:

- **Mechanical Control:** The mechanical control of leaf folder can be done only before flowering by passing the 20-30 m long coir/jute rope, forwards and then backwards,

both ways while touching the crop canopy. While passing the rope, ensure that **water must be standing** in the crop.

- **Chemical Control:** Spray the crop with 60 mL Coragen 18.5 SC (chlorantraniliprole*) or 20 mL Fame 480 SC (flubendiamide* 39.35%) or 50 g Takumi 20 WG (flubendiamide* 20%) or 400 g Supremo 50 SP (thiocyclam hydrogen oxalate) or 170 g Mortar 75 SG (cartap hydrochloride) or 1 litre Coroban/Durmet/Force 20 EC (chlorpyriphos) or 80 mL neem based bio-pesticide, Ecotin (azadirachtin 5%) in 100 litres of water per acre. Prefer Ecotin at pest initiation stage.

Planthoppers: These hoppers include, whitebacked planthopper and brown planthopper. Both nymphs and adults of these pests suck the cell sap particularly from the leaf-sheath from July to October. The crop dries up in patches. As the plants dry up, the hoppers migrate to the adjoining plants and kill them. In a few days, the area of the dry patches enlarge.

About one month after transplanting, a few plants in the field should be slightly tilted and tapped 2 or 3 times at the base at weekly interval. When minimum **5 planthoppers per hill (ETL)** are seen floating in the water, spray 94 mL Pexalon 10 SC (triflumezopyrim) or 60 g Ulala 50 WG (flonicamid) or 80 g Osheen/Token/ Dominant 20 SG (dinotefuran) or 120 g Chess 50 WG (pymetrozine) or 400 mL Orchestra 10 SC (benzpyrimoxan) or 300 mL Imagine/Viola 10 SC (flupyrimin) or 800 mL Ekalux/Quinguard/Quinalmass 25 EC (quinalphos) or 80 mL neem based bio-pesticide, Ecotin (azadirachtin 5%) or 4 litres PAU Homemade Neem Extract in 100 litres of water per acre. Prefer Ecotin or PAU Homemade Neem Extract at pest initiation stage. Repeat the spray if necessary. For better effectiveness, use knapsack sprayer while directing its spray towards the base of the plants. If the damage is noticed at hopper burn stage, treat the affected spots alongwith their 3-4 metre periphery immediately as these spots harbour high population of the insect.

Grasshoppers: The adults and nymphs of the grasshoppers eat the leaves especially in nursery. Insecticides recommended for the control of planthoppers are also effective for grasshoppers.

Rice hispa: Rice hispa is a serious pest in some areas of the Gurdaspur and Amritsar districts and is also found in the other rice growing areas of the State. The grubs of this pest tunnel into the leaves, whereas the adults are exposed feeders. The grubs cause damage by producing bold, white streaks on the leaves.

If the attack starts in nursery, clip-off and destroy the leaf tips of the affected seedlings before transplanting. On the transplanted crop, spray 800 mL Ekalux 25 EC (quinalphos) or 1.0 litre Dursban 20 EC (chlorpyriphos) in 100 litres of water per acre with a manually operated sprayer. Repeat the spraying if the attack persists.

Rice root weevil: This weevil is a localized pest in the rice area around Rajpura. However, this pest has also been observed in some other areas in the State. Its' white, legless grubs feed on roots in the soil from July to September. The attacked plants turn yellow, stunted and produce only a few tillers.

Rice-ear-cutting-caterpillar: The larvae of this insect are gregarious in habit and are commonly known as 'armyworm'. The young larvae feed on leaves, leaving only the mid-ribs and stems. The old larvae cut off the panicles mostly at the base and hence the name "rice ear-cutting caterpillar". This stage of the insect causes serious loss to the paddy crop. The larvae are shy of sunlight and generally feed at night. The damage to paddy crop is caused mostly during September to November.

B. Diseases

Sheath blight (*Rhizoctonia solani*): Greyish green lesions with purple margin develop on the leaf-sheath above the water level. Later, the lesions enlarge and coalesce with other lesions (**Plate No. 5, page 197**). Its' severe attack results in the poor filling of the grains. To manage this disease , destroy the rice straw and stubbles after harvesting the affected crop. Avoid the excessive use of nitrogenous fertilizers. Keep the bunds clean by removing the grass.

At maximum tillering to boot stage of crop, as soon as the disease appears, spray 200g Ayaan 48 WG (kresoxim methyl 40% + hexaconazole 8%) or 600g Avancer Glow 75 WG (azoxystrobin 8.3% + mancozeb 66.7%) or 150 mL Iglare/Pulsor 24 SC (thifluzamide) or 26.8 g Epic 75 WG (hexaconazole) or 400 mL Galileo Way 18.76 SC (picoxystrobin + propiconazole) or 200 mL Amistar Top 325 SC or Tilt/Bumper/Pikapika 25 EC (propiconazole) or Folicur/Orius (tebuconazole) 25 EC or 80 g Nativo 75 WG (trifloxystrobin+tebuconazole) or 320 mL Lusture 37.5 SE (flusilazole + carbendazim) or 200 mL Monceren 250 SC (pencycuron) in 200 litres of water per acre. Give second spray 15 days thereafter.

False smut (*Ustilaginoidea virens*): It is a fungal disease in which the individual grains transform into large yellowish/greenish velvety spore-balls (**Plate No. 6, page 197**). High relative humidity, rainy and cloudy days during the flowering period increase the incidence of the disease. The application of organic manures and high dose of nitrogenous fertilizers also increases the intensity of attack.

To control this disease, give spray of 400 mL Galileo Way 18.76 SC (picoxystrobin + propiconazole) or 500 g Kocide 46 DF (copper hydroxide) in 200 litres of water per acre **at boot stage of the crop** in disease prone areas.

Brown leaf spot (*Drechslera oryzae*): It produces oval, eye-shaped spots with a conspicuous dark-brown dot in the centre and light brown margin. Spots are also produced on the grains. This disease occurs in poor soils, therefore, give adequate and balanced nutrition to the crop. To control the disease, give two sprays of 80 g Nativo 75 WG (trifloxystrobin + tebuconazole) in 200 litres of water per acre. Give first spray at boot stage of crop and second spray after 15 days.

Blast (*Pyricularia grisea*): The fungus causes spindle shaped spots with greyish centre and brown margin on the leaves at maximum tillering. It also causes brown lesions on the neck of the panicle, showing neck rot symptoms and the panicles fall over. The disease is more severe on Basmati cultivars particularly in the submontaneous areas and

under application of heavy nitrogenous fertilizers. Spray the affected crop with 200 mL Amistar Top 325 SC (azoxystrobin + difenoconazole) or 500 g Indofil Z-78, 75 WP (zineb*) per acre in 200 litres of water, at the boot and ear-emergence stages.

- **To prevent rice diseases, avoid excessive use of nitrogen.**
- **Early transplanting, excessive ponding of water, continuous dizzling, 25-30°C temperature and high relative humidity are favourable for development of diseases.**
- **Monitor the crop for sheath blight appearance and apply recommended fungicides for its timely management.**
- **For the management of false smut, apply preventive application of recommended fungicide at boot stage.**

Bunt/Kernel Smut (*Neovossia horrida*): Only a few grains in the panicle are infected. Frequently, only a part of the grain is replaced by a black powder. Sometimes, entire grain is also attacked and the black powder scatters on to other grains or leaves, and this is often the easiest way to detect the disease in the field. Also avoid heavy doses of nitrogenous fertilizers.

Sheath rot (*Fusarium moniliforme*): The rot occurs on the uppermost leaf-sheaths where oblong to irregular and grey-brown to light-brown lesions develop. The lesions often coalesce to cover the entire sheath. In severe cases, young panicles either do not emerge or emerge partially. A white-powdery growth of the fungus appears on the panicle inside the sheath. The glumes of infected florets are discoloured, dark-red or purple brown to black and often do not fill. The fungus over-winters in rice straw and grains. Destroy the rice straw after harvesting the infected crop. Use disease free seed for sowing.

Give two sprays of 26.8 g Epic 75 WG (hexaconazole) in 200 litres of water per acre. The first spray should be given at boot stage and second 15 days afterwards.

Stem rot (*Sclerotium oryzae*): The fungus affects the stem at earing and black lesions are produced on the sheath at water level. Later on, the stem gets infected and rots leading to withering and lodging of the plant. The incidence of this disease has declined on high yielding varieties due to improved cultural practices. Destroy the diseased debris of infected crop. Avoid excessive irrigation and use recommended dose of nitrogenous fertilizer.

Bacterial blight (*Xanthomonas oryzae* pv. *oryzae*): Greenish-yellow stripes appear along the leaf margins and extend both lengthwise and breadthwise. The leaf starts drying from the tip, becomes white in severe cases and dries up completely. The disease sometimes attacks the freshly transplanted seedlings which start wilting and in a few days the whole clump dries up. The bacterium perpetuates through seed, rice straw, and roots of non-host plants during the off-season. In order to mitigate the losses, adopt the following integrated measures:

- For the management of bacterial blight, grow rice varieties PR 132, PR 131, PR 130, PR 129, PR 128, PR 127, PR 126, PR 122, PR 121 and PR 113 which are resistant to most of the pathotypes of bacterial blight pathogen.

- Use disesse free seed.
- Do not grow nursery and crop under shade and near wheat straw stack (*Kup*)
- Do not apply excessive dose of nitrogen. Nitrogen should not be applied beyond six weeks after transplanting (except when LCC is used).
- Do not pond water in the field continuously.

Bacterial leaf streak (*Xanthomonas oryzae* pv. *oryzicola*): Small translucent streaks appear in the interveinal areas of the leaf. The streaks gradually enlarge and turn reddish, when the plants near maturity. Use disease free seed.

Root-knot Nematode (*Meloidogyne graminicola*): The disease first appears in uneven yellow patches. The affected seedings show poor and patchy growth with chlorotic symptoms and characteristic terminal hook or bead like galls on the roots.

For the management of root knot nematode, apply mustard cake @ 40 g per square metre (1.0 kg per *marla*)10 days before sowing of nursery with last preparatory tillage operation after *rauni*. Also, practice puddling for nursery sowing.

Caution: Exercise waiting period of 10 days between application of Mustard cake and sowing of nursery.

C. Rodents

Do rodent control before milky grain stage in August-September as per the method given in chapter 14 "Management of Rodents and Birds".

Rice Cultivation in Alkali Soils

- **Addition of Gypsum:** If the pH of soil is more then 9.3 then apply gypsum on soil test basis and give one or two heavy irrigations.
- **Preparation of Seed bed:** Do not puddle, because water intake rate in these soils is very low. Irrigate the tilled field and give a light planking to pulverize the clods.
- **Transplanting:** Transplant seedlings a week earlier than the normal time of transplanting, because the initial growth of plants in alkali soils is slow. Plant three or four 40 days old seedlings per hill. More seedlings per hill are recommended because of higher mortality in these soils. **Do not grow PR 127 under alkali conditions.**
- **Fertilizer Application:** Apply 20-25 per cent more nitrogen than in normal soils. Alkali soils are low in organic carbon and the efficiency of nitrogen fertilizer in these soils is also low. Add 60 kg of nitrogen through 130 kg of urea per acre in three splits, 1/3 at transplanting, 1/3 three weeks after transplanting and the remaining 1/3 six weeks after transplanting. Apply the same amount of phosphorus as to the normal soils. In addition, apply 25 kg of zinc sulphate heptahydrate or 16 kg zinc sulphate monohydrate per acre during the preparatory tillage. Where *dhaincha* is grown for green manuring, add the quantity of P_2O_5 recommended for rice to this legume and omit the application of phosphorus to the succeeding rice crop.

BASMATI RICE

Climatic Requirements

Like semi-dwarf rice varieties, basmati varieties require prolonged sunshine, high humidity and assured water supply. Basmati varieties with superior cooking and eating characteristics can be produced if the crop matures in relatively cooler temperature. The high temperature during grain filling period reduces the cooking and eating quality features.

Rotations

Basmati Rice-Wheat/Sunflower, Basmati Rice-Wheat-Summer *Moong*, Basmati Rice-Mentha, Basmati Rice-Berseem (Fodder & seed), Basmati Rice-Celery-Bajra (Fodder), DSBR-Potato-Mentha, DSBR-Wheat-Summer moong/Green manuring.

Improved Varieties

Pusa Basmati 1847 (2024): It is a semi-dwarf Basmati variety which is about 108 cm tall. It possesses extra long slender grains which are soft, non sticky and almost double upon cooking. Its average paddy yield is 19.0 quintals per acre. It matures in about 99 days after transplanting. It is resistant to all the ten pathotypes of bacterial blight presently prevalent in the Punjab state and also possesses moderate resistance to neck blast.

Punjab Basmati 7 (2021): It is a semi-dwarf Basmati variety which is about 111 cm tall. It possesses extra-long slender grains which are soft, non-sticky and almost double upon cooking. It is highly aromatic like traditional Basmati varieties. Its' average yield is 19.0 quintals per acre. It matures in about 101 days after transplanting. It is resistant to all the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab state.

Pusa Basmati 1718 (2019): It is a bacterial blight resistant version of Pusa Basmati 1121 which is resistant to all the ten pathotypes of bacterial blight presently prevalent in the Punjab state. Its' average plant height is 121 cm and it matures in 114 days after transplanting. It possesses extra long slender grains with good cooking quality. Its' average paddy yield is 17.0 quintals per acre.

Punjab Basmati 5 (2017): It is a semi-dwarf Basmati variety which is about 112 cm tall. It possesses extra-long slender grains with excellent cooking and eating quality characteristics. The grains almost double upon cooking, are non-sticky and highly aromatic. Its' aroma is even better than the existing traditional Basmati varieties. It is resistant to all the ten pathotypes of bacterial blight pathogen presently prevalent in the state. It matures in about 107 days after transplanting. Its' average paddy yield is 15.0 quintals per acre.

CSR 30 (2017): It is about 139 cm tall. It possesses extra-long slender grains with excellent cooking and eating quality characteristics. The grains are non-sticky, soft to eat and highly aromatic. It is susceptible to all the pathotypes of bacterial blight presently prevalent in the state. It matures in about 112 days after transplanting. Its' average paddy yield is 13.5 quintals per acre.

- **Punjab Basmati 7, 5 and Pusa Basmati 1847, 1718 are resistant to bacterial blight.**
- **Pusa Basmati 1847 is moderately resistant to neck blast.**
- **Do not apply nitrogenous fertilizer to Basmati sown after green manuring.**
- **For the control of Foot rot, treat the seed and seedlings as per recommendations.**

Pusa Basmati 1509 (2013): It is an early maturing variety which matures in about 95 days after transplanting. Its' average height is 92 cm. It possesses extra-long slender grains with excellent cooking and eating quality characteristics. Its' grains become almost double upon cooking and are scented. It is suitable for multiple cropping system. Transplant 25 days old seedlings for better tillering. It is susceptible to all the pathotypes of bacterial blight pathogen prevalent in the state. Its' average paddy yield is 15.7 quintals per acre.

Pusa Basmati 1121 (2008): It is about 120 cm tall. It possesses extra long slender grains with good cooking quality. It has longest cooked rice length among all the aromatic rice varieties recommended for Punjab. It matures in about 107 days after transplanting. It is susceptible to all the pathotypes of bacterial blight pathogen prevalent in the state. It yields on an average 13.7 quintals of paddy per acre.

Agronomic Practices

Puddled Basmati

Agronomic practices like land preparation, seed rate and seed treatment, method of nursery raising, weed control etc. are the same for Basmati varieties as for other semi-dwarf rice varieties. However, some of the agronomic practices which require special mention are discussed below:

Seed and Seedling Treatment: Foot rot is a major disease of Basmati. To control this disease, seed and seedling treatment is mandatory. Smear the seeds with talc formulation of *Trichoderma asperellum* 2% WP, PAU strain @ 15 g per kg of seed immediately before sowing and seedling root dip for 6 hrs with *Trichoderma asperellum* 2% WP, PAU strain @ 15 g per litre of water before transplanting. Alternatively treat the seed with Sprint 75 WS (carbendazim + mancozeb) by making slurry of 3 g fungicide formulation in 10 mL water for one kg seed before sowing to manage other seed borne diseases of rice.

Nursery sowing and transplanting time: The time of transplanting is a crucial factor in determining the yield and quality of Basmati.

Varieties	Time of Nursery Sowing	Time of Transplanting
Punjab Basmati 7 and 5, Pusa Basmati 1847, 1121 and 1718	First fortnight of June	First fortnight of July
CSR 30 and Pusa Basmati 1509	Second fortnight of June	Second fortnight of July

Age of Seedlings: Seedlings of Basmati varieties are ready for transplanting when they attain 5 to 6 leaf stage or are 25-30 days old. Longer stay of seedlings in the nursery bed results into node formation which reduce tillering and yield in basmati varieties. About 25 days old seedlings of Pusa Basmati 1509 should be transplanted for better tillering.

Method of Transplanting: Irrigate the nursery before uprooting and wash them to remove mud. Transplant two seedlings per hill in lines at 20 x 15 cm (33 hills/sq. metre) during the optimum period in a well puddled field. In the late transplanted crop, the spacing may be reduced to 15x15 cm (44 hills/sq. metre) to minimize the reduction in yield.

Fertilizer Application

Use organic and chemical fertilizers as under:

a) Organic Manures: Practice green manure before basmati. Do not apply urea if the field has been green manured with 45-55 days old sunnhemp/dhaincha or summer moong straw has been incorporated after picking of pods.

b) Chemical Fertilizers: Apply fertilizers on soil test and crop rotation basis. Skip phosphorus application if the recommended dose of phosphorus has been applied to the preceeding wheat crop. However in phosphorus deficient soils, apply 75 kg of superphosphate per acre before last puddling. Recommended dose of urea for different varieties is as under:

- CSR 30 - 18 kg urea per acre
- Punjab Basmati 7 & 5 and Pusa Basmati 1121 & 1718 - 36 kg urea per acre
- Pusa Basmati 1847 and 1509 - 54 kg urea per acre

High doses of nitrogen application to basmati causes excessive vegetative growth and plant height. This makes the crop more prone to lodging thus resulting into poor yield. Apply urea in two equal splits at 3 weeks and 6 weeks after transplanting. If possible, apply urea when water is not standing in the field. Irrigate on third day of the application of urea.

PAU-Leaf Colour Chart (PAU-LCC) for need based Urea application

- No basal urea should be applied at the time of transplanting of basmati rice.
- Start matching colour of first fully exposed leaf from top of plant with the PAU-LCC at 7 days interval after 21 days of transplanting.
- Every time match colour of the ten intact leaves with LCC shade 3.5 (for CSR 30) and LCC shade 4 (for Punjab Basmati 7, 5 and Pusa Basmati 1121, 1509 and 1718).
- When ever the greenness of 6 or more out of 10 leaves is lighter than the specified LCC shades, apply 9 kg urea per acre.
- No urea should be applied if colour of 6 or more out of 10 leaves is equal to or darker than specified LCC shades.
- Use of LCC should be discontinued after initiation of flowering and no more urea should be applied.

Note:

- The LCC is highly beneficial for optimum fertilizer nitrogen applications in fields amended with organic manures.
- The leaves selected for measuring leaf greenness should be free of insect-pest disease incidence.
- There should not be any water stress to the crop and the nutrients other than nitrogen should be supplied as per recommendations.

The leaf colour chart can be purchased from the PAU Seed Shop at Gate No. 1, *Krishi Vigyan Kendras* and Farm Advisory Service Centres in different districts.

Irrigation: Keep the water ponded continuously for 2 weeks after transplanting. Afterwards apply irrigation two days after the ponded water has infiltrated into the soil. The crop should not suffer any water stress particularly during flowering. Stop irrigation about a fortnight before harvesting to facilitate easy harvesting and timely sowing of succeeding *rabi* crop.

Harvesting and Threshing: Basmati should be harvested as soon as the crop matures i.e. when the ears are nearly ripe and the straw has turned yellow. Delayed harvesting may cause over-ripening and shattering of grains. The harvested crop should preferably be threshed on the same or next day of harvesting. The delayed threshing causes high shattering losses, reduced head rice recovery and ultimately reduces the market price of paddy.

Plant Protection

A. Insect Pests

Stem borers: Basmati rice varieties are highly susceptible to stem borers namely yellow stem borer, white stem borer and pink stem borer. The yellow and white stem borers are serious up to flowering stage. The pink stem borer generally appears late and is more serious at/after maximum tillering stage when its damage affects grain formation. It is, therefore, necessary to monitor the crop regularly for stem borer damage. As and when there are more than 2% dead hearts (ETL) in the field, adopt the following control measures:

- **Monitor the insect-pests regularly and apply insecticides on the basis of Economic Threshold Level.**
- **For effective management of neck blast spray the fungicides at boot stage.**

Stem borers can be managed by spraying neem based biopesticide, 80 mL Ecotin (azadirachtin 5%) or 1000 mL Achook/Neem Kavach (azadirachtin 0.15%) or 20 mL Fame 480 SC (flubendiamide* 39.35%) or 50 g Takumi 20 WG (flubendiamide* 20%) or 60 mL Coragen 18.5 SC (chlorantraniliprole*) or 400 g Supremo 50 SP (thiocyclam hydrogen oxalate) or 170 g Mortar 75 SG (cartap hydrochloride) or 1.0 litre Coroban/Dursban/Lethal/Chlorguard/Durmet/Classic/ Force 20 EC (chlorpyriphos) or 15 g Fipronil 80% WG (fipronil) in 100 litres of water per acre. Prefer Ecotin or Achook/Neem Kavach at pest initiation stage.

These insects can also be controlled by applying 4 kg Ferterra/ Marktera 0.4 GR (chlorantraniliprole*) or 4 kg Vibrant 4 GR (thiocyclam hydrogen oxalate) or 10 kg Padan/ Caldan/Kritap/Sanvex/Nidan/Marktap/Miftap/ Faltap-G/ Katsu 4 G (cartap hydrochloride) or 6 kg Regent/Mortel/Mifpro-G/Mahaveer GR/Shinzen 0.3 G (fipronil) or 4 kg Dursban 10 G (chlorpyriphos) per acre in standing water. Use gloves while applying granular insecticides.

Fame 480 SC or Takumi 20 WG or Coragen 18.5 SC or Supremo 50 SP (thiocyclam hydrogen oxalate) or Mortar 75 SG or chlorpyriphos 20 EC or Fipronil 80 WG or Ferterra/ Marktera 0.4 GR or Vibrant 4 GR or Padan/Kritap/Caldan/Sanvex/Nidan/Marktap/Miftap/ Faltap-G/Katsu 4G or Regent/Mortel/Mifpro-G/Mahaveer GR/Shinzen 0.3 G or Dursban 10 G or Ecotin or Achook/Neem Kavach also control leaf folder. Use above insecticides alternately.

Planthoppers, Rice hispa and Leaf folder: These pests also damage basmati rice in the State. For their control, follow recommendations as mentioned in rice for these pests.

B. Diseases

Foot rot (*Fusarium moniliforme*): This disease is both seed and soil borne. The infected seedlings turn pale yellow and become elongated. Later on these seedlings start drying from bottom and usually die. The symptoms also appear after transplanting in the field and

the infected plants become taller than the normal plants and are killed after a few days. Adventitious roots also appear on the lower nodes. Pinkish growth of the fungus appears on the lower sheaths. Adopt following integrated approaches to manage the disease:

- Use disease free seed
- Treat the seed and seedlings as per recommendations.
- Rogue out and destroy infected seedlings from nursery and field.

Blast (*Pyricularia grisea*): It is relatively more important in Basmati varieties. This fungus causes spindle shaped spots with greyish centre and brown margins on the leaves at maximum tillering stage. It also causes black lesions at the neck of panicle leading to its dropping. For control of this disease, spray per acre 200 mL Amistar Top 325 SC (azoxytrobin+difenoconazole) or 500 g Indofil Z-78 75 WP (zineb*) in 200 litre of water at maximum tillering and ear emergence stages. Pusa Basmati 1847 is moderately resistant to neck blast.

Bacterial blight: Punjab Basmati 7, 5 and Pusa Basmati 1847, 1718 are resistant to most of the pathotypes of bacterial blight pathogen. Other practices to control the disease are same as for rice.

Note: Manage the other diseases, insects and rodents as per rice.

Unpuddled Direct Seeded Rice (DSR)

The declining water resources of the state demand the highest priority to development of water conservation technologies. Direct seeding of rice in unpuddled fields (DSR) is one such technology that has water saving potential. DSR provides several benefits such as 1) 10-20% saving in irrigation water, 2) 10-12% higher ground water recharge, 3) saves labor, 4) less prone to infestation of diseases (e.g. sheath blight, foot rot), 5) provides 100 kg/acre higher yield of succeeding wheat as compared to conventional practice of puddled transplanted rice.

DSR technology was recommended in 2010 in the state. The technology was further refined and in 2020, a novel DSR technique coined as '*tar-wattar* DSR' was recommended. In *tar-wattar* DSR, a major departure from the earlier practice is delayed first irrigation which is applied at 21 days after sowing which has many added advantages like higher saving in irrigation water, better root development, lesser incidence of nutrient deficiency especially iron, lesser weeds and wider soil adaptability. Further, a new method of DSR 'Direct seeding on raised beds in *tar-wattar* fields', which offers higher saving in irrigation water as compared to earlier methods, has been recommended in 2022.

The success of DSR lies in the adoption of improved production practices which are discussed below:

- **Suitable soils:** Sow DSR only in medium to heavy textured soils. Its' cultivation is not successful in light textured soils due to severe iron deficiency and lower crop yields.
- **Laser levelling:** Laser levelling improves irrigation water use efficiency and ensures better germination. Plough the field with disc harrow followed by cultivation with cultivator and planking, then level the field with laser leveller.

- **Suitable varieties:** Short and medium duration varieties
- **Sowing time:** 1-15 June
- **Seed rate and seed treatment:** Use 8-10 kg seed per acre. Imbibe rice seed by dipping in 2% potassium nitrate solution (prepare solution by dissolving 200 g KNO_3 in 10 litre water for 8 kg seed) for 12 hours. Dry the seed in shade and treat with 3 g Sprint 75 WS (mencozeb + carbendazim) per kg seed.
- **Method of sowing:** Rice can be direct seeded by three methods:

- **Direct seeding of rice should not be done on light textured sandy soils.**
- ***Tar-wattar* DSR technique is suitable for direct seeding in medium and heavy textured soils (including sandy loam, loam, silt loam and clay loam) which accounts for around 87% area of the state.**
- **Sowing should be done in the first fortnight of June.**
- **For effective weed control, spray 1.0 litre Stomp/Bunker 30 EC or 1.0 litre PEPE 25 SE per acre in moist soil immediately after sowing and thereafter use other herbicides as per recommendation.**

1. **Direct seeding in *tar-wattar* fields:** Divide the field into *kiyaras* of desirable size after Laser Leveling and apply *rauni* irrigation. When the field comes to *tar-wattar* (sufficiently high but workable soil moisture) conditions, prepare field *kiyara*-wise with shallow cultivation followed by 2-3 plankings with load of 3 sandbags on planker and sow immediately. Seed should be placed at 3-4 cm depth in 20 cm spaced rows. Avoid field preparation and sowing during noon hours for better results.

Preferably, use Lucky Seed Drill (which sow rice and spray pre-emergence herbicide simultaneously) for direct seeding. Alternatively, use conventional rice drill having inclined plate metering system and spray herbicide immediately. Direct seeding with Lucky Seed Drill (fitted with press wheels) help in tackling the problem of *krand* formation (which occur if there is rainfall after sowing), conserves soil profile moisture and improves the efficacy of pre-emergence herbicide.

2. Direct seeding on raised beds in *tar-wattar* fields: This method saves higher irrigation water than other two methods.

Laser level the field and make 67.5 cm wide shallow beds (bed with 37.5 cm flat top with adjacent 30 cm furrow), preferably by using same bed planter that will be used for final sowing. Then apply *rauni* (pre-sowing irrigation) in furrows only.

When field come to *tar-wattar* conditions (within 2-3 days depending on soil type), use bed planter (fitted with bed compacter) for reshaping beds and simultaneous sowing (2 rows/bed) of treated seed, and apply pre-emergence herbicide immediately. Avoid sowing during noon hours for better results.

3. Direct seeding in dry fields: Treated seed should be placed 2-3 cm deep in rows spaced at 20 cm in a dry field and irrigation is applied immediately after sowing.

- **Weed Control**

Pre-emergence: Spray 1.0 litre per acre Stomp/Bunker 30 EC (pendimethalin) or PEPE 25 SE (penoxsulam 1% + pendimethalin 24%) in 200 litres of water for control of annual grass weeds and some broadleaf weeds. Prefer PEPE 25 SE for the control of complex weed

flora comprising annual grasses, broadleaf weeds and sedges. In case of *tar-wattar* DSR, if sown using Lucky Seed Drill, sowing and herbicide spray are done simultaneously and, if conventional rice drill is used, then spray immediately after sowing. In case of sowing in dry fields, irrigation is applied immediately after sowing and herbicide is sprayed when the field comes to wattar condition which in general is within 1 to 2 days of sowing.

Post-emergence: Depending on the weed flora present in the field, any of the herbicide listed in the table below may be applied at 15-25 days of sowing, by dissolving in 150 litres of water, when weed plants are at 1-4 leaf stage as given against each herbicide (**see page 197**).

Name of herbicide	Dose per acre	Target weed flora	Time of application (days after sowing)	Weed leaf stage at time of spray
Nominee Gold 10 SC (bispyribac sodium)	100 mL	*Swank,* paddy *mothas*	15-25	2-4
Novlect 12 EC (florpyrauxifen-benzyl 2.13% + cyhalofop-butyl 10.64%)	500 mL	*Swank, chini, gha, broadleaf weeds, paddy mothas, gandi wala motha*	20-25	2-4
Ricestar 6.7 EC (fenoxaprop-p-ethyl)	400 mL	*Madhana, chini gha, chiri gha, takri gha*	20-25	2-4
Almix 20 WP (chlorimuron ethyl 10% + metsulfuron methyl 10%)	8 g	Broadleaf weeds, paddy *mothas, gandi wala motha*	20-25	2-4
Eketsu 43 WG (bispyribac sodium 38 % + chlorimuron ethyl 2.5% + metsulfuron methyl 2.5%)	40 g	*Swank, paddy mothas, gandi wala motha, broadleaf weeds*	20-25	2-4
Vivaya 6 OD (penoxsulam 1.02% + cyhalofop-butyl 5.1%)	900 mL	*Swank, chini gha,* broadleaf weeds, paddy *mothas*	15-25	1-2
Council Activ 30 WG (triafamone 20% + ethoxysulfuron 10%)	90 g	*Swank, chini gha,* broadleaf weeds, paddy *mothas, gandi wala motha*	15-25	1-2

- Always spray herbicide when weed plants are at the right leaf stage as mentioned against each herbicide.
- Always spray herbicide in moist field and maintain proper soil moisture (wattar) in the field for one week after spray.
- The leftover weeds may be uprooted before they produce seeds.

- **Fertilizers:** Apply 130 kg urea per acre in three equal splits at 4, 6 and 9 weeks of sowing. Reduce dose of urea to 90 kg per acre after green manuring with sunnhemp or FYM application @ 6 tonne per acre and 110 kg urea per acre if summer moong residue has been incorporated after picking pods. Apply phosphorus and potash on soil

test basis. In case of zinc and iron deficiency, follow the recommendations as given under puddled transplanted rice (Page 11).

PAU-Leaf Colour Chart (PAU-LCC) for need based Urea application

- No urea should be applied at the time of sowing.
- After four weeks of sowing, apply 25 kg urea per acre.
- After six weeks of sowing, start matching colour of the topmost fully exposed intact leaf of the randomly selected ten rice plants with PAU-LCC under shade of your body at 7 day interval.
- Whenever the greenness of 6 or more out of 10 leaves is lighter than the LCC shade 4, apply 30 kg urea per acre.
- No urea should be applied if colour of leaves is equal to or darker than the LCC shade 4.
- Use of LCC should be discontinued after initiation of flowering and no more urea should be applied.

Note: The leaves selected for measuring leaf greenness should be free from insect/disease incidence. There should not be water stress to the crop and nutrients other than nitrogen should be supplied as per recommendations. The PAU-LCC can be purchased from PAU Seed Shop at Gate No. 1, *Krishi Vigyan Kendras* and Farm Advisory Service Centres in different districts.

Irrigation

1. Direct seeding (flat/raised beds) in *tar-wattar* fields: Apply first irrigation at around 21 days after sowing. After that, apply irrigations at 5-7 days interval depending on soil type.

2. Direct seeding in dry fields: Apply first irrigation immediately after sowing and second irrigation at 4-5 days after sowing. Subsequent irrigations should be applied at 5-7 days interval depending on soil type.

The irrigation interval may be adjusted according to rainfall. Stop irrigation 10 days before harvesting. In this way, DSR saves around 10 to 20% irrigation water as compared to puddled transplanted rice.

For sub-surface drip irrigation and fertigation in zero till DSR, see chapter on 'Multiple Cropping' under zero till direct seeded rice-wheat cropping system.

- **Rodent management:** Rodents cause damage to direct seeded rice crop at germination stage. Control weeds and rebuild bunds to destroy rat burrows and reduce their height and width. Do burrow baiting during lean period (May-June) as per the method given in chapter 14 "Management of Rodents and Birds".

Unpuddled Direct Seeded Basmati Rice (DSBR)

Suitable soils and agronomic practices like laser levelling, field preparation, seed rate, method of sowing, weed control, irrigation for DSBR are similar to that of direct seeded rice. However, varieties, sowing time and fertilizers for DSBR are as under:

Suitable varieties: Punjab Basmati 7, Pusa Basmati 1718, Pusa Basmati 1121 and Pusa Basmati 1509 are suitable for DSBR.

Sowing time: Optimum sowing time is 15-30 June.

Fertilizers: Apply 54 kg urea per acre in three equal splits at 3, 6 and 9 weeks after sowing. Reduce dose of urea to 18 kg per acre after green manuring with sunnhemp and 36 kg urea per acre if summer moong residue has been incorporated after picking pods. Apply phosphorus and potash on soil test basis. In case of zinc and iron deficiency, follow the recommnedations as given under puddled transplanted rice (Page 11).

MAIZE

Maize occupied 94.5 thousand hectares, with a production of 361.7 thousand tonnes in the Punjab State during 2023-24. The average yield was 38.27 quintal per hectare (15.49 quintal per acre).

Climatic Requirements

Maize requires considerable moisture and warmth from germination to flowering. Higher productivity of maize can be expected if the maximum/minimum temperature during germination ranges within 36-40/21-27 °C, during vegetative growth within 31-41/24-30 °C and during flowering to grain filling within 31-37/21-27 °C. A well-distributed rainfall ranging from 500-700 mm is conducive for good growth of maize. Proper drainage of excess water during heavy rains is essential to get good yield.

Soil Type

Maize thrives better on well drained, sandy-loam to silty-loam soils.

Rotations

Maize-Wheat/Barley/Potato/*Berseem*, Maize-*Senji*-Sugarcane-Cotton, Maize-Wheat-*Moong*, Maize-Wheat-Green Manure, Maize-Potato/*Toria*-Sunflower, Maize-Potato-Wheat/Sunflower, Maize-Early Pea-Sunflower, Maize-Wheat-Cowpea (fodder), Maize-Raya/*Gobhi Sarson*, Maize-Potato-Summer *Moong*, Maize-Potato-Mentha, Maize-*Gobhi Sarson*-Summer *Moong,* Maize-Potato/Peas-Spring Groundnut

Irrigated Maize

Improved Varieties

Long Duration Varieties/Hybrids

PMH 17 (Subject to the approval by SAVC): This dual purpose single cross hybrid is suitable for both grain and silage. It has tall plants with broad and erect leaves. Tassel is semi-

open and medium. Ears are long, medium placed with flint, yellow-orange capped grains. It matures in 96 days and average grain yield is 25.0 quintals per acre. This hybrid is suitable for ethanol production. It is moderately resistant to fall army worm and maydis leaf blight.

DKC 9144 (2024): This single cross hybrid has tall plants with medium ear height. Stem is sturdy and leaves are broad. Tassel is medium and open. Ears are long with attractive yellow orange flint grains. It matures in 97 days and average grain yield is 24.6 quintals per acre. It is moderately resistant to maydis leaf blight, charcoal rot and fall army worm.

Bioseed 9788 (2024): This single cross hybrid has tall plants with medium ear height. Stem is sturdy and leaves are broad. Tassel is medium and open. Ears are long with attractive yellow orange flint grains. It matures in 96 days and average grain yield is 24.3 quintals per acre. It is moderately resistant to fall army worm.

PMH 14 (2023): This single cross hybrid has tall plants with broad and erect leaves. Tassel is semi-open and medium. Ears are long, medium placed with yellow-orange flint capped grains. It matures in 98 days and average grain yield is 24.8 quintals per acre. It is moderately resistant to fall army worm.

PMH 13 (2021): This single cross hybrid has tall plants with medium high ear placement. Leaves are dark green and broad. Tassel is medium and open. Ears are conico-cylindrical and long with light orange flint grains. It matures in 97 days and average grain yield is 24.0 quintals per acre. It is moderately resistant to maydis leaf blight, charcoal rot and maize stem borer.

ADV 9293 (2021): This single cross hybrid has tall plants with medium ear height. Stem is sturdy and leaves are broad. Tassel is medium and open. Ears are long with attractive orange flint grains. It matures in 97 days and average grain yield is 24.5 quintals per acre. It is moderately resistant to maydis leaf blight, charcoal rot and maize stem borer.

JC 12 (2020): The plants of this composite variety are medium tall in height with medium ear placement. It has medium thick stem which resists lodging and has heavy open tassel. Ears are medium long with good girth. This composite has semi-flint, yellow-orange grains. It matures in about 99 days. It yields about 18.2 quintals per acre. This variety is recommended for *kandi* areas of the state.

PMH 11 (2019): This single cross hybrid has tall plants and well developed root system. Stem is sturdy and green in colour. Leaves light green and broad. Tassel is open and heavy. Ears are long with dark orange flint grains. It matures in 95 days and average grain yield is 22.0 quintals per acre

PMH 1 (2005): This single cross hybrid has tall plants with well developed root system. The stem is zig-zag, sturdy and purple colored. The leaves are medium broad. Tassel is open and medium in size. Ears are medium long with yellow orange flint grains. The plants remains stay green at maturity. It matures in 95 days and average grain yield is 21.0 quintals per acre.

Medium Duration Variety

JC 4 (2021): The plants of this composite variety are medium tall in height. Ears are

medium placed and long. This composite has deep-orange and bold grains. It is tested 'very good' for *chappati* quality parameters *viz*, taste, texture, appearance and flavour. It matures in about 90 days. It yields about 13.0 quintals per acre. This variety is recommended for irrigated and *kandi* areas of the state. This variety is also recommended for organic farming.

Short Duration Hybrid

PMH 2 (2005): It is a short duration single cross hybrid. It has medium plant height with medium ear placement. Leaves are medium sized and dark green in colour. Tassel is of medium size and semi-open. Silk is of green colour. It has medium long ears. Grains are yellow orange flint with yellow caps. The hybrid resists lodging and is tolerant to bacterial stalk rot. It matures in about 83 days and average grain yield is 18.0 quintals per acre.

Special Purpose Varieties

Punjab Baby Corn 1 (2022): This single cross hybrid is male sterile and having medium tall plants. This hybrid is most suitable for baby corn as it gives higher yield of uniform and good quality ears. Being male sterile this hybrid does not need detasseling. Picking of ears starts around 52 days after sowing. This hybrid gives about 3 pickings per plant. This hybrid gives an average of 8.4 quintals per acre yield of dehusked ears. This hybrid gives 128 q/acre fodder yield after the completion of ear picking.

Punjab Sweet Corn 1 (2008): This composite has tall plants with medium thick stem and medium ear placement. The leaves are broad and tassel is open with creamish anthers. Ears are medium long and the cob colour is white. Silk colour at the time of emergence is usually creamish. Husk cover is well developed and grains are orange in colour at maturity. This variety is highly suitable to use as sweet corn on commercial basis because Its' developing and immature grains in green ears possess high sugar content. It matures in about 95-100 days. Its' average green ear and grain yield is 50.0 and 13.0 quintals per acre, respectively.

Pearl Popcorn (1995): This is a composite variety of popcorn. Its' ears are long and thin and grains are small and round. The commercial value of these grains is very high. It matures in about 88 days. Its' average yield is 12.0 quintals per acre and popping quality is very good.

Hybrids released for Zone II [Punjab, Haryana, Delhi, Uttrakhand (Plains) and Western U.P.] at National Level for cultivation in *Kharif* season

Private hybrids ADV 764, CP 858 and P 3302 showed 13.2, 14.4 and 13.1 per cent yield superiority over the check PMH 1, respectively. These hybrids are moderately resistant to maydis leaf blight, charcoal rot and maize stem borer.

Agronomic Practices

Land Preparation: Give four to five ploughings and plankings to make the seed-bed free from clods and weeds. Use mould-board plough, disc-harrow or cultivator for the first cultivation. Level the field to ensure proper irrigation and drainage. Maize can also be sown without any preparatory tillage with zero till drill.

Time of Sowing: Last week of May to end of June. In fields, which are prone to damage through water stagnation, sow the crop in end of May to early June, so that the crop

gets firmly established before the rains. Sowing of crop at this time not only gives higher yield but also vacates the field in time for sowing of *toria*/potato. Adoption of recommended chemical control for maize borer is very important in early planting.

Seed Rate: Use 7 kg seed for Pearl Popcorn and 10 kg seed per acre for other varieties.

Seed Inoculation: Mix half kg packet of recommended consortium bio-fertilizer with one litre of water and then thoroughly mix it with maize seed on clean pucca floor. Let it dry in shade and sow the seed immediately. The seed inoculation with consortium biofertilizer increase grain yield as well as improves soil health. This bio-fertilizer is available with the PAU Seed Shop at Gate No. 1, *Krishi Vigyan Kendras* and Farm Advisory Service Centres in different districts.

- **For higher yield, apply organic fertilizers or practise green manuring before maize planting.**
- **Sowing should be done in the last week of May to end of June.**
- **Sow the crop with a distance of 60 × 20 cm to maintain optimum plant population of 33333 plants/ acre.**
- **Use Leaf Colour Chart for need based nitrogen application.**
- **Spray 800 g per acre atrazine in medium to heavy textured soil and 500 g per acre in light soil within ten days of sowing.**
- **Ensure adequate water supply during pre-tasseling, silking and grain filling stage.**

Method of Sowing: Sow the seed 3-5 cm deep in lines with a maize planter or seed-cum-fertilizer drill, provided with a planting attachment. The row to row spacing should be kept at 60 cm whereas plant to plant spacing to be maintained at 20 cm.

A four row pneumatic planter with provision of bed making can be used for maize sowing. This machine can plant maize seeds at a depth of 55-56 mm with seed rate of 9-10 kg per acre.

Trench Sowing: Maize can be sown in trenches made by tractor drawn ridger from end-May to mid-June to facilitate easy and economical irrigation during dry and hot weather conditions. Seed drill attachment mounted on the ridger can also be used for sowing by adjusting the position of the tines. Maize crop raised in trenches resists lodging and gives higher grain yield than flat sowing.

Bed/Ridge Sowing: To avoid the adverse effect of excess rainfall, particularly at seedling emergence, sow the maize seed 3-5 cm deep on top centre of the bed with row to row spacing of 67.5 cm and plant to plant spacing of 18 cm or sowing should be done preferably 6-7 cm above base on the side of ridges spaced 60 cm with plant to plant spacing of 20 cm. Wheat bed planter can be used for bed preparation.

Zero Tillage Sowing: Maize can also be grown without any preparatory tillage with zero till drill after conventional or zero till sown wheat. If field is infested with weeds, it can be controlled by spraying half litre of Gramoxone 24 SL (paraquat) in 200 litres of water before sowing.

Intercropping: Intercrop one row either of cowpea or maize as fodder, soybean for grains and groundnut for pods in maize sown at row to row spacing of 60 cm for getting higher productivity and monetary returns as compared to sole maize. Apply recommended

fertilizers to maize and on area basis to intercrops. Harvest cowpea and maize fodder at 45-55 days after sowing.

Thinning: In case the sowing has not been done with planter, thin out the plants at the time of the first hoeing keeping a plant to plant distance of 20 cm.

Weed Control

Cultural: Give two hoeings about 15 to 30 days after sowing with *khurpa/kasaula/* wheel-hoe/*triphali/*tractor-drawn cultivator. Alternatively, uniform spreading of 30 quintal per acre of paddy straw mulch at the time of sowing provides effective control of annual weeds or grow one or two rows of cowpea in between maize rows and harvest it at 35 to 45 days after sowing as fodder, thereafter no weed control operation is required. For inter-cropping of cowpea, use 8 kg per acre seed of CL 367. It does not require any additional fertilizer. Sow maize and cowpea simultaneously.

Chemical: Spray 800 g per acre Atrataf/Atragold/Masstaf/Atari/Traxx 50 WP (atrazine) on medium to heavy textured soils and 500 g per acre in light soils within ten days of sowing, using 200 litres of water or spray 250 g per acre atrazine on 20 cm wide band over the crop rows followed by hoeing/interculture at 15 to 30 days after sowing. This herbicide is effective against annual grasses and broad leaf weeds especially *itsit*. Alternatively, spray 105 mL per acre Laudis 420 SC (tembotrione) in 150 litres of water at 20 days after sowing provides effective control of mixed weed flora. For the control of *dila/motha*, apply 400 mL per acre 2,4-D amine salt 58 SL as post emergence 20-25 days after sowing in 150 litres of water.

Fertilizer Application

a) Organic Manures: Green manure the field, to be put under maize with *Dhaincha/* Sunhemp/Cowpea. Cowpea/*Dhaincha/*Sunhemp should be sown during second fortnight of April using 12/20/20 kg seed per acre. The 50 days old green manure crop should be burried and allowed to decompose for about 10 days before sowing of maize. In case, summer moong crop is grown the straw should be burried before sowing of maize. Practice green manuring and apply full dose of nitrogen (50 kg N per acre) to get high yield of maize in maize-wheat system. It also improves the soil health.

Apply farm yard manure (FYM) or compost in adequate quantities if green manure has not been practiced. The application of organic manures to the soil ensures good tilth and improves soil water-holding capacity. If more than 6 tonnes of good quality farmyard manure per acre has been applied to the maize crop year after year, omit the application of phosphorus, potassium, zinc and nitrogen recommended as basal dose. Paddy straw compost along with recommended dose of fertilizers can be an alternate to farm yard manure. Application of nitrogen fertilizer more than recommended dose is no substitute for FYM or green manuring.

b) Bio-fertilizer: Inoculate the maize seed with recommended bio-fertilizer as described earlier.

c) Chemical Fertilizer: Apply fertilizer on soil test basis (See Chapter on 'Soil Testing'). However, in the absence of soil test, apply fertilizers as under:

Varieties	*Nutrients (kg per acre)			Fertilizers (kg per acre)				
	N	P_2O_5	K_2O	Urea	DAP	or Single Super phosphate	or Nitro phosphate	Muriate of potash
PMH 1, 11, 13, 14 & 17, DKC 9144, Bioseed 9788, ADV 9293, JC 12 and Punjab Sweet Corn 1	50	24	12	110	55	150	125	20
PMH 2, JC 4 and Pearl Popcorn	35	12	8	75	27	75	62	15

* These nutrients can also be supplied from other fertilizers available in the market.

Note

- Apply potassium only if the soil-test shows deficiency of potash.
- If maize follows wheat, which had received the recommended dose of phosphorus, omit its application to maize. When 27 kg of DAP is used, reduce the urea dose by 10 kg and when 55 kg of DAP is used, reduce the dose of urea by 20 kg. When 125 kg nitrophosphate is used reduce urea dose by 50 kg and when 62 kg nitrophosphate is used reduce urea by 25 kg.
- In phosphorus and sulphur deficient soils apply sulphated P fertilizer (13:33:0:15:N:P_2O_5:K_2O:S) if other phosphorus or sulphur containing fertilizers are not available.
- If the crop sown after applying 6 tonne per acre of fish pond sediments in field, apply 25% less dose of recommended fertilizers.

To all recommended varieties, drill one-third of nitrogen and the entire quantity of phosphorus and potassium at the time of sowing. If nitrophosphate is used omit urea application at sowing. Top dress one-third of nitrogen at the knee-high stage and the remaining one-third at the pre-tasseling stage.

PAU-Leaf Colour Chart (PAU-LCC) for need based Urea application

- Apply basal dose of 25 kg urea per acre.
- Start matching colour of the first fully exposed leaf from the top with the LCC at 10 days interval after 21 days of sowing.
- Whenever the greenness of 6 or more out of 10 leaves is lighter than LCC shade 5, apply 25 kg urea per acre.
- No urea should be applied if colour of leaves is equal to or darker than LCC shade 5.
- Use of LCC should be discontinued after initiation of silking and no more urea should be applied.

Note: Always match colour of the leaf with PAU-LCC under shade of the body. The leaves selected for measuring leaf greenness should be free of insect-pest disease incidence. There should not be water stress to the crop and nutrients other than nitrogen should be supplied as per recommendations.

The PAU-LCC can be purchased from the PAU Seed Shop at Gate No. 1, PAU, Ludhiana, *Krishi Vigyan Kendras* and Farm Advisory Service Centres in different districts.

Zinc Deficiency: The deficiency symptoms appear within 2 weeks of seedling emergence. A broad band of white or very light-yellow tissue, with reddish veins appears, on each side of the midrib, beginning at the base of the second or third leaf from the top of the plant. The white patch later extends in stripes towards the tip parallel to the midrib. The midrib and the leaf margin remain green. The plants remain stunted and have short inter-nodes. In the case of mild deficiency there is a white stripe in the upper leaves. The mild deficiency disappears by the mid-season, but the silking and tasseling are delayed.

Where zinc deficiency had been noticed in the preceding crop, broadcast 10 kg of zinc sulphate heptahydrate (21%) or 6.5 kg zinc sulphate monohydrate (33%) per acre at sowing mixed with an equal quantity of dry soil, along rows, hoe it into the soil and then irrigate the field. In standing crop, apply 10 kg of zinc sulphate heptahydrate (21%) or 6.5 kg zinc sulphate monohydrate (33%) mixed with an equal quantity of dry soil along rows, hoe it into the soil and then irrigate the field. When the symptoms are observed late in the season and interculture is not possible, spray zinc sulphate-lime mixture prepared by mixing 1.2 kg of zinc sulphate heptahydrate (21%) and 0.6 kg of unslaked lime or 0.75 kg zinc sulphate monohydrate (33%) and 0.38 kg of unslaked lime with 200 litres of water to cover one acre.

Irrigation and Drainage

Irrigation: Generally, 4-6 irrigations are required depending on the rainfall. Adequate water-supply is essential throughout the crop season particularly during the pre-tasselling, silking and grain filling stages.

For sub-surface drip irrigation and fertigation in maize-wheat-summer moong and maize-wheat on permanent beds, see chapter on 'Multiple Cropping'.

Drainage and safeguards against excess water: Maize can tolerate heavy rains provided fields are not subjected to excessive soil wetness/flooding for prolonged periods. Flooding particularly at young stage causes a great damage to the crop. To avoid flooding, drain away excess water by making a drain of adequate capacity at the lower end of the field. If such a damage occurs, spray 6 kg urea per acre in two sprays at weekly interval (3% solution) in case of moderate damage or broadcast additional nitrogen @ 12 to 24 kg (25-50 kg urea) per acre in case of moderate to severe damage only after the flooding of the crop is over.

Harvesting and Threshing: The maize crop is ready for harvesting even when the stalks and leaves are some what green but the husk cover has dried and turned brown. In the fields where wheat is to be sown, harvest the stalks alongwith the cobs, stack them. Maize dehusker cum thresher (Annexure V) can also be used for shelling of un-husked maize. However, for better results maize (with husk) be shelled when the moisture content ranges between 15 to 20%. Conventional maize sheller can also be used after removal of ears. After shelling, market the dried grains with about 15 per cent moisture content. Maize shellers operated manually or with power are also available in the market (Annexure V). Conventional grain-combines can also be used for threshing maize with husk to save labour involved in dehusking. However, some adjustments are necessary. The maize ears should preferably be dried for 3 to 4 days after harvesting.

Maize drying: A portable maize dryer 3 ton capacity has been developed as per international norms and recommended to dry maize grains from a moisture level 25 to 15% in 8-10 hours. This cross-flow dryer has three pass, indirect type diesel fired heating system. A control panel to regulate and display the temperature of heated air, exit air and speed of air blower with variable frequency drive is provided for better operation. The dryer can maintain air temperature 60-75°C with the grain temperature of 45°C for seed and 60°C for commercial purpose. The dryer is capable of drying maize grain @ 1.0 – 1.5 % per hour consuming about 4 litres per hr of diesel initially for 1 hr. A provision of heat recovery from flue gases ensures higher fuel efficiency with reduced diesel consumption to about 2 litres per hr later on. The dryer can be operated both with tractor PTO or electricity. One each of skilled and unskilled labor is required to operate this dryer.

Baby Corn

Baby corn is the young ear of female inflorescence of maize plant harvested before fertilization when the silks have just emerged. The dehusked young ear is eaten raw as salad and used for cooking as vegetable, preparing pickle, *pakora* and soup. Baby corn salad and soup is delicacy in hotels, air lines and shipping companies because of its crispiness and sweet flavour. Baby corn has export potential as it is extensively consumed in developed countries. The crop raised for baby corn is completed in about 60-65 days and rest of the plant can be used for feeding cattle.

Punjab Baby Corn 1 and Parkash are appropriate hybrids for taking baby corn crop, which give on an average 8.4 and 7.0 quintals per acre, respectively yield of dehusked ears.

Note: Get certified seed of hybrids from PAU or Punjab State Seed Corporation. If the grain-produce of a hybrid crop is used as seed, it will give 15 to 20 per cent less yield.

The sowing of baby corn crop can be done at any time during April to first week of August. It is possible to have two or more crops from the same piece of land as this crop completes in less than 60 days. Staggered sowing should be done to maintain the supply as per demand. Sow the crop having row to row spacing of 30 cm and plant to plant of 20 cm using 20 kg seed per acre. Apply 24 kg N (52 kg urea) per acre in two equal splits i.e. at sowing and knee high stage. Use PAU-Leaf colour chart (PAU-LCC) for need-based urea application as below:

- Apply basal dose of 18 kg urea per acre at the time of sowing.
- Match colour of the youngest leaf (with fully exposed collar) from the 10 randomly selected baby corn plants with PAU-LCC shade 5, starting from 21 days after sowing for spring and summer season while 28 days after sowing for winter season up to initiation of silking stage at 10-day interval.
- Whenever the greenness of 6 or more out of 10 leaves is less than LCC shade 5, apply 18 kg urea per acre.
- No urea should be applied if leaf colour is equal to or darker than LCC shade 5.
- Use of LCC should be discontinued after initiation of silking and no more urea should be applied.

Note: Always match colour of the leaf with PAU-LCC under shade of the body. The leaves selected for measuring leaf greenness should be free of insect-pest or disease incidence. There should not be water stress to the crop, and nutrients other than nitrogen should be supplied as per recommendations. The PAU-LCC can be purchased from PAU Seed Shop at Gate number 1, PAU Ludhiana, KVKs and FASCs of PAU in different districts of Punjab.

Pick the young baby corn ears just at the silk emergence stage and ears picked later on would be pithy, woody and of poor quality. Take only three picks from each plant as ears appearing later are not of good quality. It is important to remove the tassel as soon as it appears to check the pollination in Parkash hybrid. Ears with single layer of husk are taken to market after doing dehusking. The other agronomic practices including land preparation, weed control, fertilizer requirement to raise the crop are same as for grain crop.

Rainfed Maize

Improved Varieties

PMH 2 (2005): It is a short duration drought tolerant hybrid. It has medium plant height with medium ear placement. Its' leaves are medium sized and dark green. Tassel is of medium size and semi open. Silk is of green colour. Ears are medium long with orange flint grains having yellow caps. The cob colour is white. It matures in about 82 days. Its' average yield is 16.5 quintals per acre under rainfed conditions with well distributed rains. The hybrid resists lodging and is tolerant to bacterial stalk rot.

Parkash (1997): It is an early maturing single cross hybrid. It has medium tall plants with medium ear placement. Its' leaves are dark green, medium sized and semi-erect. Tassel is of medium size and open. Short anthesis-silking interval confers drought tolerance to the hybrid. Ears are uniform and long with slightly blank tip. Grains are attractive orange flint. Cob is thin and white. Plants have stay green characteristic. It matures in about 82 days. Its' average yield is 15 quintals per acre.

Agronomic Practices

Time of Sowing: June 20 - July 7 (sow as early as possible depending on the rains)

Seed Rate: 10 kg per acre

Method of Sowing: Sow the seed 3-5 cm deep in lines with row and plant spacing of 60 cm and 20 cm, respectively.

Moisture Conservation: Crop may suffer due to moisture stress under scanty rainfall during crop growth. Following moisture conservation practices are recommended:

- Repair the field bunds and do minor levelling wherever needed before the onset of rains.
- Plough the field against slope after the pre-monsoon showers to enhance rain water absorption/infiltration.
- Sowing and other operations should be done on contour/across the slope.
- Spread locally available mulching material in the standing maize crop in the last week of August.

Fertilizer Application: It pays to apply fertilizers to the rainfed maize crop. The response to fertilizer varies with the water stored in the soil. In the absence of a soil-test report, apply fertilizer at the following rates.

Soil type	*Nutrients (kg per acre)			Fertilizers (kg per acre)			
	N	P_2O_5	K_2O	Urea	DAP	or Single phosphate	Muriate of potash
Sandy loam to clay loam soils with adequate moisture stored	32	16	8	70	35	100	15
Loamy sand to sandy soils with low moisture stored	16	8	4	35	18	50	8

* These nutrients can also be supplied from other fertilizers available in the market (Annexure VII)

Drill 1/2 N and all P and K at sowing and top dress the other half of N one month after sowing.

Note:

- These recommendations are valid for medium fertility soils; for low and high fertility soils see chapter on "Soil Testing".
- Apply only when the soil-test shows deficiency of potash.
- Where 35 kg DAP is used, reduce the urea dose by 15 kg and where 18 kg DAP is used, reduce the urea dose by 8 kg.
- Omit the application of phosphorus and potassium if maize is adequately fertilized with farmyard manure.
- Light textured soils e.g. sandy to loamy sand soils usually have a low water retention capacity and on such soils, wheat followed by maize gives poor yield. For the best results, green manure with sunhemp or grow fodder crop during *kharif* and take a crop of wheat, wheat + *raya/taramira* in rows during *rabi*.

The other agronomic practices are same as recommended for irrigated maize.

Plant-Protection

A. Insect Pests

Maize borer: The maize borer is a serious pest from June to September. Its' larvae first scrape the leaves and then bore into the stem through the whorl or leaf sheath. The central leaves of the attacked whorl get perforated. In a young plant, the growing point is killed and a dead-heart results. Adopt the following integrated control measures:

- Kill the borer larvae hibernating in plant remnants like stubbles, stalks, cobs and cores. Plough up the fields after harvesting the maize crop, collect the stubbles and destroy them. Use maize stalks, cobs and cores by the end of February. Chop the remaining stalks, if any, for subsequent use. For seed, keep only healthy cobs, free from borer attack.
- Remove and destroy the plants showing severe borer injury, while hoeing the crop.
- Use trichocards twice having 40,000 eggs of *Corcyra cephalonica* parasitized by *Trichogramma chilonis* per acre. First release on 10 days old crop and second 7 days after the first release. Cut trichocards into 40 strips, each having approximately 1000 parasitized eggs. Staple these strips uniformly on the underside of the central whorl leaves in evening hours. These tricho-cards are available at the Biocontrol Labs, Department of Entomology, PAU, Ludhiana and Regional Station, Gurdaspur.

- Spray the crop 2-3 weeks after sowing as soon as borer injury to the leaves is noticed with 30 mL Coragen 18.5 SC (chlorantraniliprole*) using 60 litres water per acre with knap-sack sprayer.

- **Regularly monitor the crop for the attack of fall armyworm.**
- **Use recommended insecticides for control of maize borer within 2-3 weeks of sowing.**
- **Control maize borer using *Trichogramma* cards on 10 and 17 days old crop.**
- **Ensure proper drainage conditions and do not allow water to stagnate in the field to control bacterial stalk rot.**

Fall armyworm: The young larvae feed by scrapping the leaf surface making papery windows. The bigger larvae feed voraciously on the central whorl leaves causing round to oblong holes and produce a large amount of faecal matter. The larva can be identified by predominant white-coloured inverted Y-shaped mark on the head and presence of four spots arranged in square pattern at the tail end. Adopt the following control measures:

- Sow the crop at recommended time only.
- Avoid staggered sowing of maize in adjacent fields to minimize spread of this pest.
- Regularly monitor the field to collect and destroy egg masses of fall armyworm from leaves. Egg masses are covered with hairs and are easily visible.
- Spray the crop with Coragen 18.5 SC (chlorantraniliprole*) @ 0.4 mL per litre water or Delegate 11.7 SC (spinetoram*) @ 0.5 mL per litre or Missile 5 SG (emamectin benzoate) @ 0.4 g per litre using 120 litres of water per acre, for crop up to 20 days old. Thereafter for older crop, the amount of water used per acre needs to be increased up to 200 litres with corresponding increase in dosage of above insecticides. For effective management of this pest, direct the nozzle towards the whorl.
- If the infestation is in patches or the crop is more than 40 days old and spraying is difficult, apply soil-insecticide / biopesticide mixture (about half gram) in the whorls of the infested plants to manage fall armyworm. To prepare soil–insecticide mixture, add 5 mL of Coragen 18.5 SC (chlorantraniliprole*) or Delegate 11.7 SC (spinetoram*) or 5 g of Missile 5 SG (emamectin benzoate) or 25 g of Delfin WG (*Bacillus thuringiensis* subsp. *kurstaki**) or 25 mL of Dipel 8 L(*Bacillus thuringiensis* subsp. *kurstaki**) in 10 mL of water and mix well in one kg of soil.

Precaution: Use gloves for preparation and application of the mixture.

Jassid, thrips, pyrilla, grey weevil and leaf-feeding insects: These attack the *kharif* crop.

Armyworm and silk cutter: These insects feed on the leaves in the whorl. The pesticides used against the maize borer are effective in controlling these pests also.

Hairy caterpillars: Hairy caterpillars, if appearing in an epidemic form, cause serious damage by feeding on the leaves and the tender stems. When young, they feed gregariously. The grown up caterpillars may migrate from one field to another. Adopt the following control measures:

- Use light-traps for the destruction of moths.
- Young larvae are gregarious. Destroy them by plucking the infested leaves or by pulling out the infested plants and bury them.
- Destroy grown up caterpillars by crushing them under feet or by picking and putting them into kerosenized water.

Mite: The attack of mite is serious in June on the young crop or in September-October when the crop is nearing maturity. The affected leaves turn pale and can be recognized from the presence of dusty webs.

B. Diseases

Seed rot and seedling blight (Several fungi): Poor germination, unthrifty seedlings and seedling mortality are the symptoms. Use disease free seed.

Banded leaf and sheath blight *(Rhizoctonia solani)*: Water soaked, straw colored necrotic lesions alternating with dark brown bands develop on basal leaf sheaths. Lesions enlarge and coalesce with each other. Later, sclerotia develop on diseased sheaths, husk and cobs. In severe cases, developing ears are completely damaged and dry up prematurely with cracking of husk. To manage this disease, spray 100 mL Amistar Top 325 SC (azoxystrobin + difenoconazole) in 200 litres of water per acre at disease appearance. If needed, repeat the spray at 15 days interval.

Maydis leaf blight (***Drechslera maydis***)***:*** This disease is characterized by the presence of spindle shaped, necrotic to brown lesions on the leaves. Such lesions may merge to form large, irregular patches. Sometimes the symptoms also appear on leaf sheaths, cob husks and ears. Late sowing, high humidity (>80%) and temperature of 25 $\pm$ 2°C favours the development of disease. Destroy the infected crop residue in the field. Grow improved varieties. Follow spray schedule as against Brown stripe downy mildew.

Bacterial stalk rot (*Dickeya zeae*): Water soaking and rotting of basal stem especially the leaf sheaths followed by rapid rotting of basal internodes. The rind loses its natural green colour and gives appearance as if boiled in water. The rotten stalks emit a characteristic fermenting odour and may break over from the second or third basal internode. The infected plants wilt. Destroy the diseased plant debris. Excessive rains and poor drainage favours the disease, so keep the fields well drained.

Brown stripe downy mildew (*Sclerophthora rayssiae var zeae*): It is characterized by the presence of long, narrow, brownish, interveinal stripes on leaves. Whitish downy fungal growth may be observed on close examination on underside of the stripes. Destroy the collateral host *Takri* grass *(Digitaria sanguinalis)* from the maize field. Keep the fields well drained. Spray 200 g Indofil M-45 (mancozeb*) in100 litres of water after about a fortnight of sowing. Give two more sprays at 10-day intervals. Grow recommended varieties.

Post flowering stalk rots (*Fusarium* spp., *Macrophomina* spp., *Cephalosporium* spp.): Plants wilt after flowering. The rind and basal internodes become discoloured. On splitting, the discolouration of the pith progressing upward is also seen. Grow improved varieties such as PMH 13, PMH 11 and PMH 1).

C. Birds : See under Chapter 'Management of Rodent and Birds'

Seed Production of Maize Hybrids

Every year fresh hybrid seed has to be produced for cultivation. The parental lines of these hybrids are given below:

Hybrid	Parental Lines		Ratio of Female to Male line with Seed rate per acre	Remarks
	Female	Male		
PMH 1	LM 13	LM 14	3 (12 kg): 1 (3 kg)	Sowing of male and fermale lines at same time
PMH 2	LM 15	LM 16	3 (7 kg): 1 (3 kg)	Sowing of male and fermale lines at same time
Parkash	CM 139	CM 140	3 (7 kg): 1 (3 kg)	Sowing of male and fermale lines at same time
PMH 7	CM140	LM 20	3 (7 kg): 1 (3 kg)	Female line should be planted one week later than male line
PMH 8	LM 5	LM 20	3 (12 kg): 1 (3 kg)	Female line should be planted 10 days prior to male line
PMH 10	LM 23	LM 24	3 (9 kg): 1 (3 kg)	Female line should be planted 5 days prior to male line
PMH 11	LM 25	LM 11	3 (12 kg): 1 (3 kg)	Female line should be planted 5 days prior to male line
PMH 13	LM 27	LM 17	3 (12 kg): 1 (3 kg)	Female line should be planted 4-6 days later than male line
PMH 14	LM 28	LM 29	3 (12 kg): 1 (3 kg)	Male line should be planted 4-6 days later than female line
PMH 17	LM 30	LM 29	3 (12 kg): 1 (3 kg)	Male line should be planted 5-6 days later than female line
Punjab Baby Corn 1	I 193	LM 13	3 (9 kg): 1 (3 kg)	Female line should be planted 3-4 days later than male line

The seed production of these hybrids can be successfully done by sowing the crop in second fortnight of July and first week of August which will escape pollen wash with rains.

Important Hints for Hybrid Seed Production

- Obtain fresh seed of both the female and pollinator lines of the hybrids from Punjab Agricultural University every year.
- Planting should be done at the spacing 60x15 cm.
- Select an isolated field which is located atleast 200-300 metres away (depending on kind of seed) from another maize field or ensure time isolation.
- Off type plants should be rogued out before pollination.
- All the tassels in the female rows must be removed prior to pollen shedding. Tassels should be removed daily even if there is rain.
- 75 kg N per acre should be used in seed production plots. Other nutrients should be applied as for normal commercial crop.
- All other cultural practices should be used as for normal maize crop.

- The seed harvested from female rows only should be kept and used as hybrid seed. The male rows should be harvested first and kept separately. This should be followed by harvesting and shelling of female rows. The off type ears should be discarded before shelling.

Seed Production of Composite Varieties of Maize

The grain produce of composite varieties such as JC 4, JC 12, Pearl Popcorn, Punjab Sweet Corn 1, J 1008, J 1007 and J 1006 can be used as seed for 3-4 years without any marked reduction in yield. To maintain purity and the production potential of these varieties, take the following precautions:

- Avoid admixture with other varieties.
- Avoid natural cross-pollination with any other maize variety or hybrid growing in the nearby fields. This can be done by isolating the composite maize plot from other maize fields by having no maize crop in a strip of about 200 metres all around or by growing one acre of composite maize and then selecting ears from the central portion of the field, leaving a 9-metre strip all round.
- Take about 5,000 maize ears and mix the grains from all of them. Even if the seed requirement is small, never bulk the grains from less than 3,000 ears.

The grain produce of composite varieties may, however, be used as seed from the first year even when conditions No. 2 and 3 have not been met.

BAJRA

Soil and Climatic Requirements

Bajra can be grown on a wide range of soils, but being sensitive to water logging, it does best on well-drained sandy loam soils. It is a rapid growing, warm weather crop, suitable for areas with 40 to 65 cm of annual rainfall. The rain at flowering washes off the pollen and reduces the seed-set.

Rotations

Bajra-Wheat/Gram/Barley/*Raya/Gobhi Sarson*

Improved Varieties/Hybrids

PCB 167 (2024): This is a medium tall (198 cm) grain purpose composite variety with more number of productive tillers. It comes to 50 % flowering in about 50 days and matures in about 90 days. The ears are 30.5 cm long and 3.7 cm in girth. It is tolerant to all the major diseases of pearl millet. The grains are medium bold and light in color. The grains possesses better nutritional characteristics, especially crude protein, crude fibre, and resistant starch along with high iron and zinc content. The grains of PCB 167 possess good popping potential and are suitable for value addition. On an average, it gives 15.6 quintals per acre of grain yield.

PCB 166 (2022): This is a dual purpose composite variety with more number of tillers. It is a tall variety (281 cm) with long and broad leaves. It is late maturing variety and takes 124 days to mature. The ears are very long (63.8 cm) cylindrical. It is tolerant to all the major diseases of pearl millet. The grains are medium bold and slat in color. On an average, it gives 16.3 quintals per acre of grain yield.

PCB 165 (2020): This is a quick growing dual purpose composite variety with more number of tillers. It is a tall variety with average plant height of 252 cm. It is a late maturing variety and takes 111 days to mature. It bears long cylindrical ears with 31.3 cm length and 11.5 cm ear girth. The grains are soft and slate in color with very good popping potential. The grains are of good quality with high iron content. It is tolerant to all the major diseases of bajra. On an average, it gives 12.8 quintals per acre of grain yield.

PHB 2884 (2015): This hybrid is 230 cm tall and bears 2-3 productive tillers. It has long ears with average length of 28 cm and girth of 12 cm. Its' grains are medium bold and slate in colour. It is tolerant to downy mildew, ergot and smut diseases. It matures in 88 days and average grain yield is 13.2 quintals per acre.

PCB 164 (2003): This is dual purpose composite variety having medium thick stalks and flexible stem with average plant height of 207 cm. It matures in 80 days. This variety has long cylindrical dense ears having 27-28 cm length and 8-10 cm girth. The grains are medium bold and light slate in colour. The average grain yield is 15 quintals per acre. It is tolerant to downy mildew.

Agronomic Practices

Land Preparation: Fine seed bed and adequate moisture in the seedbed is conducive to good germination. Prepare the field by giving 2 or 3 ploughings followed by planking.

Sowing Time: In areas of low rainfall, sow *bajra* in early July. For other areas, sow it in the last week of July so that the crop blossoms after the monsoon rains which hinder pollination and reduce yield.

Seed Rate and Method of Sowing: Use 1.5 kg seed per acre. The seed rate can be reduced to 1.0 kg if the seed-bed is well prepared and a uniform distribution of the seed is ensured. Sow the seed about 2.5 cm deep in rows 50 cm apart. Thin the seedlings to 15 cm apart in the rows after three weeks of sowing. If the stand is poor, fill the patches by transplanting the uprooted seedlings.

Weed Control: Use wheel-hoe, triphali or tractor-drawn cultivator for interculture.

Fertilizer Application: Apply the following fertilizers:

	*Nutrients (kg per acre)		Fertilizer (kg per acre)		
	N	P_2O_5	Urea	DAP	or SSP
Irrigated Conditions					
Hybrid/composite	40	24	90	55	150
Rainfed Conditions					
Hybrid/composite	25	12	55	27	75

* These nutrients can also be supplied from other fertilizers available in the market (Annexure VII).

Note:

- These recommendations are valid for medium fertility soils; for low and high fertility soils see chapter on Soil Testing.
- Apply 10 kg zinc sulphate heptahydrate or 6.5 kg zinc sulphate monohydrate per acre at sowing in zinc deficient soils.
- Apply potash if the soil test shows deficiency of potash.
- When DAP is used @ 27 and 55 kg per acre, reduce the urea dose by 10 and 20 kg, respectively.

Under irrigated conditions, apply 1/2 N and whole of P with last ploughing. Apply the remaining N in two splits, one at thinning and one before ear formation.

Under rainfed conditions, apply 1/2 N and whole of P with last ploughing and remaining N about one month later after a shower of rain followed by hoeing so as to mix the fertilizer and also to create a soil mulch.

Irrigation and Drainage: Generally, two irrigations during the growing period of the crop are enough. *Bajra* does not tolerate water-logging so do not allow rain-water to stand for more than a few hours.

Seed Production

Hybrid: The seed of hybrid should be procured a fresh every year. For seed production of hybrid the certified seed of female and male parents should be obtained from a reliable source. The parental lines of hybrids are given below:

Hybrid	Parental Lines		Ratio of female to male line with seed rate/acre
	Female	Male	
PHB 2884	ICMA 02777	PIB 686	4 (1kg): 2 (0.5 kg)

The male and female parents are planted in an isolated field with no bajra crop in 200 m around it, in the ratio of 4 female: 2 male rows. Frequent roguing of female and male rows is required to remove off type plants before flowering.

Composite Varieties: After procuring certified seed of composite varieties from a reliable agency, the farmers can produce the seed of these varieties by growing in an isolation plot having no bajra crop in a strip of about 200 metres on all sides or by harvesting from the centre of about one acre field leaving a strip of approximately 10 metres all around.

Plant Protection

A. Insect Pests

Root bug: This insect causes damage to the *bajra* crop in south-western districts.

Grey-Weevil, Pyrilla and Fulgorid: These pests also attack this crop.

B. Diseases

Green-ear or downy mildew: This is caused by *Sclerospora graminicola*. The leaves of infected plants show discolouration, yellowing and whitening. Under humid conditions, the leaves are covered with a downy white growth of the fungus, which is prominent on the

lower-surface. The leaves turn necrotic and are torn into shreds. The ears of the infected plants are transformed wholly or partly into green heads of small, twisted, leafy structures. Adopt following integrated measures to control the disease:

- Grow downy-mildew tolerant hybrid such as PHB 2884 and composite varieties such as PCB 167, PCB 166, PCB 165 and PCB 164.
- Rogue out the diseased plants early in the season to prevent secondary infection.
- Collect the diseased ears from the crop before harvesting and destroy them by burning.
- Practise five year rotation with other crops.

Grain smut: Smut is caused by *Tolyposporium penicillariae.* Individual grains in an ear get transformed into smut balls which may later burst open to release millions of spores. The spores upon dissemination cause secondary infection on the portion of the ear which is enclosed by the sheath of the upper leaf. The intensity of the attack varies according to the humidity in the area. Remove the diseased ears early in the season and destroy them.

Ergot: This disease is caused by the fungus *Claviceps fusiformis*. At blossoming, a pinkish or light-coloured fluid (honey dew) exudes from the spikelets in different parts of the ear. Later dark sticky patches appear on the ear and small dark-brown sclerotia appear in place of grains between the glumes. The seed set is poor or completely inhibited. The ovary is replaced by a fungal mass with many folds on its surface. The fungus perpetuates through the seed-borne and soil-borne sclerotia. The contaminated grains, if fed to cattle or used by human beings can cause poisoning. Therefore, take the following precautions:

i. For Cattle: Do not feed the infected ears showing honey-dew symptoms to cattle. Even the stems and leaves of such plants are not safe as cattle feed. Cut and burn a badly affected crop to reduce the amount of inoculum.

ii. For Human beings: Immerse the grains in 10 per cent salt solution. The sclerotia, being lighter than normal grains, will float. Remove them with a sieve and burn them. Repeat the process two or three times.

Prevention of Ergot: Once the disease appears, it is not possible to eliminate it. Take the following precautions to prevent its spread.

- Immerse seed in 10 per cent salt solution and remove the sclerotia and smut-balls by skimming. Then wash the seed in ordinary water and dry it thoroughly.
- Burn the ears infested with honey-dew, as soon as they are observed in the field.
- After harvesting the crop, bury the debris with a furrow turning plough so that the ergot sclerotia rot in the soil. After threshing the ergot affected crop, the left-over-ear-heads of bajra in the threshing floor should also be burnt.
- Avoid sowing *bajra* in a field in which the crop had suffered heavily from ergot.

C. Birds: See under Chapter ‘Management of Rodents and Birds’

2. COTTON

American cotton was grown on 2.12 lakh hectares in Punjab during 2023-24. The total production was 6.24 lakh bales with an average yield of 5.0 quintals lint per hectare (2.02 quintals lint per acre).

Important hints

- Grow only recommended varieties/hybrids of cotton.
- Heavy pre-sowing irrigation is must to obtain good germination and early establishment of plants.
- Complete the sowing by 15 May.
- Give first irrigation 4-6 weeks after sowing depending on soil type. Last irrigation in September is must.
- Avoid growing *bhindi, moong, arhar,* castor and *dhaincha* in and around the cotton fields to avoid simultaneous build up and spread of pests and diseases to cotton.
- Give 4 sprays of 2% potassium nitrate (13:0:45) solution starting at flower initiation at weekly interval.
- The incidence of insect pests increases with excessive use of nitrogenous fertilizers, hence use only recommended dose.
- Regular monitoring is effective strategy for the management of whitefly, pink bollworm and mealybug. Avoid using synthetic pyrethroids before September 15 to minimize resurgence of whitefly. Use recommended insecticides.
- Avoid tank mixing and use of readymade insecticidal mixtures.

Climatic Requirements

A daily minimum temperature of 16^{o}C is required for germination and 21^{o}C to 27^{o}C for proper crop growth. During the fruiting phase, the day temperature ranging from 27^{o}C to 32^{o}C and cool nights are needed. The cotton picking period from mid-September to November must have bright sunny days to ensure a good quality of the produce.

Soil Type

Cotton can be successfully grown on all soils, except sandy, saline or waterlogged types. Proper drainage of excess water during rains is essential.

Rotations

Cotton–Wheat/Barley, Cotton–Sunflower, Cotton–*Senji*/*Berseem*/Oats, Cotton-Raya, Cotton–Sunflower-Paddy-Wheat

Improved Varieties

Bt cotton variety

PAU Bt 3 (2022): It is a Bt cotton variety with inbuilt resistance against spotted and American bollworms. Its average seed cotton yield is 10.2 quintals per acre. Its average fibre length is 26.2 mm and ginning out turn is 36.5 %. It is tolerant to jassid and cotton leaf curl disease.

PAU Bt 2 (2022): It is a Bt cotton variety with inbuilt resistance against spotted and American bollworms. Its average seed cotton yield is 10.0 quintals per acre. It possesses average fibre length of 27.6 mm and ginning outturn of 34.4 %. It matures in 160-165 days. It is tolerant to jassid and cotton leaf curl disease.

Bt cotton hybrids

Grow Bt cotton hybrids recommended by Punjab Agricultural University (See Annexure III on **Page 167**). The list of recommended Bt cotton hybrids will be published in PAU publications such as *Changi Kheti* & Progressive Farming and shall be widely publicized through leading newspapers and other magazines well before the planting season.

Non-Bt cotton

F 2228 (2015): Its' maturity period is 180 days with an average seed cotton yield of 7.4 quintals per acre. It is moderately resistant to jassid and bacterial blight.

LH 2108 (2013): It matures in 165-170 days with an average seed cotton yield of 8.4 quintals per acre.

Agronomic Practices

Sub Soiling: Cross sub soiling at 1.0 m spacing should be done before preparing the field. This is done by tractor drawn sub-soiler (chiseler) to the depth of 45-50 cm. Give planking to break the clods and then prepare fine seed bed. This will help in breaking the hard pan, increasing water infiltration rate and better root development of cotton plants.

Land Preparation: A fine seed-bed is essential for securing a good plant stand.

Time of Sowing: Sow the crop during 1 April to 15 May. Sowing during this period ensures better yield and escapes the attack of insect pests and diseases. Sowing should be done in morning and evening hours.

Seed Rate: Use following quantity of seed:

	Cultivars	Seed rate (kg per acre)
Bt varieties	PAU Bt 2 and PAU Bt 3	4.0 + 1.0 (refuge)*
Bt hybrids	Recommended hybrids	0.900+0.240 (refuge)* or two pouches of 475 gram each**
Non-Bt varieties	F 2228 and LH 2108	3.5

* Grow non-Bt cotton as a refuge around Bt cotton variety/hybrids to avoid evolution of resistance in bollworm to Bt toxin.
** Already mixed refuge in seed

Acid Delinting of Seed: Mix 100 g commercial grade concentrated sulphuric acid with 1 kg cotton seed in earthen/ plastic container by stirring it vigorously for two to three minutes with a thick wooden stick. As soon as the fuzz gets dissolved, add 10 litres of water, stir well and drain out water through the perforated plastic basket. Repeat these washings three times to make the seed free from sulphuric acid residue. Dip the washed seed for about one minute in sodium bicarbonate solution (12.5 g sodium bicarbonate in 2.5 litres of water) to neutralize the acid residue on the cotton seed. Give one more washing with water and remove light, damaged and rotten inviable seeds floating on the surface. Dry the healthy fuzz-free seed in the shade by spreading in a thin layer. Adopt following precautions:

- Metal or wood container should not be used.
- The operator should wear the plastic gloves.
- The water containing acid and alkali residue should be properly disposed off in the waste land.
- Inadequate washing and delayed washing of the seed after acid treatment and residual acid on the seed if not neutralized may impair the germination of seed.

Or rub the non-delinted seed with fine earth, cow-dung or ash to remove its fuzz and ensure uniform sowing.

Seed Priming: Soak the seed in a solution of 0.5 g succinic acid and 5 litres of water for 2-4 hours in case of acid delinted seed or 6-8 hours in case of non-delinted seed to promote good establishment of plant stand, better early growth and more yield.

In soils irrigated with sodic water (RSC > 2.5 meq per L), treat the seed with the liquid bioformulations (Halo-Azo+PSB+ZnSB)* along with gypsum (25% of Gypsum Requirement) application. This will reduce the adverse effects of sodic water irrigation while sustaining soil health and cotton productivity in cotton-wheat system.

Note: The liquid bioformulations are available at ICAR-CSSRI, Regional Research Station, Lucknow at a nominal price.

Seed should be smeared with 5 g Gaucho 70 WS (imidacloprid) or 7 g Cruiser 30FS (thiomethoxam) per kg seed for preventing damage by cotton jassid.

Sowing and Spacing: Sow in lines 67.5 cm apart with a cotton sowing drill or cotton planter. The plants of non-Bt varieties within rows be kept 60 cm apart during thinning, whereas for PAU Bt 2 and PAU Bt 3, plant to plant spacing within row be kept 30 cm apart after thinning. However for Bt hybrids, plant-to-plant distance should be kept at 75 cm. Thinning may be done after first irrigation or heavy shower.

Sowing of Refugia: To avoid the development of resistance in bollworms to Bt cotton, 20 per cent area should be sown under non-Bt cotton hybrids around Bt cotton. The non-Bt hybrids should be protected against damage by insect pests as mentioned in case of non-Bt cotton hybrids. Alternatively, 5 per cent area of non-Bt hybrids can be sown around Bt cotton and this should be kept unsprayed. The refuge should be non-Bt version of the same variety/hybrid. If it is not possible, the farmers can use non-Bt varieties like F 2228 and LH 2108 as refuge.

Intercropping: Intercrop one row of maize/cowpea for fodder in cotton sown at row to row spacing of 67.5 cm for getting higher income as compared to sole cotton. Apply recommended fertilizers to cotton and intercrops on area basis. Harvest maize/cowpea fodder at 45-55 days after sowing.

Ridge sowing: Sowing of cotton on ridges prepared with cotton planter and irrigating the crop in furrows saves considerable amount of irrigation water without reduction in seed cotton yield.

Transplanting of cotton seedlings: For gap filling, 3 week old nursery grown in 4"x6" polythene bags, filled with 1:1 mixture of soil and FYM, can be transplanted.

Weed Control: Hoe the crop two or three times. The first hoeing should be done before first irrigation. Use tractor mounted cultivator/ tractor operated rotary weeder/triphali or wheel hand hoe for weeding. Their use after fruiting should be avoided.

For control of weeds particularly *itsit*, *madhana/makra*, apply 1.0 litre per acre Stomp 30 EC (pendimethalin) as pre-emergence within 24 hours of sowing. In situations where weeds emerge after first irrigation or with the rain shower, Stomp 30 EC can also be applied as post-emergence after first irrigation in 200 litre of water. If some weeds emerge before the application of the herbicide, a light hoeing/interculture may be done. The herbicide can also be sprayed with tractor mounted sprayer fitted with flat fan nozzle either in morning or evening hours. Ensure a fine seed bed free from plant residues and clods, adequate moisture in the field at the time of spray of herbicides.

Alternatively, spray 500 mL per acre Hitweed Maxx 10 MEC (pyrithiobac sodium 6%+quizalofop ethyl 4%) by dissolving in 150 litres of water after first irrigation, in moist soil, to control annual grass and broadleaf weeds. This herbicide also provides effective control of *lapeta* (*guara*) *vel* (*Ipomoea* sp.) when weed plants are at 2 to 5 leaf stage.

Alternatively, at 6-8 weeks after sowing when the crop is about 40-45 cm in height, spray 500 mL per acre Gramoxone 24 SL (paraquat) or 900 mL per acre Sweep Power 13.5 SL (glufosinate ammonium) in 100 litres of water as a directed spray to control weeds in between the crop rows. The directed spray can be done by using a protective hood. Paraquat and glufosinate are non-selective herbicides and can cause injury to the crop if these fall on the crop leaves.

Fertilizer Application: Apply fertilizer on soil test basis (See Chapter on 'Soil Testing'). The fertilizer recommendations for medium fertility soils are as under:

	***Nutrients (kg per acre)**		**Fertilizers (kg per acre)**		
	N	P_2O_5	Urea	DAP	or Single Superphosphate
Non-Bt varieties	30	12	65	27	75
Bt varieties	37	12	80	27	75
Bt hybrids	42	12	90	27	75

* These nutrients can also be supplied from other fertilizers available in the market (Annexure VII).

Note:

- Omit application of phosphorus to cotton when it follows wheat which had received recommended dose of phosphorus. Where 27 kg DAP is used, reduce the urea dose by 10 kg.
- Apply 20 kg muriate of potash and 10 kg zinc sulphate heptahydrate (21%) or 6.5 kg zinc sulphate monohydrate (33%) per acre to cotton in light soils.

Drill all phosphorus at sowing. Apply 25 kg magnesium sulphate as basal dose at the time of sowing. Apply half nitrogen at thinning and remaining half at the appearance of flowers. If the soil is low in fertility, the first half dose of nitrogen may be applied at sowing instead of at thinning.

Apply 400 g boron (4 kg borax) per acre at sowing to boron deficient (<0.5 kg available boron per acre) calcareous soils having 2% or more calcium carbonate. However, boron should not be applied indiscriminately, as excessive boron application may cause toxicity.

PAU-Leaf Colour Chart (PAU-LCC) for need based Urea application

- Match leaf colour greenness of the topmost fully developed intact leaf from the randomly selected ten cotton plants with PAU-LCC under shade of your body at thinning and initiation of flowering.
- Apply urea based on leaf greenness of six or more leaves out of ten leaves as per following table:

Leaf Colour as per PAU LCC	More than LCC shade 4.5	LCC shade 4.5	LCC shade 4.0	LCC shade 3.5 or below
Urea dose (Kg per acre)	0	20	35	50

Note: The leaves selected for measuring leaf greenness should be free from insect/disease incidence. There should not be water stress/logging and nutrients other than nitrogen should be supplied as per recommendations. The PAU-LCC can be purchased from PAU Seed Shop at Gate No. 1, *Krishi Vigyan Kendras* and Farm Advisory Service Centres in different districts.

To get higher yields, give 4 sprays of 2% potassium nitrate (13:0:45) at weekly interval starting at flower initiation. For high yield and management of leaf reddening in Bt cotton, give 2 sprays of 1% magnesium sulphate (1 kg magnesium sulphate in 100 litres of water per acre) at 15 days interval during full bloom and boll development stages.

Use of growth retardant

In heavy soils, cotton attains excessive vegetative growth during rainy season. Thick crop canopy prevents the penetration of sunlight which results in shedding of flower buds, flowers or bolls and ultimately causes yield reduction. To check excessive vegetative growth in heavy soils, give 2 sprays of 300 mL per acre Chamatkar (mepiquat chloride 5% w/w) at 60 and 75 days after sowing using 80-100 litres of water.

Irrigation and Drainage

Cotton requires 4-6 irrigations depending upon the seasonal rainfall. The first irrigation should be given 4 to 6 weeks after sowing and the subsequent ones at interval of two or three weeks. However on light soils or in crop sown on ridges, the first irrigation

may be advanced, if necessary. Sowing cotton on ridges and irrigation in furrows save considerable amount of water. Under poor quality irrigation water conditions, give pre-sowing irrigation with canal water and subsequent irrigations can be applied with poor quality tube well water in alternate furrows. In soils irrigated with saline water (EC upto 10 dS/m), application of 16 quintal per acre of rice-residue biochar reduces adverse affect of salinity and increases seed cotton yield.

The crop must not be allowed to suffer from water stress during the flowering and fruiting stages, otherwise a lot of shedding of flowers and bolls will take place resulting in low yield. Cotton during its early growth is very sensitive to water stagnation. Therefore, drain out the stagnant water if such a situation arises. To hasten boll opening, give the last irrigation by the end of September.

Water stress management through Salicylic acid: To minimize loss of cotton yield owing to water stress (due to no rainfall or sudden canal closures), dissolve 12.5 g Salicylic acid in 375 mL of Ethyl alcohol and then add it to 125 litres of water for spraying crop per acre on stress appearance.

Caution: Application under well watered conditions may not increase yield.

Drip irrigation and Fertigation

American Bt cotton hybrids should be drip irrigated at 7 days interval with a lateral pipe laid at 67.5 cm apart and dripper placed at 75 cm apart having dripper discharge of 2.2 litre per hour as per the following schedule. Start fertigation of 100 kg urea (45 kg N) /acre at 35 days after sowing and complete in 110-120 days in 10 equal splits at 7 days interval.

Month	Time of irrigation (min)*
May/June	50
July	45
August	40
September	35

If discharge rate is different, then time of irrigation may be adjusted proportionally by the formula:-

Adjusted time (min) = (2.2 × Time of irrigation (min)*) ÷ Discharge of dripper (litre/hour)

Under scarcity of good quality irrigation water, alternate use of good quality canal water and saline tubewell water through surface drip irrigation is recommended in light-textured soil for obtaining sustainable seed cotton yield with a minimal adverse effect on soil quality.

For sub-surface drip irrigation and fertigation, see chapter on ‘Multiple Cropping’ under cotton-wheat cropping system.

Plant-Protection

A. Insect-Pests

i. Cultural and Mechanical Management

- Grow only recommended Bt cotton cultivars.
- Prefer to grow *desi* cotton in area of high infestation of whitefly and leaf curl.
- Even the apparently healthy seed-cotton (*kapas*) may be harbouring larvae of pink bollworm. It should be acid delinted or thoroughly dried in the sun in a thin layer for 3-4 consecutive days in April.
- Complete the sowing up to 15th May.
- Avoid excessive use of nitrogenous fertilizer.
- Eradicate weeds like *kanghi buti, peeli buti, puth kanda*, congress grass, *itsit* growing on field bunds, waste lands, road side and irrigation channels/canals to avoid further spread of whitefly, mealybug, tobacco caterpillar and spotted bollworm to cotton fields
- Regular surveillance on alternate host crops like brinjal, cucurbits (cucumber, long melon, *chappan kadu*), tomato, chilli, okra from February onwards and on cotton, moong from April onwards should be carried out for timely management of whitefly on these crops.
- Use low cost yellow sticky traps @ 40 per acre during initial phase of cotton crop to check early infestation of whitefly.
- Grow bajra, maize and *jawar* as barrier crops, being least preferred hosts for the mealybug.
- Do not grow *bhindi*, moong and *arhar* in the cotton crop and as border rows in order to reduce the incidence of American bollworm, spotted bollworms, jassid and whitefly. Bhindi, moong, dhaincha and castor are also the most preferred hosts of tobacco caterpillar, helping the pest to multiply and shift to cotton. The above pests on these crops grown in the vicinity of cotton fields, should be properly controlled in order to check their migration to the cotton crop.
- Do not throw the uprooted infested plants in cotton fields/water channels to check further spread of mealybug.
- Prevent movement of sticks from infested areas to new areas to avoid spread of mealybug.
- The trees/fruit plants near cotton fields harboring mealybug population should be sprayed with recommended insecticides.
- Egg masses and young larvae of tobacco caterpillar feeding gregariously should be collected along with leaves and destroyed.
- Terminate the crop as early as economically feasible. For this purpose give last irrigation by end of September. It would reduce bollworms damage and their carryover.

- After the final picking, PBW infested cotton field should be shredded with the help of shredder to kill the larvae.
- Destroy all trash collected during the ginning process. Remove all seed from the ginneries by the end of March. Fumigate the seed left uncrushed in the mills before end of April with Celphos/Phostoxin/Delicia @ one 3-g tablet per cubic metre space, giving an exposure of 48 hours or use two tablets with an exposure of 24 hours. No un-fumigated seed should be retained or sold by the ginneries. Only cotton-seed cake (*khal*) should be fed to the cattle and no seed should be kept for this purpose.
- The seed meant for sowing must be acid-delinted in the ginneries before it is sold. The acid treatment kills the larvae of the pink bollworm. It also removes fuzz and thereby facilitates mechanical sowing.
- Even the apparently healthy seed-cotton (kapas) may be harbouring larvae of pink bollworm. Hence, kapas retained by the farmers should be ginned by the end of March and seed fed to cattle. If this seed is to be retained for sowing, it should be acid-delinted/fumigated or thoroughly dried the sun in a thin layer for 3-4 consecutive days in April.
- After the last picking, allow sheep, goats and other farm animals into cotton fields to feed on plant debris and un-opened bolls.
- Do not stalk the cotton sticks under shade or in the field. Beat the sticks on ground to dislodge the pink bollworm larvae surviving in the unopened bolls. Stalk the cotton sticks vertically.
- Prevent the movement of the cotton stalk from the infested areas to the new areas.
- **Mating disruption based management of pink bollworm:**

Apply 125 g per application per acre of gossyplure 4% (7, 11 Hexadecadienyl acetate) paste based formulation, CREMIT-PBW/Natamate-PBW in the form of dollops (peanut size) starting from the appearance of squares (45-55 days after sowing) at 400 uniformL y distributed spots, followed by next two applications at 30 days intervals. The paste should be applied at the nodal junction of the 5th or 6th main stem leaf from the top **(Plate no. 1, page no. 198).** To realize the optimum efficacy, timely and area-wide application is indispensable. If it rains within 4-5 hours, the application has to be repeated.

or

Mating disruption based management of pink bollworm using PB knot (Gossyplure 4%; 7,11 Hexadecadienyl acetate) in a block of 25 ha area at square formation stage (40-50 days after sowing). The PB knot wire should be tied on the upper canopy of cotton plants at one meter distance on the borders of the block whereas inside the block, the wire should be placed five meters at equidistant from each other inside each blocks. A total of 9875 wires should be tied on cotton plants in a 25 ha area of each block. To realize the optimum efficacy, timely and area-wide application is indispensable. It is also rain fastness. It allows the application of insecticides for the management of other major insect-pests of cotton.

ii. Chemical Control

a. Insect Pests (Bt cotton)

Bt cotton provides effective protection against all cotton bollworms except pink bollworm. Regular monitoring should be done at weekly interval during reproductive phase. If at all American bollworms cross ETL level during late crop season, use insecticides as mentioned in Table 2. Bt cotton does not provide control of sucking pests.

Sucking Insect Pests: Among sucking pests, whitefly, jassid, mealybug, thrips and aphid are most serious on Bt cotton and they cause maximum damage during July-September.

Whitefly adults and nymphs suck sap from leaves and excrete honey dew on leaves which become sticky (**Plate No. 2, page 198**). Affected leaves and seed cotton turn black due to development of sooty mould.

Nymphs and adults of jassid suck sap from leaves and cause shedding in case of severe infestation (**Plate No. 3, page 198**).

Aphids appear sporadically. The **nymphs and adults of aphid** suck sap and excrete honey dew on leaves on which black fungus develops. Petioles, internodes, flowers, buds, mature bolls and even leaves fall down and growth of the plant is retarded.

- **Spray against whitefly should be done when population reaches 6 adults per leaf in the upper canopy of plants before 10 AM**
- **Initiate spray against jassid whenever some of the fully formed leaves in the upper canopy show curling and yellowing at the margins on 50 per cent of the plants**
- **Spray against thrips should be done when population of nymphs and adults reaches twelve per leaf in the upper canopy of plants.**
- **Spray against aphid should also be done on the appearance of honey dew on 50 per cent plants.**
- **Avoid using synthetic pyrethroids (cypermethrin, fenvalerate, deltamethrin), acephate and acetamiprid to minimize resurgence of whitefly**

Both **nymph and adults of thrips** first lacerate the leaf tissue and later feed on the oozing cell sap. Initially silver streaks appeared especially around the midrib and veins of the leaves. Later silvering got more severe and slight cupping of the leaves. Under severe infestation, leaves gave blasted appearance and extreme level of cupping observed. The decision regarding spray of insecticide should be taken based on Economic Threshold Level (ETL).

Spray against whitefly should be done when population reaches six adults per leaf in the upper canopy of plants before 10 AM or when honey dew appears on 50 per cent of the plants. Initiate spray against jassid whenever some of the fully formed leaves in the upper canopy show curling and yellowing at the margins on 50 per cent of the plants. Spray against thrips should be done when population of nymphs and adults reaches twelve per leaf in the upper canopy of plants. Spray against aphid should also be done on the appearance of honey dew on 50 per cent plants. Spray the crop as soon as the crawlers/ adults of mealybug appear on the cotton plant. Use following insecticides (Table 1) for control of sucking insect pests given below.

Table 1. Insecticides for the management of sucking insect pests

Brand (Insecticides)	Dose/acre
Whitefly	
Clasto 20WG (pyrefluquinazon*)	200 g
Sefina 50 DC (afidopyropen)	400 mL
Osheen 20 SG (dinotefuran)	60 g
Polo/Craze/ Ruby/ Ludo/Shoku 50 WP (diafenthiuron)	200 g
# Lano/Daita10 EC (pyriproxyfen)	500 mL
# Oberon/ Voltage 22.9 SC (spiromesifen)	200 mL
Ulala 50 WG (flonicamid)	80 g
Dantotsu 50 WG (clothianidin)	20 g
Fosmite/E-mite/Volthion/ Gold Mit 50 EC (ethion)	800 mL
Nimbecidine or Achook (Neem based biopesticide)	1.0 litre
*PAU Homemade neem extract	1200 mL
Jassid	
(a) Seed treatment: At the time of sowing, smear the seed with any of the following insecticides.	
Gaucho 70 WS (imidacloprid)	5 g/kg seed
Cruiser 30 FS (thiamethoxam)	7 g/kg seed
(b) Spray: Spray any of the following insecticides, if incidence is noticed in standing crop.	
Keefun 15 EC (tolfenpyrad)	300 mL
Osheen 20 SG (dinotefuran)	60 g
Neon 5 EC (fenpyroximate)	300 mL
Ulala 50 WG (flonicamid)	80 g
Actara/Extra super/Dotara/Thomson 25 WG (thiamethoxam)	40 g
Thrips	
Delegate 11.7 SC (spinetoram)	170 mL
Curacron/ Celcron 50 EC (profenophos)	500 mL
Polo 50 WP (diafenthiuron)	200 g
Mealybug	
Transform 21.8 SC (sulfoxaflor)	150 mL

These insecticides are more effective against nymphs of whitefly. Wait for 5-7 days to see the effective results.

* **Method of preparation:** Boil 4.0 kg terminal parts of the shoots of neem trees including leaves, green branches and fruits in 10 liters of water for 30 minutes. Then filter this material through muslin cloth and use the filterate for spraying at the recommended dose.

Note: In the beginning of crop season on appearance of whitefly, first spray of Nimbecidine or Achook @ 1.0 lire per acre should be given.

- Do not spray any insecticide for the management of thrips on cotton up to 30 day old crop. In case thrips attack observed, irrigate the field immediately.
- In case of attack of aphid use the same insecticides as recommended for jassid.
- Use fix type solid cone nozzle. Thorough coverage of plants with insecticides is essential to check the multiplication of whitefly and mealybug.
- Spray insecticides before 12 PM or in the evening. Community approach should be adopted at village level for the application of insecticides
- Use only recommended insecticides with recommended dose and time. Avoid tank mixing and use of readymade insecticidal mixtures
- Mealybug is initially restricted to a few plants in a row, thus spot treatment with recommended insecticides is advocated. Spray of mealybug infested plants/rows of cotton after last picking

b. Insect Pests (Non-Bt cotton)

Sucking Insect Pests: See under Bt-cotton

Bollworms: Bollworms are the most harmful insects which attack cotton in the Punjab state. Spotted bollworms damage growing points during May-June and cause heavy shedding of squares, buds, flowers and bolls during July to October. The American bollworm causes severe shedding of fruiting bodies during September-October especially on American cotton. The colour of its larvae greatly varies. They have one line on upper side and two wavy lines on lateral side of body. Their body also has sparse hairs. Pink bollworm does maximum damage from mid-July to mid-October (**Plate No. 4, page 198**). Due to severe attack of bollworms, the plants continue to grow without having adequate number of bolls.

Tobacco caterpillar: It is a polyphagous pest. The larvae cause serious damage to crop from August to October. The small larvae are black whereas grown up larvae are dark green with black triangular spots on body. Its' moths lay eggs in masses covered with brown hairs on the lower side of mature leaves. After hatching, first and second instar larvae feed gregariously and skeletonize the foliage. Later on grown up larvae disperse and feed singly. Besides leaves, they also damage the buds, flowers and green bolls. Control the tobacco caterpillar by spraying any of the insecticides given in Table 2.

The larvae of leaf-roller, semi-loopers, hairy-caterpillars and bud moth may also appear sporadically and damage the crop during July-October.

The **monitoring of bollworms** and **tobacco caterpillar with sex pheromone** should be done with the initiation of flowering stage of crop. Observations on moth catch should be recorded on every alternate day. This monitoring strategy will help in making decision for effective management of bollworms and tobacco caterpillar.

Pink bollworm: Use Sticka/Delta traps with at least 10 micro litre of gossyplure and place it at 15 cm above crop canopy. Replace the lure after 15 days and use 1 trap per ha.

Spotted/Spiny bollworms: Use Sleeve/Moth catch traps for spotted bollworms and replace the lure at 15 days interval. Place the trap at 15 cm above the crop canopy and use 2 traps per ha.

American bollworm: Use Sleeve/Moth catch traps with at least 2 mg of pheromone and place it at 15 cm above crop canopy. Replace the lure after 15 days and use 2 traps per ha.

Tobacco Caterpillar: Use Sleeve/Moth catch trap for tobacco caterpillar. Replace the lure after every 15 days. Place the trap 15 cm above crop canopy and use 2 traps per ha.

In order to control bollworms, conduct sprays on different varieties during their effective boll formation period based on ETL. Farmers should examine their fields twice a week in order to ensure that bollworms damage does not exceed 5 per cent among the freshly shed fruiting bodies (squares, buds and young bolls). For this purpose divide the field into four quarters and collect 25 freshly shed fruiting bodies at random in each quarter. The fruiting bodies damaged by bollworms will have feeding holes or their larvae. In case the damage exceeds 5 per cent, the crop should be sprayed immediately and thereafter spray as when need arises.

Note: For early sown crop (first fortnight of April), first spray against pink bollworm should be done when 10-20 per cent plants start producing squares particulary in the fields adjoining cotton sticks or cotton ginning mills to prevent intial build up of the population**.** The subsiquent sprays should be given on five per cent damage in flowers & green bolls.

Table 2. Insecticides for the control of bollworms in cotton

Brands (Insecticides)	**Dose/acre**
Pink and spotted bollworms	
A. Synthetic Pyrethroids	
Danitol/Meothrin 10 EC (fenpropathrin)	300 mL
Fastac/Alphagaurd/Merit Alpha 10 EC (alphamethrin)	100 mL
Bulldock 0.25 SC (β-cyfluthrin)	300 mL
Ripcord/Bilcyp/Bullet/Ustad/Cypergaurd 10 EC (cypermethrin)	200 mL
Cymbush/Cyperkill/Hillcyper/Colt/Basathrin/Agrocyper/Cypergaurd 25 EC (cypermethrin)	80 mL
Decis/Rukrain/Decicare 2.8 EC (deltamethrin)	160 mL
Sumicidin/Fenval/Agrofen/Fenlik/Triumph card/SB Fenvalerate/Milfen/ Markfenval 20 EC (fenvalerate)	100 mL
Pink, spotted and younger larvae of American bollworm	
A. Spinosyn	
Delegate 11.7 SC (spinetoram)	170 mL
B. Macrocyclic lactones or evermectins	
Proclaim 5 SG (emamectin benzoate)	100 g
C. Carbamates	
Larvin 75 WP (thiodicarb)	250 g

D. Organophosphatic	
Curacron/Carina/Profex/Celcron 50 EC (profenophos)	500 mL
Fosmite/E-mite/Volthion 50 EC (ethion)	800 mL
E. Miscellaneous group	
Fame 480 SC (flubendiamide*)	40 mL
Grown up larvae of American bollworm	
A. Naturalyte	
Tracer 48 SC (spinosad)	60 mL
B. Oxadiazine	
Avaunt 15 SC/ Avaunt 15 EC (indoxacarb)	200 mL
C. Miscellaneous group	
Sumipleo 10 EC (pyridalyl)	300 mL
Coragen 18.5 SC* (chlorantraniliprole)	60 mL
D. Organophosphates	
Coroban/Dursban/Durmet/Chlorgaurd/Radar/Lethal/Force/Markpyriphos 20 EC (chlorpyriphos)	2 litres
Orthene/Asataf/Starthene/Markphate 75 SP (acephate)	800 g
Tobacco catearpillar	
A. Insect Growth Regulator	
Rimon 10 EC* (novaluron)	150 mL
B. Miscellaneous group	
Coragen 18.5 SC* (chlorantraniliprole)	60 mL

Note:

- Do not repeat the insecticide of same group in subsequent sprays.
- Do not use synthetic pyrethroids on cotton for the control of bollworm complex before September.
- Repeat the spray immediately if it rains with in 24 hours after spray.
- If hairy caterpillars damage cotton crop during June-July use 500 mL quinalphos 25 EC in 100 litres of water per acre.
- **PRECAUTIONS: Cotton is highly sensitive to the 2, 4-D herbicide.** Some farmers spray the ester form of 2, 4-D for controlling weeds in maize grown near the cotton fields. Owing to the volatile nature of 2, 4-D ester, its vapours cause serious injury to the cotton crop. Hence avoid the application of this herbicide in maize, if cotton is grown in the adjoining fields.
  - After using 2, 4-D on any crop, fill all spraying equipment as well as tubs, buckets, etc. with 0.5 per cent washing soda solution (500 g of washing soda in 100 litres of water) in the evening. Next morning, flush all equipments thoroughly with fresh water.
  - To avoid the use of contaminated insecticides on cotton. It is advisable to test insecticide at least two weeks in advance on a few plants. If the insecticide is contaminated with 2, 4-D the tender leaves and shoots could become distorted and lanceolated within 10 days. Reject such an insecticide.

Spray Technology

The insecticides recommended for control of sucking pests, bollworms and tobacco caterpillar should be sprayed using 125-150 litres spray material per acre with the manually operated knapsack sprayer or 75 litres with the shoulder-mounted power sprayer and tractor mounted sprayer or 12-15 litres spray material per acre by using backpack type air-assisted electrostatic sprayer or 300-400 litres spray material per acre by using Auto rotate gun type sprayer or 250-400 litres spray material per acre by using PAU multipurpose high clearance sprayer. Quantity of spray material may vary with different types of sprayers and nozzles. However, actual amount of insecticide recommended should not be reduced. Making pathways by pressing the branches on both sides helps in efficient spraying. Make such pathways at 2 meters distance for the manually operated knapsack sprayer and at 4 meters for the shoulder-mounted power sprayer.

Tractor mounted sprayer should have hallow cone nozzles fixed on the boom. Each nozzle should discharge 500-600 mL spray solution per minute. The tractor should be operated at 4.0 and 2.5 km per hour speed for spraying against sucking pests and bollworms, respectively. Use the same tyre tracks and run the tractor in the same direction for all sprays. Keep the spray boom about 50 cm above the crop canopy.

Insecticide Resistance Management (IRM) Strategy

- IRM is component of Integrated Pest Management (IPM) programme. The adoption of this strategy helps in reducing/delaying the insecticide resistance to insects. It also increases functional life of the insecticides.

i. Sucking pests management (From sowing up to first week of July)

- Sow recommended varieties which are tolerant to sucking pests and cotton leaf curl virus to avoid early sprays
- Destroy alternate hosts of cotton whitefly, leaf curl virus and mealybug
- Timely sowing, judicious use of fertilizers, irrigation, proper spacing and clean cultivation will prevent the early build up of pests and help conserve natural enemies
- Treat seed with Gaucho/Cruiser to control the cotton jassid in susceptible cultivars
- Do not use any insecticide during this period to conserve natural enemies

ii. Sucking pests and bollworms management (From second week of July to first week of August)

- Avoid the use of synthetic pyrethroids for the control of spotted bollworms
- Avoid the use of neonicotinoid compounds against jassid as these are toxic to natural enemies
- Do not use organophosphates/carbamates against bollworms

iii. Bollworms and tobacco caterpillar management (From second week of August to end August)

- Use profenophos/quinalphos/flubendiamide in alternation with synthetic pyrethroids for the control of bollworms

- Use spinosad only in case of severe infestation of American bollworm.

iv. Bollworms and tobacco caterpillar management (September to October)

- Use profenophos/quinalphos/thiodicarb/flubendiamide for younger larvae of American bollworm. Prefer chlorpyriphos for grown up larvae. Chlorpyriphos, thiodicarb and quinalphos will also provide effective control of tobacco caterpillar
- Use of indoxacarb/spinosad in case the American bollworm is serious
- Use ethion for the management of whitefly. It will also provide effective control of pink and spotted bollworms

B. Diseases

Leaf curl: Disease is caused by whitefly transmitted virus. The diseased plants become stunted and have twisted internodes. Leaves remain small, show cupping and curling. Veins on the lower-side of the leaves become thickened with netted appearance. Small leaflets (enations) also develop on the under side of the leaves on the main as well as lateral veins (**Plate No. 5, page 198**). Number of fruiting bodies are reduced in the diseased plants. The disease can be reduced by adopting the following integrated measures:

- Avoid growing American cotton in and around citrus orchards and adjoining *bhindi* crop.
- Uproot and destroy the diseased plants from time to time.
- Protect the crop against whitefly vector by using recommended insecticides.
- Follow clean cultivation and destroy *Kanghi buti* (*Abutilon* sp.) and *Peeli buti* (*Sida* sp.) which act as collateral hosts.

Parawilt: Parawilt is a physiological disorder and no pathogen is involved. It generally occurs after droughts when the crop is heavily irrigated or there is heavy rain. Plants show sudden drooping of leaves which ultimately get wilted but the root system remains intact (**Plate No. 6, page 198**). The affected plants can be saved by spraying cobalt chloride @ 10 mg per litre of water (10 ppm) immediately after the appearance of symptoms. There would be no recovery if permanent wilting has already set in.

Root rot: This disease is caused by *Rhizoctonia solani* and *R. bataticola*. The main symptom are drying and shedding of leaves leading to complete wilting and death of the plant. The disease spreads in field in round patches. The affected plants can be pulled out very easily. The bark of the roots is broken into shreds.

Bacterial blight: It is caused by *Xanthomonas axonopodis* pv. *malvacearum* which survives in seed and plant debris. Lesions on the leaves appear as minute, water-soaked, angular spots, which subsequently turn brown and then are transformed into black angular dead lesions on both sides of the leaf. The bacterium also infects the young developing bolls and causes small, round, water soaked spots depressed in the centre. Use disease free seed.

Leaf spots: Foliar leaf spots are caused by different fungi. Leaf spots caused by *Myrothecium roridum* appear on leaves, bracts as well as on bolls. The disease is

characterized by circular to semicircular brown coloured spots with broad violet margins. At later stage, shield shaped, small size fruiting bodies appear in the central necrotic portion of the spot. The pathogen is seed borne and also survives on the dead leaves. High humidity and intermittant rains are congenial for the development of the disease.

The fungus *Alternaria gossypina* also causes blightening of the leaves. In the early-stages, the spots have a pale green area with irregular margins. As the spots enlarge, irregular concentric zones are formed. Sometimes severe shedding of leaves occur due to this disease. The plants with low vigour because of drought or deficiency of potash favour the development of this disease. The disease perpetuates through diseased debris.

Another type of leaf spots are caused by *Cercospora* sp. which generally appears towards the end of the season. It produces small, circular to irregular spots having whitish centre with dark brown margin. In advance stages, necrotic central portion may fall out giving shot hole appearance. Low temperature (<25^{o}C) and high relative humidity favours development of disease. Diseased debris is the main source of primary inoculum of the disease. Use disease free seed.

To control these fungal leaf spots, spray the crop with 200 mL Amistar Top 325 SC (azoxystrobin + difenconazole) in 200 litre of water per acre immediately on the appearance of symptoms. If needed, repeat the spray at 15-20 days interval.

Tirak: It is a physiological disorder. It is characterized by the yellowing and reddening of leaves, followed by the bad opening of the bolls. The disease appears now and then. The attack is more pronounced in the dry belt adjoining Rajasthan and Haryana. It is particularly serious in pockets where cotton suffers from persistent drought, inadequate water supply, nutrient deficiency on light sandy soils, too early sowing or lack of plant protection measures. These factors may operate singly or in different combinations. Spells of high temperature prevailing during the flowering and fruiting further aggravate the intensity of this malady. Judicious fertilization and timely watering particularly during flowering and fruiting stages, and the adoption of recommended plant protection schedule help to mitigate the intensity of this disease.

Defoliation in cotton: Chemical defoliation with single spray of Ethrel 39% (Ethephon 39%) @ 5.0 mL per litre of water should be applied in last week of October. It leads to 85-90% defoliation after ten days of spray. Defoliation allows better sunlight penetration thereby resulting in early and uniform boll opening with increased productivity.

Picking: Cotton should be picked clean and dry to get a good price in the market. Picking should be done after every 15-20 days to avoid loss because of the *Kapas* falling to the ground. Do not keep the picked cotton in wet water channels in the field, as this practice impairs the quality of cotton. Store kapas in a dry godown. Keep produce of different varieties separately.

Removal of cotton sticks: Soon after the last picking, remove the cotton sticks alongwith the roots from the field and bury the remaining plant debris with furrow turning plough as sanitary measure against pests and diseases. Use or burn cotton sticks by the end of February at the latest.

Use two-row tractor operated Cotton Stalk Uprooter for uprooting of cotton stalks. The Cotton Stalk Uprooter should be operated at a speed of 7 to 9 km per hr and at a depth of 12 to 15 cm with 45 hp tractor for efficient field operation. This equipment will provide 10 to 15% more cotton sticks by weight than conventional manual stalk chopping method with a field capacity of 1.25 to 1.50 acre per hr.

Marketing Hints

- Cotton should be picked dry, free from trash, with no dew on it.
- The first and the last pickings are usually of low quality and should not be mixed with rest of the produce. High-grade kapas mixed with low grade kapas sells at a relatively low price.
- Store cotton in damp proof and rat-free room.
- Store different varieties separately.

DESI COTTON

In Punjab, *desi* cotton was grown on 1.6 thousand hectares during 2023-24. The total production was 4.1 thousand bales with an average lint yield of 4.31 quintals per hectare (1.74 quintal per acre).

Note: Climatic requirements, soil type, rotations, agronomic practices, seed treatment, time of sowing, weed control, fertilizer application, irrigation etc. are same as recommended for American cotton.

Improved Varieties

LD 1019 (2018): This is a shattering tolerant variety requiring 2 or 3 pickings as compared to atleast 5 pickings needed by other *desi* cotton varieties. Average seed cotton yield of LD 1019 is 8.6 quintals per acre. It possesses ginning out-turn of 35.7% and its fibre length is 22.6 mm. It has green, broad leaves and cream flowers. LD 1019 is tolerant to jassid, whitefly, Fusarium wilt and bacterial blight.

LD 949 (2016): Its' plants are reddish-brown with narrow- lobed deep cut leaves and pink flowers. It possesses lint percentage of 40.1. Its' fibres are short, coarse and suitable as absorbent cotton. This variety is moderately resistant to Fusarium wilt and bacterial blight. It is tolerant to whitefly and jassid. Its' average seed cotton yield is 9.9 quintals per acre.

FDK 124 (2011): It has green plant body and narrow lobed leaves. It is synchronous in maturity and takes about 160 days to mature. It is short staple, coarse fibre variety with 2.5% span length of 21.0 mm and ginning outturn of 36.4%. It produces an average seed cotton yield of 9.28 quintals per acre. It is resistant to jassid and whitefly.

Seed Rate: Use 3.0 kg seed per acre.

Acid delinting of seed: As per American cotton.

Sowing and Spacing: Sow in lines 67.5 cm apart with a cotton sowing drill. The plants of *desi* cotton varieties within rows be kept 45 cm apart at thinning.

A. Plant-Protection

Insect Pests

Sucking Insect Pests: See under American Cotton

Bollworm: In case of *desi* cotton, the first spray against bollworms should be done when 25 per cent plants start producing squares. Subsequent spray should be need based. For its effective management use the insecticides given in Table 2 for American cotton.

Note: *Desi* cotton grown on medium to high fertility soils generally attain unmanageable height for effective spraying against bollworms. The top portion of plants with excessive height usually remain unsprayed. Fruiting bodies of these uncovered plant portions contribute very little towards yield but greatly help in bollworms build up. Plants attaining height more than **1.5 m should be detopped** as and when required by using pruning scatteur/sickle/green mulberry stick.

Tobacco caterpillar: See under American Cotton

B. Diseases

Wilt: It is a fungal disease caused by *Fusarium oxysporum* f.sp. *vasinfectum*. The pathogen of disease is both soil and seed-borne. In the diseased seedlings and plants, the leaves loose their turgidity, first turn yellow, then brown, start wilting and finally drop off. Discoloration of the leaves start from the margins and spreads towards the mid-ribs. The older leaves are affected first, followed by the younger ones towards the top. Wilting may be complete or partial. In the later case only one side of the plant is affected while the other remains apparently healthy. In complete wilting, the plant remains stunted, wilt rapidly and dies. The most prominent diagnostic symptom of the disease is browning and blackening of the vascular tissues. Five to six year rotation with non-host crops may help in controlling the disease. In the infested field, sow wilt tolerant *desi* cotton varieties namely LD 1019 and LD 949. In the highly infested fields grow American cotton because it remains free from this disease.

Note: Desi cotton is resistant to cotton leaf curl disease. For the management of other diseases, see under American cotton.

Picking

Cotton should be picked clean and dry to get a good price in the market. *Desi* cotton is ready for picking in the third week of September. Picking should be done after about 15 days to avoid loss because of the Kapas falling to the ground. Do not keep the picked cotton in wet water channels in the field, as this practice impairs the quality of cotton. Store kapas in a dry godown. Keep produce of different varieties separately.

Note: Removal of cotton sticks and marketing hints for *desi* cotton are same as those of American cotton.

3. PULSES

MOONG

Moong occupied 3.3 thousand hectares and the total production was 3.3 thousand tonnes during 2023-24 in Punjab. Its' average yield was 9.96 quintals per hectare (4.03 quintals per acre).

Climatic Requirements

It requires a hot climate.

Soil Type

A well-drained loamy to sandy loam soil is suitable. Saline-alkaline or waterlogged soils are unsuitable.

Rotations

Moong-Raya/Wheat, Summer *Moong-Kharif Moong-Raya*/Wheat, Moong-Potato/ Peas-Spring Groundnut

Improved Varieties

ML 1808 (2021): Its' plants are erect and medium statured (71 cm). Pod formation is profuse and each pod contains 11-12 seeds. It is resistant to mungbean yellow mosaic virus, cercospora leaf spot and bacterial leaf spot diseases. It matures in about 71 days. Grains are shining green and medium bold with good cooking quality. The average grain yield is 4.8 quintals per acre.

ML 2056 (2016): Its' plants are erect and medium statured (78 cm). Pod formation is profuse and each pod contains 11-12 seeds. It is tolerant to mungbean yellow mosaic virus, cercospora leaf spot and bacterial leaf spot diseases. It matures in about 71 days. Grains are shining green and medium bold with good cooking quality. The average grain yield is about 4.6 quintals per acre.

ML 818 (2003): Its' plants are erect and medium statured (75 cm). Each pod contains 10-11 seeds. It is tolerant to mungbean yellow mosaic virus, cercospora leaf spot and bacterial leaf spot diseases. It matures in about 72 days. Its' average grain yield is about 4.2 quintals per acre. Its' grains are medium bold, shining green with good cooking quality.

- **ML 1808, ML 2056 and ML 818 varieties are tolerant to yellow mosaic virus, cercospora leaf spot and bacterial leaf spot diseases.**
- **Before sowing, inoculate the seed with recommended biofertilizer.**
- **Sowing should be done in the second fortnight of July.**

Agronomic Practices

Land Preparation: Give 2-3 ploughings followed by planking to crush the clods and eradicate the weeds. *Moong* can also be sown without any preparatory tillage with zero till drill.

Time of Sowing: Sowing should be done in the second fortnight of July.

Seed Rate: Use 8 kg seed per acre.

Seed Inoculation: Inoculate the *moong* seed with recommended *Rhizobium* culture at the time of sowing. Wet the seed recommended for one acre with minimum amount of water. Mix thoroughly one packet of *Rhizobium* with it on a clean *pucca* floor and let it dry in shade. Sow the seed immediately. The inoculation of seed with culture increases the grain yield by 12-16 per cent. The *Rhizobium* and fungicide can be applied simultaneously. The bio-fertilizer is available with the PAU Seed Shop at Gate No. 1, *Krishi Vigyan Kendras* and Farm Advisory Service Centres in different districts.

Method of Sowing: Sowing should be done at a row spacing of 30 cm. The plant to plant distance should be about 10 cm and sow 4 to 6 cm deep with seed drill/*pora/kera*. For getting higher yield, adopt bi-directional method of sowing *i.e.* sow the crop in both directions at 30 cm row spacing using half the seed rate in each direction. *Moong* can be sown without seed bed preparation using zero till drill.

Raised Bed Sowing: *Moong* can be successfully grown on raised beds. Sowing of *moong* on medium to heavy textured soils should be done on beds spaced 67.5 cm apart (37.5 cm bed top and 30 cm furrow) by using wheat bed planter. Sow two rows per bed with row spacing of 20 cm using the same quantity of seed, fertilizers and following other cultivation practices as in flat sowing of *moong*. Raised bed sowing not only saves irrigation water but also saves the crop from adverse effect of heavy rainfall.

Weed Control: Give the first hoeing 4 weeks after sowing of the crop and second hoeing, if needed, about 2 weeks thereafter.

Irrigation: Irrigation is required for the *kharif* season crop if the rain fails.

Fertilizer Application: Drill 5 kg of N (11 kg of Urea) and 16 kg of P_2O_5 (100 kg of single superphosphate) per acre at sowing.

Harvesting and Threshing: The crop should be harvested with sickle when 80% of the pods mature. Do not uproot the plants. Spike tooth type power thresher for wheat can be used to thresh *moong* after proper modifications (See Annexure-V).

Plant-Protection

A. Insect Pests

Whitefly, Jassid and Aphid: Nymphs and adults of whitefly and aphid suck sap from the leaves, thus lowering the vitality of the plants. Whitefly excretes honeydew on which sooty mould develops, resulting in blackening of leaves and decrease in the normal photosynthesis. In case of severe attack, there is total blackening of the crop, resulting in drying of leaves and ultimately total crop failure. Whitefly is a vector of mungbean yellow mosaic virus. Spray the crop upon pest appearance with 1.0 litre of homemade neem extract using 80-100 litres of water per acre with manually operated knapsack sprayer. To prepare neem extract, boil 5.0 kg mixture of neem leaves and fruits in 10 litres of water for 30 minutes. Then, filter this material through muslin cloth and use the filterate for spraying at

the recommended dose. Repeat the spray after one week, if necessary. Jassid nymphs and adults suck sap from the leaves resulting in yellowing and drying of leaves.

Pod sucking bug (*Clavigralla gibbosa*): The adults are brown-grey in colour. Both nymphs and adults use their mouthparts to pierce the pod wall and suck the sap from the developing seeds. The attack is noticeable from the white patches that appear on the surface of pods and leaves. As a result of continuous sap feeding, premature drying of pods is noticed. When such pods are opened, shriveled and malformed seeds are observed. Further, such seeds easily succumb to secondary infection by fungal pathogens and pose problems in post harvesting process. Seeds spoiled by the pod bug neither germinate nor are acceptable as human food.

To control this pest, spray the crop upon pest appearance at podding stage with 1250 mL of homemade neem extract using 80-100 litres of water per acre with manually operated knapsack sprayer. Repeat the spray after one week, if necessary.

Hairy caterpillar: The body of the caterpillar is covered with hair. The caterpillar eats the green matter of leaves, leaving behind only the midribs. The crop may be totally denuded due to severe attack. When young, they feed gregariously but on few plants in scattered spots. Since, the young larvae are gregarious, they can be destroyed by pulling out the infested plants along with larvae and burying them underground. The grown up caterpillars can be destroyed by crushing them under feet or by picking and putting them into kerosenized water.

Semilooper: The larvae are green in colour measuring 2-4 cm in length. When touched, they form a loop. The larvae feed extensively on the leaves of *mash* and *moong.* In case of severe damage, the plants are totally defoliated within a few days.

Tobacco caterpillar (*Spodoptera litura*): It is a polyphagous pest. The small larvae are black whereas grown up larvae are dark green with black triangular spots on body. Its' moth lays eggs in masses covered with brown hairs on the lower side of leaves. After hatching, first and second instar larvae feed gregariously and skeletonize the foliage. Later on, the grown up larvae disperse and feed singly. Besides leaves, they also damage buds, flowers and pods. For management, egg masses and young larvae of tobacco caterpillar feeding gregariously should be collected along with leaves and destroyed.

Blister beetle: Blistle beetle is diurnal and general feeder. Adult beetles are robust with bright black and red stripes on the forewings. When disturbed, the beetles emit a fluid containing cantharidin that causes blisters on human skin. The adult beetles attack *arhar, moong, mash* and other pulse crops. The major damage is caused at the flowering stage. They feed on tender buds and flowers of the plant, thus preventing pod formation.

Pod borer (*Helicoverpa armigera*): The larvae damage the crop by feeding on leaves, flower buds, flowers, pods and seeds in the pods, thus causing heavy loss in yield. The larvae may be pale green, yellow, brown or black in colour measuring about 3-5 cm in length when fully grown. Larval presence can be observed from damage to plant and from dark green faeces below the plants on the soil. The larvae fall on the ground when plants are shaken vigorously.

Mite: The mite causes webbing on the underside of the leaves which turn pale. Such infested leaves turn light-brown to dark reddish-brown.

Dhora (*Callosobruchus* spp.): For its control, see Annexure VI.

B. Diseases

Yellow mosaic virus: It is a viral disease transmitted by whitefly and is more severe on *kharif moong*. The leaves of the diseased plants develop irregular yellow and green patches. Infected plants bear no or only a few pale pods. Rogue out the diseased plants early in the season. Grow yellow mosaic virus tolerant varieties of *moong*, ML 1808, ML 2056 and ML 818.

Cercospora leaf spot: It is caused by *Cercospora cruenta* and *C. canescens*. The disease spots are circular, brown and necrotic which coalesce to cover bigger area and cause defoliation. Intermittent rains are favourable for disease development. Grow disease resistant varieties of *moong,* ML 1808, ML 2056 and ML 818.

Root rot: Root rot caused by *Macrophomina phaseolina* produces dark lesions on leaves, branches, stems and roots. The tissue of the affected portion become weak and shred easily. Pycnidia can be seen on the affected portion.

Anthracnose: It is caused by *Colletotrichum lindemuthianum*. Dark brown spots (horse shoe shaped) appear on the leaves and other parts of the plant. Under severe conditions lesions rapidly coalesce to girdle stems, branches, peduncles and petioles.

Bacterial leaf spot: Bacterial leaf spots caused by *Xanthomonas campestris pv. phaseoli* are circular to irregular and brown. Use disease free seed. *Moong* varieties ML 1808, ML 2056 and ML 818 are fairly resistant/ tolerant to this disease.

Web blight: It is caused by *Rhizoctonia solani*. It starts from leaf margins or petioles or young branches. Eventually, the tops of plants become blighted and patches of such plants are conspicuously seen in the field. Whitish web-like growth develops on leaves in humid weather. Dark brown sclerotia develop on infected tissue. Infection on crop comes from the weeds in the field. Keeping the field weed-free helps to check the disease.

MASH

Mash was grown on 1.3 thousand hectares and the total production was 0.6 thousand tonnes in the Punjab state during the year 2023-24. The average grain yield was 4.40 quintals per hectare (1.78 quintals per acre).

Climate and Soil Requirements

Mash thrives in a hot and humid season (July to October). However, short duration varieties (70 to 75 days) can be grown in the central and sub-montaneous tracts in summer (March to June). *Mash* can do well on all soils ranging from sandy loam to heavy clay except the saline-alkaline or waterlogged soils. Its' cultivation improves soil fertility. The *mash*-wheat rotation is suitable for irrigated areas.

Improved Varieties

Mash 883 (2022): This variety is recommended for the whole state. Plants are dwarf, erect and compact. It matures in about 77 days. Podding is profuse and each pod contains 6-7 seeds which are medium bold, black and possess good culinary properties. Average grain yield is about 4.2 quintals per acre. It is resistant to yellow mosaic disease and tolerant to other foliar diseases.

Mash 114 (2008): This variety is recommended for the whole state. Plants are dwarf, erect and compact. It matures in about 83 days. Podding is profuse and each pod contains about 6-7 seeds, which are bold, black and possess very good culinary properties. Average grain yield is about 3.6 quintals per acre. It is fairly resistant to yellow mosaic virus, bacterial leaf spot and cercospora leaf spot diseases.

Mash 338 (1993): This variety is recommended for the whole state. Plants are dwarf, erect and compact. It matures in about 90 days. Podding is profuse and each pod contains about 6 seeds, which are bold, black and possess very good culinary properties. Average grain yield is about 3.5 quintals per acre. It is tolerant to yellow mosaic virus, bacterial leaf spot and cercospora leaf spot diseases.

Agronomic Practices

Land Preparation: Two or three ploughings followed by planking are enough. At sowing, field should be free from weeds.

Time of Sowing: Sow the irrigated crop from 15 to 25 July in the Sub-montaneous region and from last week of June to first week of July in other areas of the state. The rainfed crop may be sown with the onset of the monsoon.

Seed Rate: Use 6-8 kg seed per acre.

Seed Inoculation: Inoculate the seed with recommended *Rhizobium* culture at the time of sowing. Wet the seed recommended for one acre with minimum amount of water. Mix the seed thoroughly with one packet of *Rhizobium* on a clean pucca floor and let it dry in shade. Sow the seed immediately. The inoculation of seed with culture increases the grain yield. The bio-fertilizer is available with the PAU Seed Shop at Gate No. 1, *Krishi Vigyan Kendras* and Farm Advisory Service Centres in different districts.

Method of Sowing: It should be sown in lines, 30 cm apart by using the *kera/pora* method or with a seed drill, 4 to 6 cm deep.

Intercropping: To make cultivation of *mash* more economical, maize may be inter-cropped at every fifth row. The rows 30 cm apart should be oriented preferably along North-South direction. *Mash* and maize intercrop culture should be fertilized as per recommendation for *mash* at the sowing time. Subsequent top-dressings of N to maize rows be carried out at the recommended level and proportionate to area under maize.

Weed Control: Give one hoeing at one month after sowing.

Fertilizer Application: Drill at sowing, 5 kg of N (11 kg of Urea), along with 10 kg of P_2O_5 (60 kg of single superphosphate) per acre.

Irrigation: The crop normally needs no irrigation. If the rains fail for a long period, then apply one irrigation.

Harvesting: Harvest the crop when the leaves are shed and most of the pods turn greyish black. The matured crop should not be uprooted.

Plant Protection:

A. Insect Pests

Hairy caterpillar: The body of the caterpillar is covered with hair. The caterpillar eats the green matter of leaves, leaving behind only the midribs. The crop may be totally denuded due to severe attack. When young, they feed gregariously but on few plants in scattered spots. Adopt the following control measures:

- Young larvae are gregarious. They can be destroyed by pulling out the infested plants along with larvae and burying them underground.
- The grown-up caterpillars can be destroyed by crushing them under feet or by picking and putting them into kerosenized water. If the population is high, spray 500 mL of Ekalux 25 EC (quinalphos) in 80-100 litres of water per acre with a manually operated knapsack sprayer.

Whitefly, Jassid, Aphid, Semilooper, Tobacco caterpillar, Blister beetle, Pod borer and Mite: Regarding pest details, see under *moong.*

Dhora (*Callosobruchus* spp.): For its control, see Annexure VI.

B. Diseases

Yellow mosaic virus: It is a viral disease transmitted by whitefly and is more severe on *kharif moong*. The leaves of the diseased plants develop irregular yellow and green patches. Infected plants bear no or only a few pale pods. Rogue out the diseased plants early in the season. Grow yellow mosaic virus tolerant varieties, *Mash* 883, *Mash* 114 and *Mash* 338.

Cercospora leaf spot: It is caused by *Cercospora cruenta* and *C. canescens*. The disease spots are circular, brown and necrotic which coalesce to cover bigger area and cause defoliation. Intermittent rains are favourable for disease development. Grow disease resistant varieties, *Mash* 883, *Mash* 114 and *Mash* 338.

Bacterial leaf spot: Bacterial leaf spots caused by *Xanthomonas campestris pv. phaseoli* are circular to irregular and brown. Use disease free seed. *Mash* varieities, *Mash* 883, *Mash* 114 and *Mash* 338 are fairly resistant/ tolerant to this disease.

Root rot, Anthracnose and Web blight: Regarding disease details, see under *moong*.

ARHAR

Arhar was grown on 1.2 thousand hectares and the total production was 1.4 thousand tonnes during 2023-24. It gave an average yield of 11.27 quintals per hectare (4.56 quintals per acre).

Climatic Requirements

It requires a hot climate.

Soil Type

Arhar grows well on a wide range of soils. It does best on fertile and well-drained loamy soils. The saline-alkaline or waterlogged soils are unfit for its cultivation.

Rotations

Arhar-Wheat/Barley

Improved Varieties

AL 882 (2018): It is short statured and early maturing variety with semi-determinate growth habit. It matures in about 132 days and vacates the field well in time to sow the succeeding wheat crop. Its' plants are compact and about 1.6 to 1.8 metre tall. Pods are borne at the top of the plant in multiple and sparse clusters. Podding is profuse and each pod contains 3-5 yellowish brown and medium sized seeds. The average grain yield is about 5.4 quintals per acre.

PAU 881 (2007): It is an early maturing variety with indeterminate growth habit. It matures in about 132 days and vacates the field well in time to sow the succeeding wheat crop. Its' plants are about 2 metre tall. Pod formation is profuse and each pod contains about 3-5 yellow brown and medium sized seeds. Its' average grain yield is about 5.1 quintals per acre.

Agronomic Practices

Land Preparation: Prepare the land well by cultivating 2-3 times followed by planking to free it from clods and weeds. *Arhar* can also be sown with zero till drill without any preparatory tillage.

Time of Sowing: Sow the crop in the second fortnight of May for obtaining high grain yield as well as early maturity of the crop for timely sowing of the succeeding crop.

Seed Rate: Use 6 kg of seed per acre.

Seed Inoculation: Inoculate the seed with the recommended *Rhizobium* culture before sowing. For this purpose wet the seed recommended for one acre with minimum amount of water. Mix thoroughly one packet of *Rhizobium* culture with seed on a clean *pucca* floor and let it dry in shade. Sow the seed immediately. The inoculation of the seed with *Rhizobium* increases the grain yield by 5-7%. The bio-fertilizer is available with the PAU Seed Shop at Gate No. 1, *Krishi Vigyan Kendras* and Farm Advisory Service Centres in different districts.

Method of Sowing: Sow the crop at a row spacing of 50 cm and the plant spacing of 25 cm. Timely sowing and the maintenance of optimum plant population are essential

for obtaining a good yield. *Arhar* can also be sown with zero till drill without any tillage operation.

Sowing of *arhar* at high plant density: If sowing of *arhar* delays then sow *arhar* variety AL 882 from 15 June to 25 June at 30 cm row spacing using 12 kg seed per acre for obtaining high seed yield.

Raised Bed Sowing: *Arhar* can be successfully grown on raised beds. Sowing of *arhar* in medium to heavy textured soils should be done on beds spaced 67.5 cm apart (37.5 cm bed top and 30 cm furrow) by using wheat bed planter. Sow one row per bed using the same quantity of seed, fertilizers and following other cultivation practices as in flat sowing of *arhar* crop. Raised bed sowing not only saves irrigation water but also saves the crop from adverse effect of heavy rainfall.

- **Inoculate the seed with recommended biofertilizer, before sowing.**
- **Sow variety AL 882 from 15 June to 25 June at 30 cm row spacing using 12 kg seed per acre.**
- **Spray 600 mL per acre Stomp 30 EC as pre-emergence followed by hand hoeing 6-7 weeks after sowing.**
- **Initiate spray against spotted pod borer if the average number of webs is two per plant from 10 randomly selected plants per acre at flower initiation stage.**
- **Spray insecticides on the crop during evening as the population of honey bees and pollinators is minimum at that time.**

Intercropping: *Moong* can be successfully grown between the rows of *arhar*. It will yield about 1.2 quintals of grain per acre without reducing the yield of *arhar*.

Fertilizer Application

The following doses are recommended. Drill all fertilizers at sowing.

*Nutrient (kg per acre)			Fertilizer (kg per acre)			
N	P_2O_5	K_2O	Urea	DAP	or Single Superphosphate	Muriate of Potash
6	16	12	13	35	100	20

* These nutrients can also be supplied from other fertilizers available in the market (Annexure VII).

If arhar follows wheat, which received recommended dose of Phosphorus, omit its application to arhar. Where DAP is used, omit nitrogen application. Apply potash fertilizer only when the soil test shows deficiency of potash. Apply 5 kg borax per acre as basal dose for obtaining higher arhar yield in boron deficient soils.

Weed Control: Two hoeings may be given, one about 3 weeks and the other about 6 weeks after sowing. Alternatively, spray 1.0 litre per acre Stomp 30 EC (pendimethalin) within 2 days of sowing of the crop using 200 litres of water or use 600 mL per acre Stomp 30 EC followed by one hoeing at 6-7 week after sowing.

Irrigation: Apply the first irrigation 3 to 4 weeks after sowing. Further irrigation may be given only if the rains fail. After mid-September, do not apply irrigation otherwise the maturity of the crop will be delayed.

Harvesting: Crop ripens by the end of October.

Plant-Protection

A. Insect Pests

Blister beetle: Regarding pest details, see under *moong*.

Pod borer complex: Pod borers, especially spotted pod borer *(Maruca vitrata)* and gram pod borer *(Helicoverpa armigera)* are the most important insect pests of *arhar*. *Maruca vitrata* appears at the initiation of flowering. Full grown larva has a pale body lined by rows of conspicuous black or brown spots on its dorsal surface. Its' larvae damage the flower buds, flowers and green pods. The larva feeds from inside a webbed mass of leaves, flowers, flower buds and pods webbed together with silken threads. Monitor the crop at flower initiation stage to record the number of webs of spotted pod borer on per plant basis. Record the observations from a minimum of 10 randomly selected plants per acre. If the average number of webs is two per plant, spray the crop with 60 mL Coragen 18.5 SC (chlorantraniliprole*) or 40 mL Fame 480 SC (flubendiamide*) or 200 mL Kingdoxa 14.5 SC (indoxacarb) or 60 mL Tracer 45 SC (spinosad) using 100-125 litres of water per acre with manually operated knapsack sprayer. Repeat the spray at pod initiation/podding stage of the crop. The insecticides used for the management of spotted pod borer also control other pod borers infesting *arhar*.

Precautions: Because honey bees and other pollinators may be killed by the use of above insecticides it is, therefore, advised to spray the crop during evening as the population of these pollinators is minimum at that time.

Pod sucking bug (*Clavigralla gibbosa*): Regarding pest details, see under *moong*. To control this pest, spray the crop at seed filling stage upon pest appearance with 1250 mL of homemade neem extract using 100-125 litres of water per acre with manually operated knapsack sprayer. To prepare neem extract, see method under *moong*.

B. Diseases

Phytophthora stem blight: It is caused by *Phytophthora drechslera f.sp. cajani*. The disease affects young seedlings as soon as they emerge and get killed. On stem, brown to black necrotic lesions are produced which have definite margin and are slightly depressed. In some cases, stem swells into a cankerous structure at the edge of the lesion and may break at the lesions site. On leaflets, lesions are circular to irregular in shape and whole foliage can become blighted. Avoid sowing *arhar* in soil with poor drainage and follow rotation in badly infested fields.

Sterility mosaic: It is a viral disease transmitted by an eriophyid mite *(Aceria cajani)*. Typical symptoms are mild mosaic and either no or little flowering and pale green colour of the leaves. The leaves are crowded and auxiliary buds give rise to bushy growth. Do not allow any *arhar* plant standing around sugarcane, cotton and other fields during winter season in order to check the primary source of infection.

Cercospora leaf spot: Leaf spots are caused by *Cercospora cajani*. Greyish brown to dark spots are produced on the under surface of the leaf. Often several spots coalesce to form irregular blotches. Sometimes lesions occur on petioles and stems. Infection causes premature defoliation of leaves. Use disease free seed to reduce the infection.

Bacterial leaf spot: This disease is caused by *Xanthomonas campestris pv. cajani*. Angular dark-brown spots appear on the leaf surface and usually concentrated on one side of the mid-rib. Spots may develop on veins, petioles, main stems and branches. Use disease free seed to reduce infection.

SOYBEAN

Soybean is a high value crop with multiple food, feed and industrial uses. Edible oil, soymilk and its products, bakery products, antibiotics and fresh green beans are some of its major uses. Soybean has a potential to play an important role in crop diversification in the state.

Climatic Requirements

It requires a hot climate.

Soil Type

Soybean can be grown on a wide range of soils but thrives well on fertile, non-saline/ alkaline and well-drained loamy soils.

Rotations

Soybean-Wheat/Barley, Soybean-Peas-Summer *moong*, Soybean-*Gobhi sarson* (Transplanted)

Improved Varieties

SL 958 (2014): It has shining, light yellow coloured grains with black hilum. Its' grains contain 41.7% protein and 20.2% oil. It is highly resistant to yellow mosaic virus and soybean mosaic virus. It takes about 142 days to mature. Its' average seed yield is about 7.3 quintals per acre.

SL 744 (2010): It has shining, light yellow coloured grains with grey hilum. Its' grains contain 42.3% protein and 21.0% oil. It is resistant to yellow mosaic virus and soybean mosaic. It takes about 139 days to mature. Its' average seed yield is about 7.3 quintals per acre.

SL 525 (2003): It has uniformly bold, shining, cream coloured grains with light black (grey) hilum. Its' grains contain 37.2% protein and 21.9% oil. It is resistant to yellow mosaic virus and tolerates stem blight and root-knot nematode. It matures in about 144 days. Its' average seed yield is about 6.1 quintals per acre.

Agronomic Practices

Land Preparation: Give two ploughings to the field, followed by plankings to free it from clods and bring it into good tilth to ensure good germination. Soybean can also be sown with zero till drill without any preparatory tillage.

- **SL 958, SL 744 and SL 525 are varieties resistant to yellow mosaic virus.**
- **Inoculate the seed with recommended biofertilizer before sowing.**
- **Use 25 to 30 kg seed per acre and sow the crop in the first fortnight of June in good moisture conditions.**

Time of Sowing: Sow the crop in the first fortnight of June.

Seed Rate: Use 25-30 kg seed per acre.

Seed Inoculation: Moisten the seed recommended for one acre with minimum amount of water and mix throughly one packet of *Bradyrhizobium* sp. (LSBR 3) with it and let it dry in shade. Sow the seed immediately. Inoculation of seed with culture enhances grain yield upto 8%. The bio-fertilizer is available with the PAU Seed Shop at Gate No. 1, *Krishi Vigyan Kendras* and Farm Advisory Service Centres in different districts.

Method of Sowing: Sow the crop in good moisture conditions with a pre-sowing irrigation *(Rauni)* before the monsoon has set in. Heavy rains after sowing adversely affect soybean germination. Sow the seeds 2.5 to 5.0 cm deep in lines 45 cm apart with a plant-to-plant spacing of 4-5 cm. Soybean can also be sown with zero till drill without any tillage operation.

Raised Bed Sowing: Sowing of soybean in medium to heavy textured soils should be done on beds spaced 67.5 cm apart (37.5 bed top, 30 cm furrow) by using wheat bed planter. Sow two rows per bed using same quantity of seed, fertilizer and following other cultivation practices as in flat sown soybean. Irrigation should be applied in furrows by taking care that beds are not inundated. This practice not only saves the crop from damage by rains especially at emergence, but also saves about 20-30% irrigation water along with increased yield over conventional flat sowing method. Ensure good moisture conditions while sowing and in case it is not so, apply irrigation in furrows within 2-3 days after sowing for optimum germination and emergence.

Intercropping: Soybean can be successfully intercropped with maize. Sow one line of soybean between two lines of maize sown at 60 cm.

Mulching: The rows should be covered with wheat or paddy straw to ensure proper germination and seedling emergence.

Weed Control: Weeds can be controlled by giving two hoeings at 20 and 40 days after sowing. Alternatively, spray 600 mL per acre Stomp 30 EC (pendimethalin) within 2 days of sowing using 200 litres of water per acre and if need arises, one hoeing may be given after about 40 days of sowing or spray 300 mL per acre Parimaze 10 SL (imazethapyr) at 15-20 days after sowing using 150 litres of water per acre.

Fertilizer Application

To get higher yield apply organic manures, bio-fertilizers alongwith chemical fertilizers as under:

a. Organic Manures: Apply 4 tonnes of FYM per acre before sowing. Alternatively green manure the field with sunnhemp using 20 kg seed per acre during second fortnight of April. Green manure crop should be buried when about 40-45 days old and allowed to decompose for about 5-7 days before sowing of soybean. Practice green manuring and apply full dose of nitrogen (12.5 kg N/acre) to get high yield of soybean in soybean-wheat system. The practice of green manuring also improves the soil health.

b. Bio-fertilizers: Inoculate the seed with recommended bio-fertilizer before sowing.

c. Chemical Fertilizer: Apply at sowing 12.5 kg of N (28 kg of Urea) and 32 kg P_2O_5 (200 kg of single superphosphate). However, apply only 24 kg of P_2O_5 (150 kg of single superphosphate) per acre to soybean when it follows wheat which had received recommended dose of phosphorus. For obtaining higher yield, in addition to the recommended dose of fertilizers, spray 2% urea (3 kg in 150 litres of water per acre) at 60 and 75 days after sowing.

In phosphorus and sulphur deficient soils, apply sulphated P fertilizer (13:33:0:15:N:P_2O_5:K_2O:S) if other phosphatic (DAP or single superphosphatic) and gypsum fertilizers are not available.

Iron deficiency: Iron deficiency symptoms in soybean appear at first-to third-trifoliate leaf stage showing distinctive yellow leaves with green veins.

For obtaining higher yields and ameliorate iron deficiency, spray ferrous sulphate (0.5%; 1 kg in 200 litres of water) at 30 days and mixed foliar application of ferrous sulphate (0.5%) and urea (2%; 4 kg in 200 litres of water per acre) at 60 days after sowing.

Irrigation: If the rains are good and well distributed, there may be no need of irrigation. Otherwise crop will require 3 or 4 irrigations. One irrigation at the time of pod-filling is very useful.

Harvesting: Harvest the crop when most of the leaves fall-off and the pods change colour. Do not delay harvesting otherwise the shattering of pods will take place. During threshing, avoid severe beating or trampling as it reduces the quality and germination capacity of the seeds.

Storage: The moisture content of grains should not exceed 7 per cent. The grains should be stored in dry bins or in bags kept on wooden racks.

Plant-Protection

A. Insect Pests

The **hairy caterpillar, tobacco caterpillar, pod borer and whitefly** damage this crop. For controlling these pests, see under *Moong*.

B. Diseases

Yellow mosaic virus: It is a viral disease and is transmitted by whitefly. Disease appears as a blend of yellow and green patches on the infected leaves. Infected plants bear a few pale pods. Grow resistant varieties SL 958, SL 525 and SL 744.

4. SUGARCANE

Sugarcane occupied 90.2 thousand hectares in Punjab during 2023-24. The average cane yield was 832.5 quintals per hectare (337 quintals per acre). The average sugar recovery was 9.38 per cent.

Important Hints

Plant crop

- Do not plant the crop in a field where the preceding crop was infected with red rot or wilt.
- Use seed cane from a healthy and completely disease free seed crop.
- Use recommended seed rate to ensure good stand of the crop.
- Avoid late planting. It reduces tillering and the crop is more prone to attack by insect pests, especially shoot borer.
- Keep the crop free from weeds using cultural control measures and recommended chemicals.
- Do not apply excessive dose of nitrogen than recommended. Over dose will cause lodging of the crop, resulting in poor cane yield and quality.
- Do not allow the crop to suffer from water stress especially during hot months.
- To prevent lodging, earth up the crop in May-June and prop up the crop during August-September.

Ratoon crop

- Do not ratoon a diseased crop.
- Do not harvest the crop to be ratooned before the end of January. Harvest the crop as close to the ground as possible.
- Remove the trash and irrigate the field.
- Remove late tillers and water shoots.
- Interculture the crop with tractor drawn tillers or rotary weeder to control weeds during early stages of growth. Alternatively, adopt chemical control measures.
- Fill the gaps by planting three budded setts in the beginning of March.
- Inspect the ratoon crop regularly to prevent the attack of early shoot borer and black bug, as it is more prone to damage by these insects.

Hints for obtaining high sugar recovery

- Do not plant whole area under a single variety. Plant recommended early and mid-late maturing varieties in the ratio of 3:2 on area basis.
- Save the crop from lodging by timely earthing up and propping.
- Save the crop from diseases and insect pests through recommended control measures.
- Protect the crop from frost by giving light irrigations.

- Avoid excessive irrigation and late application of nitrogen near crop maturity.
- Harvest the crop at proper maturity. Ratoon crop should be harvested first.
- Ensure removal of roots, mud, trash and immature tops (spindles) at the time of harvest.
- Supply cane to sugar mills without excessive binding material, immediately after harvesting as staling reduces sugar recovery.

Climatic Requirements

Sugarcane is best suited to regions having tropical climate, but it can be grown successfully in sub-tropical areas also. In the Punjab, about 80 per cent of the total growth of the crop takes place during July, August and September owing to favourable temperature and humidity.

Soil Type

Sugarcane can be successfully grown on all types of soils ranging from sandy loam to clay loam. However, it thrives best on well-drained loamy soils. Sugarcane is semi-tolerant to sodicity and salinity. Sustainable sugarcane yields with assured levels of sugar recovery can be successfully obtained in sodic and saline-sodic soil/irrigation water conditions by adopting the following practices:

- If the soil/irrigation water is sodic, apply gypsum @ 50% of gypsum requirement on cumulative basis after the harvest of the previous crop or well decomposed farm yard manure @ 8 tonnes per acre before sowing. Higher and complimentary benefits can be obtained if both gypsum and FYM are used simultaneously.
- Do not apply gypsum if the soil/irrigation water is saline or saline-sodic. Apply only FYM.
- Under saline water conditions in south-western districts of Punjab, CoJ 88 should be planted.

Spring Sugarcane

Rotations

Rice (short duration) – *Rabi* fodder/Potato - Sugarcane - ratoon I - ratoon II - Wheat, Rice / *kharif* fodder - *Toria / Raya* - Sugarcane - ratoon I - ratoon II - Wheat, Maize/Cotton-*Senji* - Sugarcane - ratoon I - ratoon II - Wheat, *Arhar* - Oat/*Senji* - fodder - Sugarcane - ratoon I - ratoon - II - Wheat

Improved Varieties

1. Early-Maturing Varieties

CoPb 95 (2021): The canes of this variety are tall, thick* with zigzag internode alignment and purplish green in colour with broader leaf canopy. Its' juice contains 17% sucrose in the month of December. It has field resistance to the prevalent pathotypes of red rot disease, moderately resistant to smut and also less susceptible to top borer. It is a good ratooner, non-lodging and frost tolerant. The average cane yield is about 425 quintals per acre.

* Medium thin, medium thick and thick canes mean diameter up to 1.5 cm, 1.5 to 2.5 cm and above 2.5 cm, respectively.

CoPb 96 (2021): The canes of this variety are medium thick, cylindrical and yellowish green in colour. Its' juice contains 16-17% and 18% sucrose in the months of November and December, respectively. It is a good ratooner. It is tolerant to the prevalent pathotypes of red rot disease. Quality of *gur* is very good. The average cane yield is about 382 quintals per acre.

- **CoPb 95, CoPb 96, Co 15023, CoPb 98, CoPb 92, Co 118, CoJ 85, CoPb 93 and CoPb 94, CoPb 91, Co 238 and CoJ 88 are tolerant to most of the prevalent pathotypes of red rot disease.**
- **Gur (jaggery) from CoPb 96, CoPb 92, Co 118, CoJ 64 and CoJ 88 is of excellent quality.**
- **Seed rate of Co 118 and CoJ 85 should be kept 10% higher on weight basis.**

Co 15023 (2021): The canes of this variety are medium thick, cylindrical and yellowish green in colour. Its' juice contains 16-17 and 18% sucrose in the month of November and December, respectively. It is tolerant to the prevalent pathotypes of red rot disease. The average cane yield is about 310 quintals per acre.

CoPb 92 (2017): The canes of this variety are tall, medium thick and purple green in colour. Its juice contains 16-17% sucrose in the month of November and 18% in December. It is a good ratooner. It is tolerant to most of the prevalent pathotypes of red rot disease and frost. Quality of *gur* is also good. The average cane yield is about 335 quintals per acre.

Co 118 (2015): It has thick, purple green coloured canes. Its juice contains 16% sucrose in the month of November and 17% in December. It has field resistance to the prevalent pathotypes of red rot disease. It is a shy tillering variety and an average ratooner. Its *gur* quality is excellent. The average cane yield is about 320 quintals per acre.

CoJ 85 (2000): It is a shy tillering variety with thick* green coloured canes. Its juice contains 16-17% sucrose in the month of November and 18-18.5% in December. It is tolerant to most of the prevalent pathotypes of red rot disease and is tolerant to frost. It is an average ratooner and susceptible to red stripe disease. Due to its heavy canes it is prone to lodging, hence requires proper earthing up. The average cane yield of plant crop is about 305 quintals per acre.

CoJ 64 (1975): This variety is a good germinator, with profuse tillering and medium-compact growth. Its canes are medium thick, greenish yellow and solid. The sucrose content in juice in November is 16-17%. It has become highly susceptible to red-rot disease and also to top borer. Its quality of *gur* is excellent. The average cane yield is about 300 quintals per acre.

2. Mid-Late Maturing Varieties

CoPb 98 (2021): The canes of this variety are tall, thick, cylindrical and yellowish green in colour. Its' juice contains 17% and 19% sucrose in the months of January and March, respectively. It is a good ratooner. It is tolerant to the prevalent pathotypes of red rot disease. The average cane yield is about 400 quintals per acre.

CoPb 93 (2017): The canes of this variety are tall, thick and yellowish white in colour. Its juice contains 17% sucrose in the month of January and 19% in March. It is a good

ratooner. It is tolerant to the prevalent pathotypes of red rot disease. Quality of *gur* is also good. The average cane yield is about 390 quintals per acre.

CoPb 94 (2017): The canes of this variety are tall, thick, cylindrical and yellowish green in colour. Its juice contains 16% and 19% sucrose in the months of January and March, respectively. It is a good ratooner. It is tolerant to the prevalent pathotypes of red rot and smut diseases. The average cane yield is about 400 quintals per acre.

Co 238 (2015): The canes of this variety are tall, medium thick and yellow green in colour. Its juice contains 17% sucrose in the month of January. It is susceptible to top borer and tolerant to the prevalent pathotypes of red rot disease. It is a good ratooner. Quality of *gur* is also good. The average cane yield is about 365 quintals per acre. The crushing of this variety by sugarmills can be done along with early maturing varieties.

CoPb 91 (2014): The canes of this variety are tall, thick and yellowish green in colour. Its juice contains 17% sucrose in the month of January. It is tolerant to the prevalent pathotypes of red rot disease. It is a good ratooner. Its average cane yield is about 410 quintals per acre.

CoJ 88 (2002): The canes of this variety are tall, medium thick and greyish green in colour. Its juice contains 17-18% sucrose in the month of December. It tends to behave as early-mid in maturity and is also suitable for saline water conditions. It is tolerant to the prevalent pathotypes of red rot disease. It is an excellent ratooner. It is good for co-generation. Quality of *gur* is excellent. The average cane yield of the plant crop is about 335 quintals per acre.

Unrecommended variety:

Co 89003: This is an early maturing variety. It is highly susceptible to wilt disease and root borer which reduce its sugar recovery.

Agronomic Practices

Sub-soiling: Cross sub-soiling at 1.0 m spacing should be done once in three to four years, before preparing the field. This is done by tractor drawn sub-soiler, upto a depth of 45-50 cm. Do planking to break the clods and then prepare seed bed. This will help in breaking the hard pan, increase water infiltration rate and better penetration of roots.

Land Preparation: Give three to four ploughings, each followed by planking. Use a furrow turning plough for the first ploughing. If the crop is to be sown after harvesting of senji (fodder), 3 to 4 ploughing are enough for seed bed preparation.

Time of Planting: Mid-February to the end of March is the optimum time for planting sugarcane in the Punjab. Do not plant early maturing varieties after March. Avoid late planting. If late planting has to be done, adopt the following practices:

- In case of late planting, any mid late maturing variety should be preferred.
- Use higher seed-rate, viz. 30 thousand three-budded sets per acre.
- Control the early shoot-borer effectively as it is particularly serious in the late-planted crop.

Seed Selection: The seed should be free from red-rot, wilt, smut, ratoon-stunting and grassy shoot diseases. Use only the top two-third portion of the selected canes for planting.

Seed Rate: Use 20 thousand three-budded setts or 15 thousand four-budded sets or 12 thousand five-budded setts per acre. Longer setts are particularly good for rain-fed conditions. In other words, 30-35 quintal of seed, depending upon the variety, is required for sowing one acre. Due to thick canes, seed rate of Co 118 and CoJ 85 should be kept about 10% higher (on weight basis).

Seed Treatment: To improve the germination, soak the setts in ethrel solution overnight. To prepare the solution, dissolve 25 mL of Ethrel 39 SL in 100 liters of water. Alternatively, soak the setts in water for 24 hours before planting.

Spacing and Planting Techniques

1. Trench Planting: Plant crop in rows 75 cm apart and 20-25 cm deep trenches. After placing the setts in trenches, cover the setts with 5 cm soil. Apply irrigation immediately after planting, if the planting is not done under proper moisture (*watter)*conditions. Repeat the irrigation at 4-5 days interval.

2. Paired Row Trench Planting: Adopt paired row trench planting for saving irrigation water. Plant two rows of sugarcane 30 cm apart in 20-25 cm deep trenches. Place the cane setts at the bottom of the trenches and cover with the soil left in between two rows. Distance between two trenches should be 90 cm. Trenches can be drawn using tractor operated PAU designed trencher. In addition to water saving, this method gives comparatively higher cane yield, easy propping up operation and reduces lodging.

Use **tractor operated paired row trench planter** to sow paired rows of sugarcane in trenches. The complete sugarcane, is fed by two labourers sitting on the machine, is cut automatically into pieces before dropping in the furrows, fertilizer is applied simultaneously. Length of setts varies from 36 to 38 cm. The speed of operation is 2-3 km/h. Capacity of machine varies from 2-3 acres per day.

For ease of mechanical harvesting with sugarcane harvester, the crop should be planted at either 120 cm row spacing or by 120:30 cm paired row trench method.

3. Furrow Irrigated Raised Bed Planting (FIRB): Sugarcane can also be planted in standing wheat crop sown by furrow irrigated raised bed (FIRB) planter. The furrow should be reshaped in January to loosen the soil. Apply irrigation in reshaped furrows preferably in the evening before planting. Plant treated sugarcane setts next day by pressing under feet. Sugarcane is planted in pre-opened furrows between the beds, using treated 3 budded setts, during the second fortnight of February to March.

4. Sugarcane Cutter Planter: Use two-row tractor operated whole cane cutter planter. The complete sugarcane which is fed by the labour sitting on the machine is cut automatically into pieces before dropping into the furrows. Fertilizers and chemicals are also applied simultaneously. The seed rate varies from 32 to 35 q per acre. The labour requirement is 33 man-h/2.5 acre. Length of setts varies from 23 to 42 cm. The speed of operation is 1.20 to 1.90 km per hr. The capacity of machine varies from 2-3 acres per day.

The machine can save about 25% cost of operation in comparison to traditional method. Use this machine on custom hiring basis.

Intercropping: Intercrop one row of the recommended varieties of summer moong or summer mash in between two rows of sugarcane to get an additional grain yield of 1.5 to 2 quintals per acre of summer moong/summer mash. This does not affect the cane yield and improves the soil fertility. The details are as under:

Practice	Summer moong	Summer mash
Seed rate per acre	4 kg	5 kg
Time of sowing	March 20 to April 10	March 15 to April 7

Mentha can also be grown as an intercrop. Plant one row of mentha between two rows of sugarcane. Mentha and sugarcane can be planted simultaneously in the first fortnight of February. Use one quintal of mentha suckers per acre. In addition to fertilizers recommended for sugarcane, apply 18 kg N (39 kg Urea) and 10 kg P_2O_5 (62 kg Super Phosphate) per acre. Half N and full phosphorus may be applied at planting and remaining half N about 40 days after planting. Take only one cutting of Mentha.

Okra can also be grown as an intercrop. Intercrop two rows of okra 45 cm apart in between the two rows of sugarcane planted either at 90:30 or 120:30 cm paired row planting systems in the second fortnight of February month. Use 11 kg seed of okra per acre for 90:30 cm planting system and 9 kg for 120:30 cm. Fertilizers to the intercrop should be applied as recommended for sole crop of okra. Terminate the okra crop in the second fortnight of June to avoid the intercrop competition.

One row of **cucumber** can be sown within the two rows of sugarcane as intercrop in paired row trench planted sugarcane either at 90:30 cm or 120:30 cm. The cucumber seeds should be sown by keeping plant to plant distance of 45 cm by using 1 kg seed per acre in the second fortnight of February. Use 40 kg nitrogen (90 kg urea), 20 kg phosphorus (125 kg superphosphate) and 20 kg potash (35 kg murate of potash) to cucumber crop in addition to fertilization to sugarcane crop.

Fertilizer Application

Organic and Bio-fertilizers: Apply 8 tonnes of FYM/press-mud per acre 15 days before planting and mix into the soil with a plough or tiller. In case of trench planting, apply press-mud at the base of the trench and mix it into soil with a *kasola*. In case FYM/ press-mud is applied, use 40 (90 kg urea) kg N per acre. However, on coarse textured soils if FYM is applied along with recommended dose of nitrogen, approximately 10% higher yields can be obtained. On sandy soils, nitrogenous fertilizer may be applied after irrigation in moist soil and the number of splits may be increased. Application of Azotobacter/ Consortium bio-fertilizer @ 4 kg per acre in the furrows at the time of planting would be helpful in increasing the cane yield. If FYM is in limited quantity, apply 4 kg consortium bio-fertilizer with 4 tonnes FYM per acre to plant as well as ratoon sugarcane crop. This

bio-fertilizer is available at the PAU Seed Shop at Gate No. 1, *Krishi Vigyan Kendras* and Farm Advisory Service Centres in different districts.

Chemical Fertilizers: Apply fertilizers on soil test basis (See Chapter on 'Soil Testing'). In the absence of a soil test, apply the following quantity of fertilizers on medium fertility soils:

Crop	Nutrients (kg per acre)		Fertilizers (kg per acre)	
	N	P_2O_5	Urea	Single Superphosphate
Plant crop	60	#	130	#
Ratoon crop	90		195	

If the soil is low in available phosphorus, apply 12 kg P_2O_5 (75 kg single super phosphate) per acre at sowing.

- In soils testing low in available potassium, application of 50 kg per acre murate of potash to planted sugarcane in furrows at the time of planting and with first hoeing/earthing in ratoon crop improves yield and quality.
- Apply only 100 kg urea per acre if, sugarcane is grown after potato crop.

Method of Fertilizer Application

(i) Plant Crop: Apply one half dose of nitrogen as top dressed/drilled alongside the cane rows with first irrigation after germination. Top dress or drill the remaining half dose of nitrogen along side the cane rows in May or June. Apply full dose of phosphorus (based on soil test) in furrows below the cane setts at the time of planting.

(ii) Ratoon Crop: Top-dress one third of nitrogen in February with first hoeing, one-third in April and the remaining one-third in May. Phosphorus (on soil-test basis) should be drilled along the cane rows at the time of first cultivation in February.

(iii) Rainfed Crop: If the moisture in the soil is optimum, apply one half of the dose of nitrogen at planting. In case the moisture is deficient, the whole dose should be applied with the onset of rains.

Iron deficiency: Iron deficiency has been observed both in the ratoon and plant crops on light-textured and calcareous soils. Deficiency symptoms first appear in young leaves as yellow stripes between the green veins. Later, the veins also turn yellow. In severe cases, leaves become white and the plants remain stunted. Spray the crop 2 or 3 times with 1% solution of ferrous sulphate (1 kg ferrous sulphate in 100 litres of water) at weekly intervals soon after the symptoms appear.

Weed Control

Cultural Control: Two or three hoeings can be done with a *triphali* or tractor mounted tiller or tractor operated rotary weeder.The spreading of trash-blanket between the cane rows after the emergence of the shoots helps to suppress weeds. This practice has the added advantage of conserving soil moisture, particularly in rainfed areas.

Chemical Control: Pre-emergence application of 800 g per acre Atrataf/Solaro/Masstaf/ Markazine 50 WP (atrazine) or Sencor 70 WP (metribuzin) or Karmex/Klass 80 WP (diuron) or 1000 g per acre Authority NXT 58 WP (sulfentrazone+clomazone) in 200 litres of water within 2-3 days of planting effectively controls the broadleaf weeds and annual grasses. For control of hardy weed like *Bans Patta*, use only Sencor 70 WP or Karmex/Klass 80 WP.

Alternatively, post-emergence application of 1200 g per acre Triskele/Trishuk (2,4-D sodium salt 44% + metribuzin 35% + pyrazosulfuron ethyl 1.0%) WDG or 1000 g per acre Sindica (2,4- D sodium salt 48% + metribuzin 32% + chlorimuron ethyl 0.8%) WDG in 200 litres of water at 3-5 leaf stage of weeds provides effective control of seasonal grass, sedge and broad leaf weeds. For fields infested with *dila*, post-emergence application of 800 g per acre 2, 4-D sodium salt 80 WP in 200 litres of water is recommended. In fields infested with *Ipomoea* spp. (*lapeta vel*) and other broadleaf weeds, apply 800 g of 2,4-D sodium salt 80 WP or 400 mL per acre 2,4-D amine salt 58 SL by dissolving in 200 litres of water when these weeds are at 3 to 5 leaf stage.

Straw Mulching: After complete germination by mid-April, uniformly spread paddy straw or rice husk or sugarcane trash or tree leaves at the rate of 20-25 quintals per acre between the rows. Mulching reduces soil temperature and conserves soil moisture. It also suppresses weeds and reduces the incidence of shoot-borer. Straw-mulching increases the yield of sugarcane both under rainfed and irrigated conditions.

Irrigation and Drainage: Hot and dry period during April to June is the most critical period for the growth of sugarcane. During this period, irrigate the crop at 7 to 12 days interval. During the rainy-season, adjust the frequency of irrigation according to rainfall. Drain away excess water from the sugarcane fields, if these get flooded during the rainy season. During winters (November to January), irrigate the crop at monthly intervals. To save the crop from frost, apply one irrigation around mid-December and another in the first week of January.

Sub Surface Drip Fertigation: Paired row (30:120 cm) planted sugarcane should be drip irrigated every third day with a lateral pipe placed 20 cm deep and 150 cm apart having dripper spacing 30 cm. Drip irrigation with dripper discharge of 2.2 litre per hour should be given as per the following schedule:

Month	Time of irrigation (Minutes)*
April-June	120
July-Aug	100
Sept-Oct	80
Nov-Dec	60

If discharge rate is different, then time of irrigation may be adjusted proportionally by the formula:-

Adjusted time (min) = (2.2 × Time of irrigation (min)*) ÷ Discharge of dripper (Litre/hour)

Start fertigation of 104 kg urea per acre for plant crop and 156 kg urea per acre for ratoon crop in the month of April and complete in 90-100 days in 10 equal splits.

Prevention of Lodging: To prevent the crop from lodging, adopt the following measures:

- Earth up heavily the flat-planted as well as the trench-planted crop at the end of June, before the onset of the monsoon. Trench-planting is particularly effective in preventing lodging.
- Prop up the crop in the end of August or in the beginning of September by using the trash-twist method which consists of the tying of a single cane row instead of tying two rows together. Twist the leaves and the trash to make a rope and pass it alternately along the cane clumps in the row. This method does not hinder the growth and photosynthesis of the plants as in the case when two cane rows are tied together.

Protection from frost: Protect the crop from frost as under:

- Grow frost-resistant varieties viz. CoPb 95, CoPb 96, CoPb 98, CoPb 92, Co 118, CoJ 85, CoJ 64, CoPb 93, CoPb 94, CoPb 91, Co 238 and CoJ 88.
- Raise a bumper crop with adequate fertilization, irrigation and plant protection measures, because a poor and stunted crop suffers more from frost.
- Prevent lodging. A lodged crop is more damaged by frost.
- Irrigate the crop, as adequate soil-moisture during the frosty period keeps the soil comparatively warm and saves it from frost. Irrigate the harvested fields if meant to be ratooned. Plough the patch of land between the cane rows.
- In frosty areas, plant setts only from the top portion of the cane, as these buds are less damaged by frost. The top portion can be buried in the soil during the frosty spell and taken out in the spring for planting.

Autumn Sugarcane

Sugarcane can also be grown successfully as an autumn crop with various intercrops. Growing intercrops in autumn cane will enhance the total productivity/net profit per unit area per unit time. Recommendations concerning intercrops are given in Table 1.

Rotations

Kharif fodder/Green manure/Maize/Rice (short duration)/*Moong*-Sugarcane with intercrop (as in Table) ratoon I-ratoon II-Wheat.

Improved Varieties: Plant CoPb 95, CoPb 96, Co 15023, CoPb 92, Co118, CoJ 85 and CoJ 64

Agronomic Practices

Time of Planting: 20 September to 20 October. The planting should not be delayed further.

Seed Rate: Plant 20 thousand of three budded or 15 thousand of four budded or 12 thousand of five budded setts per acre. The seed for autumn planting should be obtained from a well grown spring or autumn crop.

Spacing and Method of Planting: Flat planting in rows 90 cm apart. Adopt paired row trench planting method as described under spring planting.

Intercropping: For higher returns per unit area, adopt intercropping in autumn sugarcane as given in Table 1.

Fertilizer Application: Apply fertilizers on soil test basis (See Chapter on 'Soil Testing'). In the absence of a soil test, apply the following quantity of fertilizers on medium fertility soils:

Nutrients (kg/acre)		Fertilizers (kg/acre)	
N	P_2O_5	Urea	Single Superphosphate
90	#	195	#

If the soil test is low in phosphorus, apply 12 kg P_2O_5 (75 kg single super phosphate) per acre at sowing.

- In soils testing low in available potassium, application of 50 kg per acre murate of potash to planted sugarcane in furrows at the time of planting and with first hoeing/earthing in ratoon crop improves yield and quality.

Apply urea in three equal doses, 1/3 dose of N should be applied at planting, 1/3 at the end of March and the remaining 1/3 by the end of April. The fertilizer recommendations for intercrops are given in Table 1.

Weed Control: For control of *gulli danda* in wheat intercropped in autumn sugarcane, spray 400 ml Axial 5 EC (pinoxaden*) or 13 g per acre Leader/SF-10/Safal/ Marksulfo 75 WG (sulfosulfuron*) using 150 litres of water at 30–35 days after sowing of wheat. A post- emergence application of 500 g per acre Isoproturon 75 WP at 30–40 days after sowing of wheat is recommended for controlling weeds in fields where *gulli danda* has not developed any resistance.

For controlling broadleaf weeds, use 10 g per acre Algrip/ Algrip Royal/Markgrip/ Makoto 20 WP (metsulfuron*) in 150 litres of water at 30-35 days after sowing. If there is infestation of *button booti*, spray 20 g per acre Aim/ Affinity 40 DF (carfentrazone ethyl*) in 200 litres of water at 25-30 days after sowing.

For control of mixed infestation of grass (*gulli danda* and wild oats) and broadleaf weeds, spray 16 g Total/Markpower 75 WG (sulfosulfuron + metsulfuron*) or 160 g per acre Atlantis 3.6 WDG (mesosulfuron + iodosulfuron) using 150 litres of water per acre at 30–35 days after sowing wheat.

Irrigation: Apply first irrigation one month after planting, followed by three irrigations upto February and subsequent irrigations as per the recommendations for the spring crop.

Table 1: Intercrops in autumn sugarcane

Name of of Intercrop	Variety	Sowing/ planting time	Seed rate (kg per acre)	No. of intercrop rows	Spacing between the rows of intercrop	Fertilizers recommended per acre	Harvesting time	Remarks
1	2	3	4	5	6	7	8	9
Wheat	Recommended varieties	Last week of Oct. to 15th Nov.	16	2	20 cm	25 kg N (54 kg urea) 12 kg P_2O_5 (75 kg single superphosphate, SSP) 12 kg K_2O (20 kg muriate of Potash, MOP)	Mid-April	---
Raya (Brassica juncea)	Recommended varieties	Whole Oct.	0.40	1 (in paired row trenches at 90:30 or 120 :30cm)	-	For sugarcane planted at 90:30 cm 20 kg N (44 kg urea) 8 kg P_2O_5 (50 kg SSP) For sugarcane planted at 120:30cm 16 kg N (36 kg urea) 4.8 kg P_2O_5 (30 kg SSP)	April	Preferably, intercrop should be sown after first irrigation to sugarcane.
Gobhi Sarson (B. napus)	Recommended varieties, including Canola	October 10 to 31						
African Sarson (B tournefortii)	PC 6	Mid Oct. to mid Nov.						
Toria (B campestris) var. Toria	Recommended varieties	20-30 Sept.	1	2	30 cm	15 kg N (33 kg urea) 5 kg P_2O_5 (32 kg single super phosphate)	End Dec.	Wheat can also be sown after harvesting toria.
Gram	Recommended varieties for different zones	25th Oct. to 10th Nov.	12	2	30 cm	6 kg N (13 kg urea) + 8 kg P_2O_5 (50 kg SSP)	April	---

1	2	3	4	5	6	7	8	9
Potato	Chandermukhi or any other short duration variety	20 Sept. to 15th Oct.	800	1	-	36 kg N (78 kg urea) 16 kg P_2O_5 (100 kg SSP) 35 kg K_2O (60 kg MOP)	End of Dec.	Wheat can also be taken after harvesting potato crop in end-December.
Cabbage	Recommended varieties	Last week of Oct. to Nov.	--	1	--	25 kg N (54 kg urea) 12.5 kg P_2O_5 (78 kg SSP) 12.5 kg K_2O (20 kg MOP)	Jan & Feb	Transplant 4 to 5 weeks, old seedling from end of October to November
Radish	Recommended varieties	October	4-5	2	30cm	25 kg N (54 kg urea) 12 Kg P_2O_5 (75 kg SSP)	Janu-ary	---
Peas	Recommended Varieties	October	22	2	30 cm	14 kg N (31 kg urea) 16 kg P_2O_5 (100 kg SSP)	---	---
Tomato	Recommended Varieties	Nursery: Oct -Nov Transplanting: Nov-Dec	0.05 (nurs-ery)	1 (in paired row trenches at 120:30cm)	At centre between two cane rows	12.5 kg N (28 kg urea) 12.5 kg P_2O_5 (78 kg SSP), 12.5 kg K_2O (21 Kg MOP)	End Mar to mid May	Protect intercrop from low temperature injury from end Dec-end Feb
Garlic	PG-17 PG-18	4th week of Sept. to first week of Oct.	112 to 125 kg	3	15cm	10 ton FYM, 25 kg N (54 kg urea), 12 kg P_2O_5 (75 kg SSP)	April	In paired row trench planted sugarcane, use 85 to 95 kg garlic seed

1	2	3	4	5	6	7	8	9
Onion	Recommended Varieties	Nursery: Mid Oct- mid Nov Transplanting: Jan.	2.0 to 2.5 (nursery)	5 (in paired row trenches at 120:30cm)	15 cm	21 kg N (45 kg urea) 10 kg P_2O_5 (62.5 kg SSP), 10 kg K_2O (17 Kg MOP)	Mid May	Number of intercrops rows can be adjusted with sugarcane row spacing
Capsicum	Recommended varieties	Nursery: Mid Oct.	0.08	1 (in paired row trenches at 120:30cm)	-	28 kg N (62 kg urea) 11.2 kg P_2O_5 (70 kg SSP; 4.8 kg K_2O (8 kg MOP)	Mid Mar. to end May	Capsicum crop should be protected from low temperature injury from end December to end February
Broccoli/ Cauliflower	Recommended varieties	Nursery: Mid September Transplanting: Mid October to first week of November	0.150 (for nursery)	2 (Sugarcane planted in paired row trenches either at 90:30 cm or 120:30cm)	45 cm	For 90:30 cm system: apply 37.5 kg N (82 kg urea), 18.75 kg P2O5 (116 kg SSP), 18.75 kg K2O (30 Kg MOP) For 120:30 system: apply 30 kg N (65 kg urea), 15 kg P2O5 (94 kg SSP), 15 kg K2O (25 Kg MOP)	Mid December	

Other recommendations are the same as for the spring crop.

Ratoon Management: Improve the yield of the ratoon crop as under:

- Do not harvest the crop to be ratooned before the end of January. If the crop is harvested earlier, there will be poor sprouting of the stubbles due to low temperature during December and January.
- Soon after the harvesting of early varieties in November or December, remove the trash and irrigate the field. When the soil attains the optimum moisture conditions, loosen it by hoeing, ploughing or interculture. Do not cover the stubble with cane trash.
- Harvest the canes as close to the ground as possible to promote better sprouting. If still some big stubbles are left, shave or lop them off close to the ground. Also remove late tillers or water-shoots, as they inhibit full sprouting of the stubbles.
- Plough the harvested field twice with a tractor-drawn tiller to check weeds or adopt chemical weed-control measures.
- The stand of the ratoon crop can be improved by planting the gaps with three budded setts in the beginning of March.

- **Harvest the crop during last week of January to obtain good ratoon crop.**
- **During 1st week of March fill the gap of ratoon crop with planting of 3 budded setts.**

- Nitrogen requirement of the ratoon crop is one and a half-times than that of the plant crop. Apply 90 kg N (195 kg urea) per acre to the ratoon crop in three split doses one-third in February-March, one-third in April and the remaining one-third in the beginning of June. Drill phosphorus along the cane rows in March on the basis of a soil test.
- Shoot-borer, top-borer and black bug appear in the ratoon crop. Control them as soon as noticed.

Gur (Jaggery) Making

Gur is a natural sweetener rich in minerals like calcium, iron, phosphorus etc. The best quality *gur* and *shakkar* (powdered jaggery) are obtained from CoPb 92, Co 118, CoJ 64 and CoJ 88. Making of *gur* and *shakkar* from sugarcane involves juice extraction, clarification, boiling and concentration, cooling and moulding. Use an efficient cane-crusher for extracting juice.

For clarifying the juice, add *Sukhlai* emulsion. *Sukhlai* is a shrub which grows in the Shivalik Hills and is available at Hoshiarpur. For preparing emulsion, soak the dry bark of *Sukhlai* in a bucket of water for 24 hours. Then rub the bark to obtain a thick mucilaginous fluid. Add about one litre of this fluid to 100 litres of cane juice, when the scum begins to rise in the pan. Towards the end of boiling process, heating is regulated to avoid charring. The concentrated juice is transferred to the cooling pan when its temperature reaches the striking point (114-116°C) for *gur* making and (120-122°C) for *shakkar* making. *Gur* is then moulded into desired shapes and sizes using moulding frames designed by Department of Food Science and Technology, PAU Ludhiana. For *shakkar*, at the time of solidification the

material is made into powder manually using wooden scrappers. Powder is dried to 10.5-11.5 % moisture content, sieved and packed in polythene bags.

Crushing schedule of sugarcane varieties for sugar mills of Punjab (Developed in consultation with Sugarfed, Punjab)

Varieties*	Crop	Months
CoPb 92, CoPb 96, Co 15023, Co 238, Co 118, CoPb 95, CoJ 85 and CoJ 64	Ratoon (A &S)	November and December
CoPb 93, CoPb 98, Co 238, CoPb 91, CoJ 88 and CoPb 94	Ratoon (S)	December and January
CoPb 92, CoPb 96, Co 15023, Co 238, Co 118, CoPb 95, CoJ 85 and CoJ 64	Plant (A)	December and January
CoPb 92, CoPb 96, Co 15023, Co 238, Co 118, CoPb 95, CoJ 85 and CoJ 64	Plant (S)	January and February
CoPb 98, CoPb 93, CoPb 91, CoPb 94 and CoJ 88	Plant (S)	February, March and April

* Varieties are written in the order of preference for crushing (A-Autumn; S-Spring)

Note: The above crushing schedule would give sugar recovery of 10.5 percent if varietal ratio is as given below:

- The area under early and mid-late varieties should be in ration of 3:2, respectively.
- Under early varieties Spring: Autumn should be planted in the ratio of 2:1, respectively.
- Proportion of Ratoon crop: Plant crop be maintained as 1:1, respectively.

Plant-Protection

A. Insect-Pests

Termite: The termite appears during April to June and again in October. It destroys the germinating buds and causes the drying up of shoots after germination. To avoid its attack, apply only well-rotten farmyard manure and remove the stubbles and debris of previous crop from the field. For the control of termites, apply 200 mL Coragen 18.5 SC (chlorantraniliprole*) using 400 litres of water over seed setts in furrows before covering them with soil or spray 45 mL Imidagold 17.8 SL (imidacloprid) in 400 litres of water with sprinkler along the rows at post germination stage (about 45 days after planting).

Early shoot-borer: This pest appears from April to June and causes dry dead-hearts which can be easily pulled out. To control it:

- Plant the crop early, i.e. before the middle of March.
- Apply 10 kg granules of Regent/Mortel/Rippen 0.3 G (fipronil) before the setts are covered with soil by planking. or
- Apply 10 kg Regent/ Mortel/Rippen 0.3 G (fipronil) mixed in 20 kg moist sand/ soil or 150 g Takumi 20 WG (flubendiamide) or 150 mL Coragen/Citigen 18.5 SC (chlorantraniliprole*) or 2 litres of Durmet/Classic/Dursban/Markpyriphos 20 EC (chlorpyriphos) in 400 litres of water per acre along the rows at post-germination stage (about 45 days after planting). Earth up slightly followed by light irrigation.

OR

- **Do early sowing to reduce damage by early shoot borer.**
- **Use Tricho-cards for the control of borers.**
- **Do not plant sugarcane for one year and three years for control of red rot and wilt, respectively in diseased fields.**

Use Tricho-cards having 20,000 eggs of *Corcyra cephalonica* parasitized (seven days old) by *Trichogramma chilonis* per acre at 10 days interval from mid-April to end-June. These eggs are fixed on cards of 10x15 cm size. Cut the cards into 40 pieces/strips, each having approximately 500 parasitized eggs. Staple these pieces/strips on the lower surface of the leaves uniformly at 40 spots per acre during evening hours. Normally 8 releases are required. The tricho-cards should not be stapled during rainy days.

Use of 10 pheromone traps per acre from April to June along with Tricho-card application. Change the pheromone lure at one month interval.

Black bug: This pest is active during April to June. The attacked crop looks pale. The black adults and pink young nymphs suck the sap from the leaf-sheaths. Spray the crop with 350 mL of Dursban/Lethal/Massban/Goldban 20 EC (chlorpyriphos) in 400 litres of water per acre with manually operated sprayer. Direct the spray into the leaf-whorl.

Pyrilla: Pyrilla reduces cane yield and sugar recovery heavily. This pest appears in April-May and again in August-September. The leaves of the damaged crop turn yellow. Later due to the development of a fungus, the crop turns black and the tops become unfit for feeding to cattle. The incidence of this pest is particularly high in a luxuriant crop and in the interior of field. When the attack is severe it becomes difficult to make *gur*. Spray the crop with 600 mL Dursban 20 EC (chlorpyriphos) in 400 litres of water per acre with manually operated sprayer.

Top-borer: This pest appears from March to October and causes severe damage during July-August. The typical symptoms are the shot-holes in the leaf, white or red streaks on the upper side of the leaf midrib and bunchy tops from July onwards. The central leaf of the cane top dries up and turns dark. To control it:

- Collect and destroy the moths and egg-clusters.
- Cut the attacked shoots at the ground level from April to June.
- Use Tricho-cards having 20,000 eggs of *Corcyra cephalonica* parasitized (seven days old) by *Tricogramma japonicum* per acre at 10 days old interval from mid-April to end-June. The method to use these cards is given under early shoot borer.
- Use of 10 pheromone traps per acre from May to August along with recommended Tricho-card application. Change the pheromone lure at one month interval.
- Apply 10 kg granules of Ferterra 0.4 GR or 12 kg Furadan/Diafuran/Furacarb/ Carbocil/ Fury encapsulated 3G (carbofuran) at the base of the shoots or spray 150 mL Coragen 18.5 SC (chlorantraniliprole) in 400 liters of water per acre, in the last week of June or in the first week of July only if the top borer damage exceeds 5% level. Earth up slightly to prevent the granules from flowing with the irrigation water and irrigate the

crop immediately. This operation will control the third brood of the top-borer which does the maximum damage. Take the following precautions in using carbofuran:

- Use rubber gloves while applying carbofuran granules. Never handle these granules with bare hands. A mask should be used to cover the face.
- Mix it with the moist soil to reduce the chances of its falling into the eyes of the person applying it.
- The person applying these granules should not eat or drink anything without washing his hands thoroughly with soap.
- **Carbofuran treated sugarcane leaves and weeds should not be fed to cattle for about one month after the treatment.**

Stalk borer or Tarai borer: This pest is active throughout the year. The larvae overwinter in the stubble and water-shoots. The attack remains low during April-June and increases in July. Its incidence is highest during October-November. There are no outward symptoms of the attack of this pest. Entrance or exit holes on the attacked canes can be seen only after stripping. A larva sometimes damages upto 3 nodes and the cane may be attacked at several places. The cane yield and sugar recovery are adversely affected in the case of serious attack. The control measures against the pest are as under:

- Do not use the cane-seed from the infested field.
- Use tricho-cards having 20,000 eggs of *Corcyra cephalonica* parasitized by *Trichogramma chilonis*, 10-12 times at 10 days interval from July to October. Cut one tricho-card of size 10 x 15 cm into 40 small strips (5 x 0.75 cm), each having approximately 500 parasitized eggs. Staple these strips on the underside of leaves uniformly at 40 spots per acre during evening hours. These tricho-cards are available at the Biocontrol Labs, Department of Entomology, PAU Ludhiana and Regional Station, Gurdaspur.
- Use of 10 pheromone traps per acre from July to October along with recommended Tricho-card application. Change the pheromone lure at one month interval.
- At harvest, do not leave the water-shoots in the field.
- Do not ratoon a heavily infested crop. Plough the affected fields, collect and destroy the stumps.

Whitefly: The damaged crop looks pale during August-October. The underside of the leaves is full of nymphs and pupae which suck the sap from the leaves. The leaves turn black due to the development of a fungus.

Sugarcane thrips: The thrips damage the crop from April to June. This pest suck the sap from the partly opened leaf and tips of the younger leaves, resulting in withering and drying of leaftip, which get rolled inwardly. The thrips prefer plant crop than ratoon crop.

Sugarcane mite: The mite appears from April to June and feeds on the lower side of the leaves under a fine web. The leaves turn red and later appear to be burnt. The growth of the affected crop is retarded during the pre-monsoon period. Baru (*Sorghum halepense*)

is the alternative host plant from which this mite spreads to the sugarcane crop. So destroy the weed, if growing near the sugarcane fields.

Gurdaspur borer: This borer appears from June to October and causes the withering of the central leaves (notably the 5th leaf) followed by the total drying up of the tops. The affected canes break at the point of attack with a slight jerk. Rogue out canes showing withered tops in the afternoon every week from June to September. The tops should be cut off well below the point of attack. The timely rogueing of affected plants is very important for controlling the pest. Bury the rogued-out plants. Do not ratoon a heavily affected crop. Plough up the fields not meant for ratooning and destroy the stubbles before June.

B. Diseases

Red rot: Red rot is caused by the fungus *Colletotrichum falcatum.* The disease appears from July till the crop is harvested. The third or fourth leaf of cane from top shows yellowing at first, while rest of the leaves also loose colour afterwards and dry up. Later, the whole clump dries up. On splitting open the cane, the tissue is found to be reddened but the discoloration is not uniform and is interspersed with white patches running across the width of the split cane. The pith of affected cane emits alcoholic smell. The control measures against this disease are as under:

- Use seed from absolutely disease free seed plot.
- Do not plant sugarcane in the disease affected fields for one year.
- Grow varieties fairly resistant to red rot.
- Crush the affected crop early and plough up the fields soon after harvesting the crop. Collect and burn the stubbles.
- Rogue out and bury the diseased canes. Uproot the entire clumps and not merely the affected stalks.
- Do not ratoon the diseased crop.

Wilt: This disease is caused by *Cephalosporium sacchari* or *Fusarium moniliforme*. It appears from July till the crop is harvested. The leaves of the affected cane at first turn yellow and finally the top dries up. On splitting open a diseased cane, the pith shows a dirty red discoloration near the nodes. The discoloration is invariably darker than that in the remaining portion of the internodes. The affected stalks become light and hollow. The control measures against this disease are the same as those for red rot. As the causal fungus persists in the soil over long period, the affected field should not be cultivated with sugarcane for 3 years.

Smut: Smut is caused by *Ustilago scitaminea*. This disease is prevalent throughout the year but is severe from May to July and again in October-November. Its incidence increases in the ratoon crop. It is easily recognised by the appearance of long whip-like shoots covered with dusty black mass of spores. These whips may arise from the top of the canes as well as from the lateral sprouted buds. Adopt the following control measures:

- Use only smut free canes for seed. Reject even the healthy looking canes in the diseased stools or those growing in the vicinity of the smut infected clumps.
- Remove the smut whips gently (without shaking) after putting them inside a closely woven drill bag. Then uproot the entire diseased clumps and bury them deep. Immerse the bag used for collecting the smut whips in boiling water for 5 minutes after every roguing of the crop.
- Do not ratoon the smut infected crop.

Ratoon Stunting: A coryniform bacterium (*Clavibacter xyli*) has been found to be associated with the disease. The affected crop remains stunted with thin canes. The leaves are comparatively pale and the roots are poorly developed. The disease can be identified by slicing mature canes longitudinally a little below the rind with a sharp knife. In the lower part of the node, parallel to the zone of the whitish waxy band, the pith shows discolored dots, commas and straight or bent streaks upto 2 to 3 mm in length. They may be yellow, orange, pink, red or reddish brown. Do not use the diseased crop for planting. Select the cane-seed from a vigorously growing and healthy crop. The moist hot air treatment of seed canes at 54^{o}C for 4 hours is effective in destroying the causal organism. Do not ratoon the diseased crop.

Grassy Shoot Disease: The disease is caused by mycoplasma like bodies. The affected plants give rise to numerous thin tillers. The leaves become reduced in size, thin, narrow and usually turn chlorotic. If the attack is light, one or two weak canes may be formed. Uproot and destroy the affected clumps immediately after appearance. The moist hot air treatment of the seed-canes at 54ºC for 4 hours inactivates the causal organisms of this disease. Its incidence increases in the ratoon crop, therefore, do not ratoon the diseased crop.

Red Stripe: Red stripe is a bacterial disease caused by *Pseudomonas rubrilineans*. It appears during June-August. The affected leaves show bright red streaks which are long, narrow and run longitudinally on the leaf-blade, causing the rotting of tops in severe cases. Rogue out the affected canes and burn or bury them.

Top Rot (*Pokkah boeng*): This disease is caused by *Fusarium moniliforme*. It appears during the rainy season from July–September. The young leaves in the top portion of the plant become chlorotic at the base and get distorted and shortened. They turn dark red and fall off gradually. In severe cases, the rotting of the top portion of the cane occurs. Remove the affected clumps and bury them.

Leaf Scald: The disease is caused by the bacterium *Xanthomonas albilineans*. Whitish or cream coloured one or two narrow stripes are observed on the leaf extending sometimes down to leaf sheath. The affected plants produce side-shoots starting first from lower nodes with similar stripes on young leaves. The stripes become reddish and later the leaves start withering from top downwards giving scalded appearance. On splitting open the affected canes, reddish brown vascular streaks are observed in the internodes. Sometimes affected plants suddenly wilt and die without any obvious internal symptoms. As the disease is sett-borne, healthy and disease free seed should be planted. Treatment of seed-cane with moist hot air at 54ºC for 4 hours inactivates the bacterium. Sterilization of cutting knives by flaming

or by dipping in 2% Lysol solution during seed preparation should be practised to minimise spread of the disease. Rogue out the diseased clumps.

C. Rodents

Being a long duration crop, sugarcane provides shelter to rodents and suffers heavy damage. The rat, *Bendicota bengalensis*, which digs extensive burrows with characteristic soil heaps, is often abundant in sugarcane. A lodged crop gets highly damaged. For effective rodent control in sugarcane, see Chapter 'Management of Rodents and Birds'.

Management of Seed Crop

To obtain disease-free seed, a separate seed nursery should be maintained. Do not use the commercial crop for seed, as many pests and diseases go unnoticed in such a crop. Alternatively, tissue culture raised plants can also be used to raise a healthy seed crop. The plants should be spaced 60 cm apart with a row to row spacing of 90 cm, followed by immediate irrigation. The crop thus raised, should be used for raising a subsequent seed crop by planting three budded setts, following conventional practices. For seed production, the following package of practices are recommended:

- Plant the crop in the last week of March.
- Obtain the seed stalks propagated from moist hot-air-treated seed. The treated seed is planted at the Research Stations and is further propagated at the sugar factory farms and the farms of selected cane growers. This seed is supplied to the growers to raise the seed-crop.
- Give a fertilizer dose of 90 kg of N (195 kg urea) per acre. Apply nitrogen in 3 equal doses i.e. at planting, in May and in mid-July. High dose of nitrogen will result in good quality of immature seed cane.
- Follow plant protection schedule strictly, to keep the crop free from insect pests and diseases.
- Frost injury results in low germination of sugarcane. Therefore, protect the seed crop against frost by irrigating it frequently during December and January.

5. OILSEED CROPS

GROUNDNUT

Groundnut was grown on 1.6 thousand hectares during 2023-24 in Punjab. Its' production was 2.8 thousand tonnes with an average yield of 17.40 quintals per hectare (7.04 quintals per acre).

Climatic Requirements

A well distributed rainfall of at least 50 cm during July, August and September is essential for successful cultivation of groundnut under rainfed conditions.

Soil Type

A well-drained sandy soil overlaying a loamy sub-soil is considered ideal for the rainfed crop. Where irrigation facilities are available, loamy sand and loamy soil can also be put under groundnut.

Rotation

Groundnut–Late *Kharif* Fodder/Potato/Peas/*Toria*/*Rabi* crops, Spring Groundnut-Maize/Moong-Potato/Peas, Groundnut-Peas-Sunflower rotation can be taken up successfully where irrigation facilities exist.

Avoid sowing groundnut in the same field year after year as this practice results in heavy build-up of soil-borne diseases.

Improved Varieties

J 87 (2020): It is recommended for sowing in both spring and *kharif* seasons. It is bunch type variety. The kernels of this variety are bold, oblong in shape and light pink in colour. Each pod bears 2-3 kernels. Its' 100 kernel weight is 79 g. It has 69 per cent shelling outturn. Its' average pod yield is 15.3 q per acre in spring season and 12.8 q per acre in *kharif* season. It has oil content of 49 per cent and sucrose content of 5.2 per cent. It has 65.7 per cent oleic acid and is suitable for confectionery. It matures in 112 days.

TG 37A (2018): It is an early maturing bunch type variety which is suitable for cultivation during spring season. It has 65 per cent shelling outturn with 100 kernel weight of 42.5 g. Each pod bears 2-3 kernels. The kernels are spherical in shape and pink in colour. Its' average pod yield is 12.3 quintals per acre. It has 48.6 per cent oil content. It has soluble sugar content of 5.8 per cent. It matures in 101 days.

SG 99 (2004): It is a bunch type variety. Its' average pod yield is 10 quintals per acre and is tolerant to bud necrosis disease. The pods are medium in size with slight beak and moderate constriction. The pods are borne around the main root, which allows easy harvesting of crop with minimum pod losses. It has 66 per cent shelling outturn, with 100 kernel weight of 54 g and 52 per cent oil content. The kernels have light brown colour. It matures in about 123 days.

M 522 (1995): It is a semi spreading type variety. It yields about 9 quintals per acre of pods. The pods are medium bold in size with mostly two kernels per pod. The pods are borne towards the main root. It has 68 per cent shelling outturn, 65 g 100 kernel weight and 51 per cent oil content. The kernels have light brown colour. It matures in about 120 days.

Agronomic Practices

Land Preparation: Plough the land twice soon after the previous crop has been removed. Give a third ploughing if necessary for rainfed crop for better infiltration of rain water. Use disc harrow or cultivator for field preparation for sowing (Annexure V). Very deep ploughing is not necessary except in lands infested with *kans* or *doob*.

Preparation of Seed: Hand-shell healthy and well-developed pods about a fortnight before sowing. Shelling can be done efficiently with a pedal-operated sheller. Its' output is 6 to 8 times more than that of manual shelling. Discard very small, shrivelled and blemished kernels.

Seed Treatment: Treat the selected kernels with 2 mL Neonix 20 FS (imidacloprid 18.5%+hexaconazole1.5%) or 1.5 g Seedex 2 DS (tebuconazole) or 5.0 g Thiram (tetramethyl thiurum disulphide) or 3.0 g Indofil M-45 (mancozeb) per kg of kernels. Seed treatment with Neonix also controls whilte grubs and termite. Use rotatory drum for uniform application of fungicide on kernels.

Time of Sowing: Where irrigation facilities are available, spring season crop should be sown during second fortnight of February. Late sown crop may be caught up in rains. Optimum sowing time of *kharif* groundnut is from end April to end May with a pre-sowing irrigation to get higher yield and also to get the field vacated in time for the sowing of *rabi* season crops.

Sow the rainfed crop with the advent of monsoon in the last week of June or in the Ist week of July. Complete the sowing as early as possible. Delayed sowing causes progressive reduction in pod yield. Immediately after sowing groundnut, the field should be divided into small plots of suitable size by making bunds for giving protective irrigation in case of need.

Seed Rate and Method of Sowing: Sow seed about 5 cm deep with a drill. Planters are also available for sowing of groundnut (Annexure V). The following seed rates and spacings are recommended for different varieties:

Variety	Seed rate (kg kernels/acre)	Spacing (cm)
J 87	48	30 x 22.5
TG 37A	32	30 x 15
SG 99	40	30 x 15
M 522	38	30 x 22.5

Fertilizer Application: For medium fertility conditions:

Season	*Nutrients (kg per acre)			Fertilizers (kg per acre)				
	N	P_2O_5	K_2O	Urea	DAP	Single Super-phosphate	**Muriate of potash	Gypsum
Spring	10	12	10	12	26	-	17	90
Kharif	6	8	10	13	-	50	17	50

* These nutrients can also be supplied from other fertilizers available in the market (Annexure VII).

** Apply potash fertilizers only when the soil-test shows deficiency.

Method of fertilizer application: In spring season, drill nitrogen, phosphorus and potassium at sowing and apply gypsum in two equal splits, first at sowing and second at flower initiation stage. In *kharif* season, broadcast gypsum and drill all fertilizers at sowing. **In the wheat-groundnut rotation, if the recommended dose of phosphatic fertilizer has been applied to wheat, its application to *kharif* season groundnut can be omitted.** Prefer phosphorus from superphosphate.

Zinc Deficiency: The leaves in the upper half portion of the plant get reduced in size and become light yellow in colour. When the deficiency is severe, the plant growth is stunted and the kernels are shrivelled. Apply 25 kg zinc sulphate heptahydrate (21% zinc) or 16 kg zinc sulphate monohydrate (33% zinc) per acre. This dose will be sufficient for 2 to 3 years.

Weed Control: Give two hoeings, the first three weeks after sowing and the second three weeks thereafter.

Irrigation: Two or three irrigations may be necessary depending upon the seasonal rainfall. Give first irrigation at flowering. If the rainfall during the crop season is not adequate, apply one or two more irrigations, depending upon the time of recession of monsoon during the pod formation period for proper development of pods. Another irrigation a few days before the harvesting may be applied for full recovery of pods from soil.

Harvesting and Threshing: The spring sown crop matures by the end of June to early July. Crop sown during end April-end May is ready for harvesting towards end of August to early September. Foliage of spring and *kharif* sown crop remains green at maturity. Appearance of brown to black lines on the inner side of the pod shell and change of colour of kernels to pink are the indications of maturity of the crop. The rainfed crop is normally ready for harvesting towards

- **Sow J 87 and TG 37A in spring season.**
- **SG 99 is tolerant to bud necrosis disease.**
- **Treat seed with fungicide before sowing to manage diseases.**
- **Maintain plant to plant spacing of 15 cm for TG 37A and SG 99 (bunch type), and 22.5 cm for J 87 and M 522 (semi-spreading) varieties.**
- **Apply 90 kg gypsum in two equal splits at sowing and flower inititate stage to spring season crop and 50 kg gypsum per acre at sowing to *kharif* season crop to meet sulphur need of the crop.**

the beginning of November. A reliable indication of maturity is the uniform yellowing of leaves as well as the shedding of older leaves. The tractor-mounted groundnut-digger shaker developed at the Punjab Agricultural University may be used for quick harvesting (Annexure V). For its efficient harvesting, the soil should have adequate moisture and the crop should not be over-ripe. Leave the harvested crop in small heaps for two days for curing.

After curing, collect the crop at one place and give 2 or 3 shakings and beatings daily for 2 to 3 days with a toothed rake or trangli to separate pods and leaves from the stalk. Collect the pods and leaves into a heap and winnow. Tractor operated thresher can be used in place of manual threshing after curing to save labour and time. The pods should be sun dried for 4 or 5 days before storage.

Production of Pure Seed: Rogue out the off-type plants when full plant growth has been attained and again at the time of harvesting.

Plant Protection

A. Insect-Pests

Aphid: The pest becomes serious when the rainfall is low. It weakens the plant by sucking the cell sap, particularly from the growing points.

White-grub: This insect is serious in some areas only. The adult beetles emerge from the soil during June-July with the first showers of rain. They congregate on the nearby trees such as ber, guava, rukmanjani, grapevines, almonds etc. and feed on their leaves during night. The eggs are laid in the soil and the larvae (grubs) hatching from them eat away the rootlets or root hairs of the groundnut plants. The damaged plants look pale, wilted and ultimately die. Adopt the following integrated approach for its effective management:

- Plough the field twice during May-June to expose the beetles resting in the soil.
- Sow the crop early wherever possible.
- Treat the seed with 2 mL Neonix 20 FS (imidacloprid 18.5% + hexaconazole 1.5%) per kg seed before sowing.

Hairy Caterpillar: Hairy caterpillar, if appearing in epidemic form causes serious damage by feeding on the leaves and tender stems. When young, they feed gregariously. The grown-up caterpillars migrate from one field to another. For management, monitor the fields regularly. Collect and destroy the egg masses and young gregariously feeding larvae. The grown up caterpillars can be destroyed by crushing them under feet or by picking and putting them into kerosenized water.

Termite: This insect damages the crop after sowing and feeds on roots and shoots by making tunnels. Damaged plants wilt, dry and can be easily pulled out. Damaged plants can be differentiated from white grub damage in that the tunnels made by termites and damaged pods are filled with soil. Treat the seeds before sowing with 2 mL Neonix 20 FS (imidacloprid 18.5% + hexaconazole 1.5%) per kg seed.

B. Diseases

Collar-rot and seed-rot: This disease is caused by *Aspergillus niger* and other seed

and soil borne fungi which may cause seed rot before germination or the germinating seedlings may develop rotting lesion at the collar region.

Tikka or Cercospora leaf-spot: This disease is caused by *Cercospora personata* and *C. arachidicola*. Disease develops rapidly at a temperature range of 25-30°C coupled with high relative humidity.

Control the above diseases by adopting the following integrated measures:

- Select healthy and unblemished kernels for seed.
- Treat the kernels before sowing as describe under **Seed Treatment** on **page no. 95**.
- Spray the crop with 500 to 750 g per acre Sultaf 50 WP* (wettable sulphur) in 200 to 300 litres of water. Give 3 or 4 sprays at fortnightly intervals, starting from the first week of August.
- Alternatively, spray the irrigated crop with Bavistin*/Derosal*/Agrozim* 50 WP @ 50-60 g in 100 litres of water per acre. Give three sprays at fortnightly intervals, starting when the crop is 40 days old.
- Do not grow groundnut repeatedly in same field.

Root knot: This disease occurs in patches and is caused by the nematode *Meloidogyne arenaria* and *M. javanica*. The affected plants show poor growth with chlorotic leaves. The root knots become stubby. The plants affected early in the season become stunted and bushy. Disease can be checked by exposing the soil to the sun during May and June to reduce nematode population. Practise green-manuring wherever possible or add organic manures to the soil.

C. Rodents

Rodents cause severe damage to groundnut crop. For their control, see chapter 14 "Management of Rodents and Birds".

SESAME

Sesame (*Til*) was grown on 1.7 thousand hectares with a production of 0.6 thousand tonnes during 2023-24 in the Punjab. The average yield was 3.80 quintals per hectare (1.54 quintals per acre).

Soil Type

Sesame thrives best on well-drained, sandy-loam soils.

Improved Varieties

Punjab Til No. 2 (2015): This variety yields 2.8 quintals per acre. It has profuse branching and dense capsule bearing. Capsules arranged opposite to each other are long and non-hairy. Its' seeds are white, bold and have 49 per cent oil content. Seeds have less crude fibre, are soft and better in palatability. This variety is tolerant to phyllody and cercospora leaf blight. It matures in 90 days.

RT 346 (2009): This variety yields 2.6 quintals per acre. It has profuse branching, long non-hairy capsules arranged alternately. It has white, bold seeds which contain 49 per cent

oil. It is moderately resistant to *Antigastra* capsule borer. It matures in 87 days.

- **Sow the crop during first fortnight of July as early sown crop is more prone to the attack of phyllody disease.**
- **Remove phyllody infected plants time to time and burry them to check further spread of the disease.**
- **To avoid shattering of seeds harvest the crop immediately when plants turn yellow and capsules have just opened.**

Agronomic Practices

Land Preparation: The crop requires a well-prepared seedbed. Give two or three ploughings followed by planking.

Time of Sowing: The crop should be sown in the first fortnight of July after receipt of adequate rain or with the application of pre-sowing irrigation. The crop sown early in June suffers from phyllody disease.

Seed Rate and Method of Sowing: The seed rate is 1 kg per acre. Sow the seeds at row to row spacing of 30 cm. The seeds should be sown 4 to 5 cm deep with a pora or tube attached to the desi plough. After complete germination extra plants should be thinned to maintain plant to plant spacing of 15 cm.

Fertilizer Application: Drill 21 kg N (45 kg urea) per acre before sowing. Avoid excessive manuring as it induces heavy vegetative growth.

Weed Control: Weeds can be controlled by giving one hoeing at about three-weeks after sowing.

Harvesting and Threshing: Harvest the crop in time to avoid shattering of seeds. The plants turn pale at maturity. Harvest the crop immediately when capsules have just opened. After harvesting, tie the plants into small bundles and stack these bundles in upward direction. Two shakings of the bundles are enough to collect the entire produce.

Plant-Protection

A. Insect-Pests

Sesame leaf webber and capsule borer: The larvae of these insects roll the leaves and feed inside these rolls; or bore into the capsule and feed on developing grains. If the infestation takes place at early stage, the plants die. Sow the crop at recommended time. Timely sown crop is less affected by insect.

Jassid: It causes considerable damage to the crop by sucking the sap and transmitting mycoplasma, which induces the malformation of the inflorescence. Avoid early sowing in June as early sown crop suffers heavily from this pest.

B. Diseases

Phyllody: It is caused by a Mycoplasma like organism (MLO). The flowers are modified into leaf like structures and do not bear capsules. It is transmitted by jassid (*Orosius albicinctus*). Therefore, control of jassid is required. Also rogue out the diseased plants to prevent further spread.

Blight *(Cercospora sesami):* It appears at flowering stage as dark brown, angular lesions with grey centre on leaves. It also appears on petiole, stem and capsules. The diseased plants give blighted appearance followed by defoliation. Avoid excessive use of nitrogenous fertilizers and keep the field free from weeds and debris.

6. FODDER CROPS

The area under fodder crops in the state remains around 9.0 lakh hectares (5.3 lakh hectare in *kharif*) and the annual production is about 710 lakh tonnes of green fodder. As per 20th Livestock Census-2019, the total livestock population in Punjab is 70.5 lakh, out of which 65.5 lakh are bovines which are to be provided sufficient fodder of good quality. Each bovine gets green fodder supply of about 30 kg per day, but actually 40 kg green fodder per animal is required. Therefore, the present availability of green fodder is inadequate. On the basis of requirement per animal per day, approximately 956 lakh tonnes of green fodder is required. With the increase of crossbred animals which need more fodder, its deficiency will be further aggravated unless efforts are made to increase the production of fodder. Therefore, fodder production in the state need to be substantially increased.

Important Hints

- The supply of protein to animals from legumes is cheaper than from concentrates**.** The non-legume forages are rich in energy. Fodders should be grown as mixtures, in which legumes such as cowpea, guara and non-legumes such as maize, sorghum and bajra are grown together.
- Follow recommended time of sowing and seed rate and treat the seed before sowing.
- Use fertilizers in balanced amount.
- To get better quality of fodder, cut the fodder crop at proper stage
- Irrigate the fodder crop one week before cutting especially to sorghum and bajra to minimize anti-quality factors.
- Avoid use of un-recommended agrochemicals on fodder crops as this may be harmful to dairy animals
- Plants attacked by any insect-pests should be uprooted and destroyed.
- Do not grow fodder crops on soils high in selenium.
- An adequate supply of quality fodders during the lean periods of November-December and May-June can be ensured by preserving the fodder as silage and hay.

Nutritive value (on dry matter basis) of *Kharif* fodders

Fodders	Crude protein (%)	Total digestible nutrients (%)
Maize	11.4	66.2
Sorghum	9.0	55.6
Bajra	8.8	58.2
Napier-bajra hybrid	8.7	59.3
Guinea grass	10.8	62.4
Guara	18.1	60.0
Cowpea	22.5	61.2

SORGHUM

Sorghum *(jowar)* is a very important *kharif* fodder and is cultivated on about 2.6 lakh hectares. It remains green and palatable over a longer period than maize and *bajra* fodders.

Climatic Requirements

Sorghum grows well in hot and dry climate. Increased humidity enhances the incidence of the red leaf spot disease.

Soil Type

Sorghum grows on all types of soils, but heavy soils are more suitable. Adequate drainage should be provided.

Single-cut Sorghum

Improved Variety

SL 46 (2023): It is a dual purpose composite variety with more number of tillers suitable for fodder as well as grain. It has long and broad leaves. Its stem is juicy and sweet. Its grains have good popping potential. Grains are good in iron and zinc content. It is resistant to red leaf spot and moderately resistant to zonate leaf spot diseases. It possesses good fodder quality especially the *in vitro* dry matter digestibility. On an average, it gives 275 quintals per acre of green fodder and 7.0 quintals per acre of grain yield.

SL 45 (2022): It is a single cut late maturing variety having tall (297cm) plants with long and broad leaves. Its stem is juicy and sweet. It is resistant to red leaf spot and moderately resistant to zonate leaf spot diseases. It possesses better fodder nutritional quality especially the crude protein and *in vitro* dry matter digestibility. It gives 271 quintals per acre of green fodder yield.

Agronomic Practices

Land Preparation: Good preparation of land is essential to get rid of weeds as well as to enable the crop to attain initial growth. In the irrigated areas, one ploughing with harrow followed by two ploughings with a cultivator should be given before sowing.

Time of Sowing: Sowing commences in the middle of March to obtain early green fodder. The optimum period of sowing is mid-June to mid-July.

Seed Rate: 20-25 kg per acre

Seed Treatment: The seed should be treated with 10 mL Slayer 30 FS (thiamethoxam) per kg seed for preventing damage by shoot fly. To control grain smut, treat the seed with sulphur dust @ 4 g/kg seed before sowing.

Method of Sowing: Sow with a seed-cum-fertilizer drill or by using the *pora* method in rows 22 cm apart.

- **Fodder crops should be grown away from other crops in which insecticides are used frequently.**
- **Do not sow sorghum (*jowar*) and maize crops in fields where Leader/SF-10/Safal/Marksuflo/Total/ Markpower herbicide has been used in wheat.**

Sorghum can be grown under no-tillage to obtain the same green fodder yield as after conventional or zero till sown wheat.

Fertilizer Application: In the rainfed or low rainfall areas, drill 20 kg of N (44 kg urea) per acre in rows at sowing. In high rainfall or irrigated areas, apply 20 kg of N (44 kg urea) and 8 kg P_2O_5 (50 kg single superphosphate) per acre at the time of sowing and another 20 kg N (44 kg urea) per acre about one month later. Add potassium to the crop on the soil test basis.

Irrigation and Drainage: About five irrigations should be given to the summer crop and one or two irrigations to the monsoon crop, depending upon the rains. Soil drainage should be good.

Harvesting: Harvest the crop of fodder from boot to milk stage (65-80 days after sowing). Under drought conditions, apply irrigation one week before harvesting the crop.

Seed Production

Use 6-8 kg of seed per acre. Sow the seed at 8 cm depth in 30 cm spaced rows during the last week of June. Apply 16 kg of N (35 kg urea), 8 kg of P_2O_5 (50 kg Single superphosphate) and 10 kg of K (16 kg Muriate of potash) only in potassium deficient soils per acre at sowing and 16 kg N (35 kg urea) 40 days after sowing.

Multi-cut Sorghum

Improved Varieties

Punjab Sudax Chari 4 (2015): It is a multicut forage sorghum hybrid. Its' plants are tall with broad leaves and ready for first cut after 60 days of sowing. It is moderately resistant to leaf spots and shoot fly. The timely sown crop gives three good cuttings and produces 445 quintals of green fodder per acre.

Punjab Sudax Chari 1 (1991): It is a multicut forage sorghum hybrid. Its' plants are tall with long broad leaves. Stems are juicy and sweet. It is tolerant to red-leaf spot disease. The timely sown crop gives three good cuttings during the summer season and produce 480 quintals green fodder per acre.

Agronomic Practices

Time of Sowing: Last week of April to end of May.

Seed Rate: Use 15 kg seed per acre to get proper plant stand.

Seed Treatment: Same as given under single-cut sorghum.

Method of Sowing: Sow in rows 30 cm apart.

Fertilizer Application: For first cutting the fertilizer dose as recommended for single cut sorghum should be applied. However, for subsequent cuttings, apply 40 kg N (88 kg urea) per acre immediately after first irrigation.

Harvesting: The first cutting is ready in 55-65 days after sowing. Subsequently, cuttings can be taken after an interval of about 35-40 days.

Seed Production

This multicut chari is a hybrid and its seed is to be procured afresh every year from the seed producing agencies. The female parent of Punjab Sudax Chari 4 is a male sterile line 94012 A and the male parent is Sudan grass line SGL 87. Similarly, the female parent of Punjab Sudax Chari 1 is sorghum male sterile line 2077 A and the male parent is same as Sudan grass line SGL 87. The female and male parents are planted in an isolation with a distance of 200 m from other sorghum crop. The female and the male are planted in rows in the ratio of 4: 2 respectively with row to row distance of 50 cm. Four kg seed of female and 3 kg seed of male parent is required to sow one acre during the last week of June.

Plant Protection

A. Insect-Pests

Shoot fly: Shoot fly remains active throughout the year but has two peak periods of infestation, viz March-April and August-September. The crop sown from early June to second week of July normally escapes its attack. Early sown (April-May) multicut sorghum hybrids are severely attacked by shoot fly. It produces dead heart symptoms in young plants. For control of this insect pest, treat the seed with 10 mL Slayer 30 FS (thiamethoxam) per kg seed.

Caution: In case of seed is treated, green fodder should only be cut after 45 days of germination.

Mite: Mite causes the reddening of leaves.

Other pests: Grasshoppers, grey-weevils, leaf-hoppers and pyrilla also attack this crop.

B. Disease

Grain Smut: Control grain smut (*Sphacelotheca sorghi*) by treating the seed with sulphur dust @ 4 g/kg seed before sowing.

C. Birds: See under chapter 'Management of Rodents and Birds'

MAIZE

Maize is an important *kharif* fodder and is cultivated on approximately 1.0 lakh hectare in Punjab state. It takes about 50 to 60 days to become available for harvesting. The fodder is considered good for milch animals. It is grown widely around cities for sale as green fodder in the market.

Climate and Soil Requirements

Climate, soil requirements and land preparation are the same as given under the maize crop for grains.

Rotations

Maize-Berseem - *Bajra*/Maize+Cowpea

Improved Varieties

J 1008 (2024) : The first yellow seeded early maturing composite maize variety which is earlier by 12 days in milking (73 days) as compared to J 1006 (86 days) and J 1007

(84 days). It is suitable for silage making. Its grains are having more starch, protein and β carotene as compared to that of J 1006 and J 1007. Its green fodder is also having more crude protein and *in vitro* dry matter digestibility. Its average green fodder yield is 163 quintals per acre and grain yield is 20 quintals per acre.

J 1007 (2020): The plants of this composite variety are tall with broad leaves. Its' ear placement is medium. Ears are long, thick and cylindrical. Grains are white, bold and semi flint to semi dent. It is moderately resistant to maydis leaf blight and charcoal rot. It possesses better fodder nutritional characters. Its' average green fodder yield is about 168 quintal per acre.

J 1006 (1989): Its' plants are tall, vigorous and broad leaved. It is moderately resistant to maydis leaf blight and brown stripe downy mildew diseases. Its' ear placement is medium. Ears are long, thick and cylindrical. The grains are white, bold and semi-flint to semi-dent. It yields about 165 quintal of green fodder per acre.

Agronomic Practices

Seed Rate and Sowing: Use 30 kg seed per acre. Maize can be sown from the first week of March onward till the middle of September. To limit the multiplication and spread of fall armyworm, prefer sowing from mid-April to mid-August. Three crops can be taken successfully from the same field. Sow the crop by *kera* or *pora* at a row distance of 30 cm apart. The crop can also be sown with a seed-cum-fertilizer drill. When sown mixed with cowpea, use 15 kg seed of maize with 6 kg of CL 367 per acre. Maize can be grown under no-tillage to obtain the same green fodder yield as after conventional or zero till sown wheat.

Weed Control: Spray 800 g per acre Atrataf 50 WP (atrazine) on medium to heavy textured soils and 500 g per acre in light soils within ten days of sowing, using 200 litres of water. There is a common practice with the farmers to grow pure maize fodder upto end September and this is followed by wheat. Use of Atrataf 50 WP (atrazine) can be extended upto the first half of September. However, atrazine should not be used where maize fodder is sown in mixture with cowpea.

Fertilizer Application: Apply ten tonnes per acre of good quality farm yard manure before preparing the land. This application mitigates zinc deficiency and also meets all the P and K requirement and one-third of nitrogen. The fodder maize shows a remarkable response to application of nitrogen. To the soils of medium fertility, apply the fertilizers as recommended for the composite maize. Drill half N and all P and K at sowing. Apply the remaining nitrogen after 3-4 weeks.

Irrigation: Fodder maize requires 4-5 irrigation during summer and during *kharif* season irrigate the field as per rains.

Harvesting: Harvest the crop when the plants are between the milk ripe stage and the dough stage of grain development. From silking onwards, the nutritive value of the plant is mainly in the grains, hence do not remove cobs from that fodder crop. Preserve surplus fodder maize as silage (see the procedures for hay and silage making).

Seed Production: As recommended for composite maize.

Plant Protection

Maize borer attacks the crop from March to October. For effective control, the attacked plants should be uprooted and destroyed after 2-3 weeks of sowing. It can also be controlled with spray of 40 mL Coragen 18.5 SC (chlorantraniliprole*) in 60-80 litres of water per acre Do not feed the fodder for atleast 21 days after the spray of Coragen. Alternatively use tricho-cards twice having 50,000 eggs of *Corcyra cephalonica* per acre parasitized by *Trichogramma chilonis*; first release on 10 days old crop and second one week after first release. Cut tricho-cards into 50 strips, each having approximately 1000 parasitized eggs. Place these strips in the central whorl uniformly at 50 spots per acre during evening hours. These tricho-cards are available at the Biocontrol Labs, Department of Entomology, PAU Ludhiana and Regional Station, Gurdaspur.

Fall armyworm: The young larvae feed by scrapping the leaf surface making papery windows. The bigger larvae feed voraciously on the central whorl leaves causing round to oblong holes and produce a large amount of faecal matter. The larva can be identified by predominant white-coloured inverted Y-shaped mark on the head and presence of four spots arranged in square pattern at the tail end. Adopt the following control measures:

- Avoid staggered sowing in adjacent fields.
- Prefer mixed cropping of fodder maize with cowpea/ bajra/ sorghum.
- Use recommended seed rate (30 kg per acre) and follow line sowing method rather than broadcasting.
- Regularly monitor the field to collect and destroy egg masses of fall armyworm from leaves. Egg masses are covered with hairs and are easily visible.
- Spray the crop with Coragen 18.5 SC (chlorantraniliprole*) @ 0.4 mL per litre using 120 litres of water per acre, for crop up to 20 days old. On older crop (up to 40 days old crop only), the amount of water used per acre needs to be increased up to 200 litres with corresponding increase in dose of insecticide. For effective control, direct the nozzle towards the whorl. Do not harvest fodder for 21 days after insecticide application to ensure safety to farm animals.

Jassid, thrips, pyrilla and Bihar hairy caterpillar also attack this crop.

BAJRA

Bajra (pearl millet), cultivated on about 1.5 lakh hectares is a hardy fodder crop and withstands adverse agroclimatic conditions. It can grow in light soils with low moisture. It can tolerate hot and dry weather.

Rotations: *Bajra*-maize-berseem

Improved Varieties/Hybrid

PCB 166 (2022): This is a dual purpose composite variety with more number of tillers. It is a tall variety (281cm) with long and broad leaves. It is late maturing variety and

comes to 50 per cent flowering after 89 days. It is tolerant to all the major diseases of bajra. It possesses good fodder quality especially the crude protein and *in vitro* dry matter digestibility. On an average, it gives 282 quintals per acre of green fodder.

PCB 165 (2020): This is a quick growing dual purpose composite variety with more number of tillers. It is a tall variety with average plant height of 252 cm. It is late maturing variety and comes to 50 per cent flowering after 73 days. It is tolerant to all the major diseases of bajra. It possesses good fodder quality especially the crude protein. On an average, it gives 234 quintals per acre of green fodder and 86 quintals per acre of stover yield at maturity.

PCB 164 (2003): This is quick growing dual purpose composite variety having medium stalks and flexible stem with average plant height of 207 cm. It flowers in 50 days and plants remain green till maturity. It is tolerant to downy mildew. Its' fodder is of good nutritional quality. On an average, it yields 210 quintals per acre of green fodder and 59 quintals per acre of dry fodder at maturity.

FBC 16 (2003): It is a composite variety exclusively meant for fodder production. It flowers 8-10 days later as compared to other varieties and hence provides green fodder for a longer period. Its' plants attain an average height of about 235 cm and have long and broad leaves which remain green at maturity. It is tolerant to major diseases. In terms of quality, it has higher voluntary dry matter intake and contains low amount of oxalates. Its' average fodder yield is 230 quintals per acre.

Agronomic Practices

Time of Sowing: *Bajra* can be sown from March to August. The March-May sown crop is the main fodder crop. It can be grown in mixture with cowpea.

Land Preparation: Give 2 or 3 deep ploughings followed by planking.

Seed Rate and Method of Sowing: The seed rate of bajra is 6-8 kg per acre. Sow by broadcast or in rainfed areas with *pora* in rows 22 cm apart. Bajra can be grown under no-tillage to obtain the same green fodder yield after conventional or zero till sown wheat.

Fertilizer Application: Add 10 tonnes per acre of farmyard manure or compost before preparing the land and apply 20 kg of N (44 kg urea) per acre in two doses, first half as the basal dose and the second half, 3 weeks after sowing when the crop height is 10-15 cm.

Irrigation: Two or three irrigations are usually sufficient. In the hot season, however, more irrigations may be required. Standing water is harmful, hence avoid water-logging. It is preferable to give frequent but light irrigation.

Harvesting: The crop should be harvested at ear-initiation or soon after the flag-leaf emergence. In no case, it should be allowed to go beyond 50 per cent earing. At this stage, the crop has high digestibility. It also escapes the attack of the ergot disease at the flowering stage. If infected fodder is fed to cattle, it can cause "finger-and-toe," disease and abortion.

Seed Production

The procedure of the seed production of composites and maintenance of the purity are same as given in the grain bajra crop.

Plant Protection

A. Insect Pests

Root bug: This insect causes damage to the *bajra* crop in south-western districts.

Grasshopper, Grey weevil and Pyrilla also attack this crop.

B. Disease

Ergot: This disease is caused by the fungus *Claviceps fusiformis*. At blossoming, a pinkish or light-coloured fluid (honey dew) exudes from the spikelets in different parts of the ear. Later dark sticky patches appear on the ear and small dark-brown sclerotia appear in place of grains between the glumes. The seed set is poor or completely inhibited. The ovary is replaced by a fungal mass with many folds on its surface. The fungus perpetuates through the seed-borne and soil-borne sclerotia.

The contaminated grains, if fed to cattle or used by human beings can cause poisoning. Therefore, take the following precautions:

i. For Cattle: Do not feed the infected ears showing honey-dew symptoms to cattle. Even the stems and leaves of such plants are not safe as cattle feed. Cut and burn a badly affected crop to reduce the amount of inoculum.

ii. For Human beings: Immerse the grains in 10 per cent salt solution. The sclerotia, being lighter than normal grains, will float. Remove them with a sieve and burn them. Repeat the process two or three times.

Prevention of Ergot: Once the disease appears, it is not possible to eliminate it. Take the following precautions to prevent its spread.

- Immerse seed in 10 per cent salt solution and remove the sclerotia and smut-balls by skimming. Then wash the seed in ordinary water and dry it thoroughly.
- Burn the ears infested with honey-dew, as soon as they are observed in the field.
- After harvesting the crop, bury the debris with a furrow turning plough so that the ergot sclerotia rot in the soil.
- After threshing the ergot affected crop, the left-over-ear-heads of bajra in the threshing floor should also be burnt.
- Avoid sowing *bajra* next year in a field in which the crop had suffered heavily from ergot.

C. Bird: See under ‘Management of Rodents and Birds’.

NAPIER-BAJRA HYBRID

It is a vegetatively propagated *bajra* like grass developed at the Punjab Agricultural University, Ludhiana. It is perennial but yields most of the fodder between March and November. The crop once planted gives fodder for 2-3 years.

Climatic Requirements

This hybrid requires hot and moist climate and can be grown under irrigated conditions throughout the Punjab state.

Soil Type

This hybrid can be grown on a variety of soils but heavy soils are best for getting a high green fodder yield.

Improved Varieties

PBN 342 (2019): It is a leafy hybrid with long, smooth, non-hairy and broad leaves. It sprouts earlier in spring and remains in vegetative growth till the onset of winter. It yields 877 quintal of green fodder per acre.

PBN 346 (2016): It is a leafy hybrid with long, smooth, non-hairy and broad leaves. It sprouts earlier in spring and remains in vegetative growth till the onset of winter. The silage quality of this hybrid is better than PBN 233. It yields 715 quintal of green fodder per acre.

PBN 233 (2000): It is non-hairy with smooth long and broad leaves. It maintains its active vegetative growth for longer duration than PBN 83 because it sprouts earlier in spring and remains in vegetative growth upto onset of winter. Its' winter dormancy period is about 15 days less than PBN 83. It yields 1100 quintals of green fodder per acre.

Agronomic Practices

Land Preparation: The land should be prepared well and should be free from weeds. Give the first ploughing with a disc harrow and subsequent two ploughings with a cultivator. Planking should follow every ploughing.

Time and Method of Planting: Napier-Bajra hybrid can be planted from the last week of February to May. The planting should be completed by mid-April to avoid high mortality of root slips. The crop planted after May does not give sufficient yield during the *kharif* season. It can be propagated vegetatively from root slips or stem cuttings. Root-slips (30 cm long) or stem cuttings (with two or three nodes) are used for planting. Approximately, 11,000 slips or cuttings are required to plant one acre. A small part of the shoot or root-slip is allowed to remain exposed and the rest of the slip is buried in the soil. The stem cuttings can also be planted like sugarcane sets in 7 or 8 cm deep furrows which are afterwards filled with soil. The furrows may be made with a furrower. The crop should be planted at 90 x 40 cm or 60 x 60 cm apart in lines under good conditions of soil moisture. **After planting apply 4 tonnes of rice straw mulch per acre to save water.**

Weed Control: Two hand hoeings at 21 and 42 days after planting effectively manage the seasonal weeds.

Fertilizer Application: Napier *Bajra* hybrid is quick growing and responds to high fertility. To the newly planted crop, add 20 tonnes of farmyard manure or town compost to the soil before planting and apply 30 kg of N (66 kg of urea) per acre fifteen days after planting. Repeat this fertilizer dose after each cutting. To the ratoon crop, apply 38 kg of P_2O_5 (240 kg of single superphosphate) per acre every year in two doses, the first half in spring and the second half during the monsoon. The nitrogen dose for the ratoon crop is same as in newly planted crop.

Irrigation: Crop should be irrigated at 8-10 days interval during hot and dry months. In the mid-season, however irrigate after every 10 to 14 days. Drain away excess water from the field during the rainy season.

Intercropping: During winter, when the hybrid is dormant, oats, senji, metha or sarson can be intercropped.

Harvesting: The first cutting is ready in about 50 days after planting. Take subsequent cuttings when the crop is about one metre high. If the crop is allowed to grow beyond this height, its nutritive value falls drastically.

Note: If the fodder is not harvested at optimum stage (one metre plant height) and allowed to attain a height more than 2 metre, its use as a sole fodder should be avoided because such fodder becomes more lignified, less palatable and poorly digestible. The feeding of such fodder may cause rumen impaction *(Banh)* thereby resulting in constipation. In some cases, blood spots may appear with dung.

GUINEA GRASS

It is high quality multicut summer fodder. Its' plants have profuse tillering and more leaves. It is cultivated as annual fodder crop.

Climatic and Soil Requirements

It can be sown all over the state. It does best on well drained soils. Excessive moisture during germination kills the germinating seedling, hence a light irrigation should be given particularly in heavy soils.

Improved Varieties

PGG 518 (1998): Its' plants are erect with profuse tillering and leafy growth. Its' leaves are longer and broader than PGG 101. It flowers 5-7 days later than PGG 101 and thus maintains its forage quality for a longer period. The loss of nutrients is less in this variety if harvesting is delayed due to unavoidable circumstances. To harvest maximum nutrients, cut the crop for fodder at boot stage. In 5-6 cuttings from May to November, it produces 750 quintals green fodder per acre. It has low degree of seed shattering. Its' panicles are initially white in colour which change to light-yellow on maturity.

Agronomic Practices

Time and Method of Sowing: Guinea grass may be sown from mid-March to mid-May. Six to eight kg seed per acre is sown by kera in furrows 25 cm apart drawn by plough/cultivator. It can also be sown by broadcast in furrows prepared with cultivator followed by light planking with jindra/raking. The field should be irrigated immediately after sowing.

Fertilizer Application: Being a multicut grass, it responds to high fertility. Apply 20 tonnes of FYM to the soil before preparing the field. Apply 20 kg N (44 kg urea) per acre 20 days after sowing and the second dose of 10 kg N (22 kg urea) per acre 35 days after sowing. After each cutting apply 30 kg N (66 kg urea) with first irrigation.

Irrigation: First irrigation to guinea grass is given immediately after sowing. Second light irrigation essential for germination is given after about 4-6 days of first irrigation as soon as the surface gets dry. Subsequent irrigations are given at an interval of a week in summer and 10 days during September-November. During rainy season, irrigation is applied as and when needed. Excessive standing water must be drained away at the early seedling stage particularly in heavy soils.

Harvesting: The first cutting in guinea grass is ready in about 55 days after sowing. Subsequent cuttings are taken at an interval of 25-30 days. Harvesting very close to the ground delays the next cutting and may result in the death of stumps particularly in rainy season.

Seed Production

The crop sown for fodder is left for seed production in the last week of August and the seed gets matured by mid of October. Plant remains still green when seed matures. The seed crop is ready for harvest when the seed from the tip of the ear starts shattering. All the ears should be removed immediately and the green fodder could be fed to the animals later on. About 250 kg seed can be produced from one acre. One more fodder cutting may be taken from the same crop in November.

GUARA

Guara is a highly nutritious leguminous fodder for the animals. Its' dry pods and husk are relished by the cattle. It also enriches the soil.

Soil Type

Guara grows well on all types of soils. Well-drained, medium to light soils are very suitable.

Improved Variety

Guara 80 (1982): It is recommended for *barani* as well as irrigated conditions for cultivation throughout the state. It is tall, quick-growing, hairy and profusely branched type. This variety does not possess bunches on each node. It is a late maturing variety and yields about 125 quintals per acre of green fodder per acre.

Agronomic Practices

Land Preparation: One or two ploughings and a planking are sufficient.

Seed Rate and Sowing: Use 18-20 kg seed per acre. The crop may be sown from May to mid-August. The sowing should be done at a row to row distance of 30 cm by drill, *pora* or *kera* method. *Guara* can be grown under no-tillage to obtain the same green fodder yield as after conventional or zero till sown wheat.

Fertilizer Application: Drill 9 kg of N (20 kg urea) and 24 kg P_2O_5 (150 kg single superphosphate) per acre before sowing in the irrigated areas.

Irrigation: If the rainfall is well-distributed, the crop does not need any irrigation. Generally, 1 or 2 irrigations are required depending upon the rainfall.

Harvesting: The optimum stage of harvesting is between 90-100 days after sowing, corresponding to 100 per cent of flowering and pod initiation stages, respectively.

Seed Production: As recommended in *guara* seed crop.

Plant Protection Measures

Bihar hairy caterpillar *(Bhaboo Kuta)* attacks the crop during September-October. It can be controlled by collecting and destroying the egg masses and gregarious young larvae of the pest.

COWPEA

The cultivation of cowpea is recommended in the irrigated areas of the Punjab state. It can also be grown mixed with maize, bajra and sorghum to get not only higher yield but also increased nutrients from the green fodder. It enables the dairy cattle to maintain good milk yield during the hot and dry summer.

Soil Type

Well-drained loamy soil is conducive to a proper growth of the crop.

Improved Varieties

CL 367 (2005): It is dual purpose variety suitable for fodder as well as pulse purpose. Its' plants are erect with dark green leaves. It is tolerant to yellow-mosaic virus and anthracnose diseases. Its' fodder quality is superior in terms of total digestible nutrients (TDN) and digestible crude protein (DCP). It bears large number of pods. Its' seeds are small in size and creamish white in colour. The variety is also suitable for human consumption because it has very good cooking quality. On an average, it yields about 108 quintals of green fodder and 4.9 quintals of grains per acre.

Agronomic Practices

Land Preparation: Two ploughings followed by plankings are sufficient.

Seed Rate and Sowing Time: For fodder, sow 12 kg seed of CL 367 per acre from March to mid-July. When sown mixed with maize, seed rate is 6 kg of CL 367 and 15 kg of maize per acre.

Seed Inoculation: Dilute the 100 mL pack of liquid biofertilizer (*Burkholderia seminalis*) in one litre of water and thoroughly mix with the seed for one acre on a cemented floor. Air dry the treated seeds under shade and sow seed within two hours of inoculation.

Method of Sowing: Sow with a *pora* or seed-cum-fertilizer-drill or zero till drill in rows, 30 cm apart.

Fertilizer Application: Drill 7.5 kg N (16.5 kg urea) as a starter dose and 22 kg of P_2O_5 (140 kg single superphosphate) per acre at sowing. In case, cowpea fodder succeeds wheat which had received recommended level of P, omit the application of P to cowpea.

Irrigation and Drainage: The crop sown in May needs fortnightly irrigation till the advent of the monsoon. In all, 4 or 5 irrigations will be sufficient. Adequate drainage results in a good yield.

Harvesting: Harvesting stage of cowpea is between 55-65 days after sowing, which corresponds to pre-flowering stage and would produce good quality fodder.

Seed Production

Sow 8 kg seed in first week of August in lines 30 cm apart in proper soil moisture. The fertilizer application is the same as for the fodder crop.

Plant Protection

A. Insect-Pests

Jassid and black aphid: These insects attack this crop.

Bihar hairy caterpillar *(Bhaboo Kuta)***:** It attacks cowpea from August to November. To keep cowpea free from attack of this pest, plant a row of *til* (Sesamum) around cowpea field at the time of its sowing. Females prefer to oviposit on *til* rows from where larvae in gregarious phase should be collected and destroyed mechanically.

Stored Grain Insects: Pulse beetle (*Dhora*) causes severe damage to stored cowpea grains. For its control, see Stored Grain Insects in Annexure VI.

B. Diseases

Seed rot and Seedling mortality: It is caused by various seed-borne microflora. The infected seeds are shrivelled and discoloured. Infected seedlings are killed before these emerge out of soil and cause poor stand of the crop.

FODDER MIXTURES

It is advisable to grow fodders, whenever possible, as mixtures rather than as monocultures. Crop mixtures, which combine a non-legume, such as maize, *jowar*, and *bajra* with a legume, such as cowpea and *guara* provide a balanced diet for animals because legumes are important source of proteins and non-legumes are rich in energy. These mixtures would often require lower amounts of nitrogen application because of the legume component. Some of these mixtures can be sown more than once during the *kharif*. Harvest the fodder mixture when maize is in the milk-ripe to dough stages, when sorghum has one-half to one-third heads out and when *bajra* shows the emergence of ears from the flag leaves.

Bajra and sorghum can be successfully grown alone as well as in mixture with *guara* and cowpea in the rainfed *kandi* tract of the State. *Guara* and cowpea are also suitable fodder crops for mono-culture in that area.

SILAGE MAKING

An adequate supply of quality fodders during the lean periods of November-December and May-June can be ensured by preserving the green fodder as silage and Hay. Non-legume *kharif* fodders, such as, maize, sorghum, *bajra,* Napier-*bajra* hybrid and guinea grass which are rich in soluble sugars and low in protein possess excellent qualities for conserving as silage.

Stage of Harvesting: Harvest the crop for silage making when nutrient contents are at their peak stage and it has enough dry matter. A crop with 30-35 per cent dry matter conserves into a high quality silage. The optimum time for harvesting fodder crops for ensiling is given below:

Crop	Stage of harvest
Sorghum and Maize	Flowering to milk stage
Bajra	Boot stage
Napier-bajra hybrid and Guinea grass	1 metre tall

Crops harvested at the above given stages usually have the desired dry matter content. However, Napier hybrid and guinea grass need one or two days drying in the field before chaffing to reduce the moisture. To test the proper dry matter content, take a handful of chaffed fodder in between the hands and press it to form a ball. If the hands do not get moist, then, the fodder has the desired dry matter.

Silo-trench: The size of silo-trench depends upon the availability of green fodder, number of animals, quantity and period for which it is to be fed to animals . On an average, in one cubic metre space, 5-6 quintals of chaffed green fodder can be packed. In a 10 metre long, 3 metre wide and 1.5 metre deep silo-trench, about 350-400 quintals of chopped green fodder can be packed. Length and the width of the silo-trench can vary with the number of animals and their fodder requirement, but depth should always be kept at 1.5 to 2 metres. The trench should be made on a high level spot near the animal shed. It should be made pucca and cement plastered.

Method of Silage Making

- Chop the harvested crop to the length of 5 to 8 cm and pack into the silo trench.
- Press the chopped crop in the trench thoroughly with a tractor or bullock and raise it to 1 metre above the ground level, to create proper anaerobic conditions to make quality silage. Every half metre thick layer of chaffed fodder should be regularly pressed.
- Cover the fodder with 10-15 cm thick layer of kadbi or wheat bhusa. Put the mud on it and finally mud-plaster. See that the silo-trench is completely air-tight.
- Alternately, a plastic sheet may also be used to cover the packed forage. Edges of the sheet may be sealed by mud plastering.

- Keep an occasional watch and if there is any crack or hole, plug it immediately. Silage will be ready within 45 days.
- Open the silo-pit from one end only and take out the daily requirement of the feed. The remaining silage, if kept covered, stays good till used.
- A well preserved material has pH of 3.5-4.5 and is low in losses of nitrogen. A good quality silage almost retains the nutritional value of original crop and has a high lactic acid and a low butyric acid content.

Feeding the Silage: The animals may not like its taste for the first few feedings. Help them to develop the taste by mixing 5 to 10 kg of silage in their green fodder ration for the first 5 to 6 days. After taste development, 20 to 30 kg of silage along with other fodders may be fed per head per day.

HAY MAKING

The aim of hay-making is to reduce the moisture content of green fodder to below 15 per cent so that little or no change in nutritive value occurs during storage. The fodder crops having soft stems are suitable for hay-making. In legumes such as berseem, lucerne and cowpea, care should be taken to avoid shattering of leaves during drying. Non-legumes such as maize, *jowar, bajra* are more suitable for silage making than for hay making. Harvest the fodder crops at pre-flowering stage. Chop the fodder to a length of 5 to 8 cm and spread it in a 10-15 cm thick layer on a hard-surface to dry it in the sun. The usual threshing floor can also be used for this purpose.

To speed up the drying process, stir the fodder with a rake after every 2 to 3 hours during the day. When thoroughly dried (usually 2-3 days depending on the frequency of stirring), collect the dried material for storage. A practical method of determining the safe limit of moisture content for storage of dried material is to twist some of the stems. If the stem breaks easily, the hay is fit for storage. It can be stored in a room normally used for storing wheat *bhusa*. A kilogram of dried hay containing 90 per cent dry matter is equivalent to about 6 kilograms of green fodder containing 15 per cent dry matter.

7. OTHER CROPS

GUARA

Guara is one of the important legume crops which is grown for different purposes such as green fodder, grain, green manure and vegetable. It is known for its drought-resistance and soil renovation qualities. *Guara* seed is used as concentrate for animals and for extraction of gum which is an important foreign exchange earner. The gum has several uses in industry and in various food products. The *guara* meal which remains after extraction of the gum from the seed is a high protein cattle feed.

Soil Type

Guara grows well on all types of soil. Well drained, medium to light soils are very suitable.

Rotation

Adopt *guara* - wheat rotation in light textured soils for saving of water and maintenance of soil health in south-western region of Punjab.

Improved Varieties

HG-365 (2013): It is an early maturing branched variety. It matures in 105 days. Its' average seed yield is 5.3 quintals per acre.

Ageta Guara 112 (1982): Its' plants are erect, hairy, unbranched and medium in height (1-1.5 m). It bears clusters of pods at each node and has bold grains. This variety matures from the last week of October to mid-November. Its' average yield is 8 quintals per acre.

Guara 80 (1982): It is recommended for rainfed cultivation throughout the state. It is tall, quick growing, hairy and profusely branched type. It is resistant to *guara* leaf blight and stem breakage. This variety does not possess bunches on each node. Its' pods are medium sized and seeds are roundish flat in shape and light grey in colour. It is late maturing variety and yields 7 quintals per acre.

Agronomic Practices

Land Preparation: One or two ploughings and one planking are sufficient.

Seed Rate and Sowing: Use 8-10 kg seed per acre. The crop under rainfed and low fertility soil conditions should be sown with the onset of rains, but under irrigated and high fertility conditions, the crop should be sown in the first fortnight of July. Irrigated crop may be sown by using *kera* method but the rainfed crop should be sown by *pora* method in rows 45 cm apart. The seed-cum-fertilizer drill can be used for sowing.

Fertilizer Application: Apply 8 kg of N (17 kg of Urea) and 19 kg of P_2O_5 (120 kg of single superphosphate) per acre before sowing in irrigated areas.

Irrigation: The crop matures without any irrigation if the rains are normal and timely, otherwise one or two irrigations may be needed. However, the crop should not be irrigated after the third week of September as it delays the maturity of the crop and adversely affects the seed quality.

Plant Protection

Jassid suck the sap and damage the crop.

MENTHA

There are four species; *Mentha arvensis, Mentha piperita, Mentha spicata* and *Mentha citrata,* which can be grown commercially in the Punjab State. In 2023-24, area under this crop in the state was 13,652 hectares. Mentha oil obtained by distilling the green herb is used in pharmaceutical, flavour, cosmetic and perfume industries.

Climatic Requirements : Mentha can be grown all over the Punjab, wherever assured irrigation is available. It needs a well distributed rainfall of 200-250 mm and bright sunshine for good growth.

Soil Type: Well-drained, sandy loam to loamy soil with moderate to high organic matter, is best for this crop. The soil should be free from acidity, salinity, alkalinity and water-logging.

Rotations: Mentha-Potato, Mentha–*Toria*, Mentha–Oats (fodder), Mentha-Basmati, Mentha–Wheat–Maize–Potato, Mentha-Maize-Potato, Mentha-DSR-Potato, Mentha-DSBR-Potato

Improved Varieties

CIM Unnati (Subject to the approval by SAVC): It is high yielding variety of menthol mint (*Mentha arvensis* L.) with high oil content (0.81-0.83 %) in herb and suitable for planting from end of January to mid of February. Its average herb yield is 113 quintals per acre. It produces the highest herb and oil yield when harvested 145 day after planting.

CIM Kranti (2020): It is high yielding variety of menthol mint (*Mentha arvensis* L.) and suitable for planting from end of January to mid of February. Its oil content in herb is 0.6-0.7% and on an average produces 110 quintals per acre herb yield. It gets ready for harvesting 140-150 days after planting.

Kosi (2014): It is a high yielding variety of menthol mint (*Mentha arvensis* L.). On an average it gives 100-125 quintals per acre herb yield with oil content of 0.6 - 0.7%. It gives the highest herb and oil yield when harvested at 150 days after planting.

Punjab Spearmint 1: The stem is purple-green, branched, erect and hairy. Leaves are simple, opposite, oblong-ovate and dented. The flowers are purplish-white and arranged in long terminal spikes. Its plants are vigorous and on an average attain the height of 75 cm at flowering. The fresh herb contains 0.57% oil, rich in carvone.

Russian Mint: The stem is green, branched, erect, and hairy. The leaves are simple, opposite, ovate, serrate, hairy. The flowers are purplish, minute, borned in cyme. On an average its plants attain height of about 55 cm at flowering. Its fresh herb contains 0.57% oil with distinct woody flavour for which it is highly demanded by flavour industry.

- **Use two quintals of disease free sucker for planting an acre.**
- **Sow the crop during mid January to end January, however Kosi, CIM Kranti and CIM Unnati variety can be sown upto mid February.**
- **For water saving and higher yield, sow the crop on beds/ ridges and apply paddy straw mulch @ 24 quintals per acre.**
- **Grow mentha as an intercrop in sunflower/sugarcane or onion as an intercrop in mentha for higher returns.**

Agronomic Practices

Land Preparation: Two or three ploughings followed by planking are necessary to get a fine seedbed. The field should be free from stubbles and weeds.

Bio-fertilizers : Apply consortium bio-fertilizer @ 4 kg per acre as soil application before planting along with recommended fertilizer.

Seed Rate: Mentha is propagated through suckers. About 2 quintals of freshly dug 5-8 cm long suckers are enough for one acre. This quantity can be had from half kanal (10 marla) of mentha.

Method of Planting: The suckers are laid end to end, 4-5 cm deep in furrows, 45 cm apart and are then covered with soil by planking lightly. For higher biomass production and water saving, planting should be done on 67.5 cm wide beds (two rows) or ridges should be made at 60 cm spacing after broadcasting the suckers. Apply 24 quintal of paddy straw mulch per acre and apply a light irrigation after planting. Do not plant sprouted suckers, as most of such suckers die.

Time of Planting: The best planting time is the mid-January to the end of January, however, Kosi, CIM Kranti and CIM Unnati should be planted from end of January to mid of February. The crop can also be raised by transplanting in April.

Intercropping: Mentha can also be grown as intercrop. Plant one row of mentha between two rows of sugarcane. Mentha and sugarcane can be planted simultaneously in the first fortnight of February. Use one quintal of mentha suckers per acre. In addition to fertilizers recommended to sugarcane, apply 18 kg N (39 kg urea) and 10 kg P_2O_5 (62 kg super phosphate) per acre. Half N and full phosphorus may be applied at planting and remaining half N about 40 days after planting. Take only one cutting of mentha.

Mentha can be successfully intercropped with sunflower. Sow two rows of mentha in end January between two lines of sunflower grown at 120 cm x 15 cm in North-South direction. Use 150 kg of mentha suckers per acre. In addition to fertilizers recommended to sunflower, apply 23 kg N (50 kg urea) and 12 kg P_2O_5 (75 kg single superphosphate) per acre. Full phosphorus and half nitrogen be applied at planting and remaining half nitrogen at 40 days after planting.

Onion can be grown as intercrop in mentha. Both mentha and onion should be planted simultaneously from the mid-January to end January. Plant one row of onion in between the two rows of mentha planted at 45 cm, keeping plant to plant spacing of onion at 7.5 cm. Apply 13 kg N (29 kg urea), 7 kg P_2O_5 (44 kg SSP) and 7 kg K_2O (12 kg MOP) per acre in addition to recommended fertilizer of mentha. Full phosphorus and potash and half nitrogen be applied at planting and the remaining half nitrogen about 40 days after planting.

Fertilizer Application: Mentha responds favourably to organic manuring. Apply 10-15 tonnes of well-rotten farmyard manure per acre before planting. The following quantities of inorganic fertilizers are recommended:

Nutrients (kg/acre)		Fertilizers (kg/acre)		
N	P_2O_5	Urea	DAP*	or Single Super phosphate
60	16	130	35	100

* When 35 kg DAP is used, apply 115 kg urea per acre.

Drill one-fourth of nitrogen and the full quantity of phosphorus at planting. Apply another one fourth of nitrogen about 40 days after planting. Add the remaining half dose of nitrogen in two equal splits after the first cutting of the crop. The first split may be applied immediately and the second split 40 days afterwards.

Irrigation: Mentha requires frequent but light irrigations. Irrigate at 10 days interval till the end of March and at five or six days interval till the onset of the monsoon. During the rainy season, irrigate according to the need.

Drip Irrigation and Fertigation: Menthol mint should be drip irrigated at 3 days interval with a lateral pipe having dripper discharge of 2.2 litre per hour and dripper placed at 30 cm apart as per following schedule:

Month	Time of irrigation (Minutes)*
March	40
April	65
May	70
June	75

*If discharge rate is different, then time of irrigation may be adjusted proportionately by the formula:-

Adjusted time (min) = (2.2 × Time of irrigation (min)*) ÷ Discharge of dripper (litre/hour)

For first cut, apply 24 kg N and 12.8 kg P_2O_5 per acre in 10 equal splits with drip irrigation. Fertigate with first 1/10th of N and P_2O_5 with first irrigation just after planting and thereafter, remaining 9 doses of N and P_2O_5 should be fertigated in 9 equal splits at 9 days interval starting one month after planting. This will result in about 25 per cent higher oil yield along with saving of 36 per cent irrigation water and 20 per cent nutrients

over check basin. Use urea (46 %) and mono ammonium phosphate (12-61-0 grade) for supplying N and P_2O_5 respectively.

Weed Control: To obtain good yield and high-quality oil, the crop should be kept free from weeds at all the stages of growth. In the early stages of growth, a wheel-hoe may be used. Alternatively, pre-emergence application of 350 mL per acre Goal 23.5 EC (oxyfluorfen) using 200 litres of water can effectively control the weeds.

Harvesting and Yield: The crop should preferably be harvested at the flower initiation stage. If the lower leaves of the plants turn yellow and start shedding, harvesting may be done earlier. Harvest the crop, leaving 6-8 cm long stumps to secure better sprouting. Two cuttings can be taken, first in June and the second in September. The yield of the crop is 100-125 quintals per acre of fresh herbs which contains 0.5 to 0.75% oil.

Processing and Marketing: After harvesting, allow the crop to wilt overnight in the field and subject it to simple distillation. Some private distillation units provide facilities for farmers to extract oil. **The farmers are advised to plant mentha only in that area where the distillation units are available.**

Plant Protection

A. Insect Pests

1. Termite *(Odentoterms obseus):* Termites attack the underground parts of the plants and damage the roots and the stems of mentha.

2. Cutworm *(Agrotis spp.)***:** Cutworms cut the young plants at the ground-level. They remain hidden near the base of the plants during day-time.

3. Jassid and Whitefly: The attack of these sucking pests adversely affects the plant growth and oil content.

4. Hairy caterpillars: Hairy caterpillars, if appearing in an epidemic form, cause serious damage by feeding on the leaves and the tender stems. When young, they feed gregariously. The grown up caterpillars may migrate from one field to another. Adopt the following control measures:

- Use light-traps for the destruction of moths.
- Young larvae are gregarious. They can be destroyed by plucking the infested leaves or by pulling out the infested plants and burying them underground.

  The grown up caterpillars can be destroyed by crushing them under feet.

B. Diseases

1. Root rot and Stem rot *(Rhizoctonia bataticola)***:** The infected portion shows brown lesions which turn dark and later increase in size. The leaves wither and die. Uproot and destroy the infected plants. Do not take the planting stock from an infected field. Avoid growing mentha year after year in the same field.

DHAINCHA

Dhaincha (Sesbania aculeata) is an important leguminous crop, generally used as a green manure. When burried as green manure, apart from meeting some of the nitrogen requirement of the succeeding crop, it also improve the physical properties of the soil.

Soil Type

Dhaincha can grow well on all type of soils but sandy loam to loamy soils are very suitable. Dhaincha is relatively tolerant to both salinity and sodicity, however, for optimum yield gypsum should be applied to soils having pH more than 9.3 on soil test basis.

Improved Variety

Punjab Dhaincha 1: A bold seeded variety having quick growth. It has comparatively more nodules. Its' average grain yield is 7-8 quintals per ha. It takes about 150 days to mature.

Agronomic Practices

Seed Rate and Sowing: For green manure crop, sow 20 kg seed per acre with drill in lines 20-22.5 cm apart from April to July. However, for grain production, use 8 to 10 kg seed per acre for sowing from mid-June to mid-July in lines 45 cm apart.

Fertilizer Application: Apply 12 kg of P_2O_5 (75 kg of single superphosphate) per acre at the time of sowing both for grain as well as green manure purpose crop. Omit application of phosphorus if recommended dose of phosphorus has been applied to the preceding wheat.

Irrigation: The crop sown for green manure during the summer period require 3-4 irrigations depending upon the prevailing weather conditions. However, the grain crop should not suffer water stress at flower initiation and grain development stages.

Hoeing and Weeding: For grain purpose, the crop may require one hoeing after one month of sowing to keep the weeds under check.

Harvesting: For grain purpose, crop is ready for harvesting from mid-October to early November depending upon the period of sowing.

Plant Protection

Insect

Tobacco Caterpillar: The larvae of this insect feed on the leaves of germinating crop.

SUNNHEMP

Sunnhemp is an important leguminous crop, generally grown as fibre as well as green manure crop. It is very quick growing and has the advantage of tolerating adverse conditions of drought, salinity and acidity and used for reclaiming sodic soils. Incorporation of green matter of sunnhemp in the soil, improves its physical properties, prevents leaching and losses of nutrients, conserves soil moisture and creates access to deep soil layers. Its' green manuring can be done after the harvest of wheat.

Climatic Requirements

Sunnhemp grows well in tropical and subtropical climate, with 50 to 70 cm of well-distributed rainfall during the growing period.

Soil Type

Sunnhemp can grow well on all types of soils, except waterlogged soils, but loamy sand to loamy soils are more suitable.

Improved Varieties

PAU 1691: It is a quick growing variety with erect growth habit. The leaves are medium in size and green in colour. The flowers are yellow and pods are initially greenish yellow and turn blackish brown at maturity. It flowers in 60-62 days and matures in 136 days. The seeds are bold and black in colour. It attains the height of 160-220 cm and thus adds 4.0-6.5 tonnes green biomass or 1.0-2.0 tonnes dry biomass per acre to the soil when buried at 45-60 days after sowing. Its' average seed yield is 4.8 quintals per acre.

Narendra Sanai 1: It is a quick growing variety with erect growth habit. The leaves are broad in size and green in colour. The flowers are yellow and pods are initially light yellow and turn brown at maturity. It flowers in 98-100 days and matures in about 152 days. The seeds are bold and black in colour. It attains the height of 160-225 cm and thus adds 3.8-6.2 tonnes green biomass or 0.9-1.8 tonnes dry biomass per acre to the soil when buried at 45-60 days after sowing. Its' average seed yield is 3.9 quintals per acre.

Agronomic Practices

Time of Sowing: For seed production sow the crop in June. However, for green manuring this crop can be sown from April to July.

Seed Rate and Method of Sowing: For green manure crop sow 20 kg seed per acre either with drill in rows 22.5 cm apart or by broadcast. For seed production sow 10 kg seed per acre with drill in rows 45 cm apart. Soak the seed prior to sowing for better emergence.

Fertilizer Application: Apply 16 kg of P_2O_5 (100 kg single superphosphate) per acre at the time of sowing both for seed as well as green manure crop.

Irrigation: The crop sown for green manure during summer period requires 2-3 irrigations depending upon the prevailing weather conditions. However, the grain crop should not suffer water stress at the time of flowering and grain development stages.

Hoeing: For seed production, the crop may require one hoeing after one month of sowing to keep the weeds under check.

Harvesting: For seed production the crop is ready for harvesting from mid-October to early November, depending upon the period of sowing.

8. ORGANIC FARMING

Organic farming prohibits the use of synthetic agro-chemicals and relies on crop rotations, crop residues, animal manures, composts, legumes, green manures and on-farm wastes to maintain the soil productivity and to supply plant nutrients to the crops. Disease and insect-pest management is done by using biopesticides.

Basic organic standards

- Conversion from chemical to organic farming requires a three year conversion period during which all the practices should be organic.
- A buffer zone must be created around the organic field to avoid any contamination or run off from the adjoining chemical fields.
- Seed should be from the organic produce and should not be treated with any chemical. Genetically modified (GM) crops are not allowed. The cultural practices of organic crops like seed rate, sowing time and spacing may be same as that of conventional crops, if otherwise not mentioned.
- Herbicides should not be used for weed control and weeds should be managed by cultural practices/methods and need based weedings.
- Chemical fertilizers, pesticides and growth regulators are prohibited.

Organic crop production

The best fields should be preferred for organic farming. The yields of organic crops are less than the inorganically grown crops during initial 3-4 years but later on they may become equal. Organic farming can be practiced in the following cropping systems:

1. Rice/Basmati Rice-Wheat

Rice/Basmati Rice

Biofertilizers: Make a solution of one packet of *Azospirillum* biofertilizer in requisite amount of water so as to dip the root of nursery seedlings for one acre in this solution for 45 minutes and transplant immediately.

Nutrition: The nutritional requirement of crop can be met by green manuring. Grow cowpea or sunnhemp or dhaincha by using a seed rate of 20 kg per acre and incorporate about 50 days old crop just before transplanting the rice/basmati. The green manure crop can also be sown with no-till drill after harvesting wheat.

Weed Control: The water should be ponded for first 20-25 days. One manual weeding can be done as per need.

Insect-Pest Control

Stem borers: The larvae of these insects bore into the stem and cause damage from July-October. The infected young plants show dead-hearts whereas the old one produce empty earheads which turn white and stand erect. Use two tricho-cards each of *Trichogramma japonicum* and *T. chilonis* per acre, each card having 20,000 parasitized eggs of *Corcyra cephalonica*, 5-6 times at weekly interval, starting from 30 days after transplanting. Cut

each tricho-card into 20 strips, each having approximately 1000 parasitized eggs. Staple these strips on the underside of leaves uniformly at 40 spots per acre during evening hours. These tricho-cards are available at the Biocontrol Labs, Department of Entomology, PAU Ludhiana and Regional Station, Gurdaspur.

Spray the crop with 80 mL neem based bio-pesticide, Ecotin (azadirachtin 5%) or 1000 mL or Neem Kavach/Achook (azadirachtin 0.15 %) in 100 litres of water per acre at pest initiation stage.

Leaf folder: The Larvae fold the leaves, eat out the green tissue and produce whitestreaks. The mechanical control of leaf folder can be done only before flowering by passing the 20-30 m long coir/jute rope, forwards and then backwards, both ways while touching the crop canopy. While passing the rope, ensure that water must be standing in the crop.

Biological control with neem and tricho-cards is same as mentioned for stemborers.

Planthoppers: These hoppers include whitebacked planthopper and brown planthopper. Both nymphs and adults of these pests suck the cell sap particularly from the leaf-sheath from July to October. The crop dries up in patches. As the plants dry up, the hoppers migrate to the adjoining plants and kill them. In a few days, the area of the dry patches enlarges. About one month after transplanting, a few plants in the field should be slightly tilted and tapped 2 or 3 times at the base at weekly interval. When planthoppers are noticed floating in the water, spray 80 mL Ecotin (azadirachtin 5%) or 4 litres PAU Homemade Neem Extract* in 100 litres of water per acre. Prefer Ecotin or PAU Homemade Neem Extract at pest initiation stage. Repeat the spray if necessary. For better effectiveness, use knapsack sprayer while directing its spray towards the base of the plants. If the damage is noticed at hopper burn stage, treat the affected spots along with their 3-4 metre periphery immediately as these spots harbor high population of the insect.

*Method of preparation is same as given under Cotton chapter at page no. 53.

Grasshoppers: The adults and nymphs of the grasshoppers eat the leaves especially in nursery. The biopesticides recommended for the control of planthoppers are also effective for grasshoppers.

Wheat

Method of Sowing: Wheat may be sown with any one of the conventional methods as given in wheat chapter. Prefer raised bed sowing with bed planter (2 rows on 37.5 cm wide bed with 30 cm furrow between two beds) for better weed control.

Seed Inoculation: Inoculate recommended quantity of seed for one acre with 500 g consortium or 250 g each of *Azotobacter* and *Streptomyces* (Azo-S) biofertilizer and one litre of water on pucca floor. Let it dry in shade and sow immediately.

Organic Manures: The organic sources like FYM and compost can be used. The quantity of the organic sources depends on the nitrogen content of the source and the organic matter content of the soil. These organic sources can be applied at the rate of 80, 120 and 160 kg N per acre in soils having high, medium and low organic matter content, respectively. The above amount of nitrogen can be obtained from the 8, 12 and 16 tonnes

of FYM. To desi varieties of wheat apply half the doses of organic sources in respective soils. The nutritional requirement of 50 kg nitrogen per acre to wheat can also be supplied through FYM, vermicompost and castor cake, each supplying 1/3 of the total nitrogen requirement. Apply 1.7 tonnes per acre FYM (1% N), 1.1 tonnes per acre vermicompost (1.5% N) and 0.7 tonnes per acre castor cake (2.5% N). The quantity of FYM may be increased or decreased depending upon its N content.

Weed Control: Cultural methods recommended for conventional crop can be used to control the weeds. The practices like dry soil surface mulch, stale seed bed, manual weeding before first irrigation and uprooting the weeds before they produce seeds can be followed to control the weeds. Give hand weedings as per the need.

Insect-Pest Control: There is no serious problem of insect-pests. The natural predators (*Coccinella septumpunctata*) become active on the appearance of the aphid. In case aphid infestation exceeds economic threshold level of 5 aphids per earheads (recorded from 10 randomly selected ear heads in each of the 4 quarters of one acre field), spray 2 litre per acre PAU homemade neem extract* at weekly interval in 80-100 litres of water per acre using knap sack sprayer.

*Method of preparation is same as given on page no 53 under Cotton chapter

For the management of yellow rust of wheat in organic farming spray 20% fermented buttermilk (For one acre, dissolve 40 litres of fermented buttermilk in 200 litres of water) after one month of wheat sowing followed by three more spray after the appearance of yellow rust at an interval of ten days on moderately resistant varieties.

2. Maize/Soybean-Wheat

Maize

Seed Inoculation: Mix half kg packet of recommended consortium biofertilizer with one litre of water and then thoroughly mix it with maize seed on clean pucca floor. Let it dry in shade and sow the seed immediately.

Organic Manures: Incorporate the residues of previous wheat crop in the field. Apply well rotten farm yard manure on dry weight basis @ 8 tonnes per acre during the first five years and later on reduce it by 50 per cent. The green manure crop like sunnhemp/dhaincha should be sown @ 20 kg seed per acre in the third week of April or immediatly after harvesting wheat. Incorporate 40 to 45 days old green manure crop at 5 to 7 days before sowing the maize.

Weed Control: Give two hoeings about 15 to 30 days after sowing with *khurpa/kasaula/* wheel-hoe/*triphali/*tractor-drawn cultivator or grow one or two rows of fodder cowpea in between maize rows and harvest it at 35 to 45 days after sowing, thereafter no weed control operation is required. For inter-cropping of cowpea, use 16 kg per acre for variety cowpea 88 and 8 kg per acre for variety CL 367. Sow maize and cowpea simultaneously.

Insect-Pest Control: To control maize borer and other insects, apply bio-insecticides like 120 mL per acre Neemazal (1%). The maize borer can also be managed by using tricho-cards twice having 40,000 eggs of *Corcyra* parasitized by *Trichogramma chilonis*. Make first release on 10 days old crop and second one week after first release. Cut tricho-

cards into 40 equal strips and staple them uniformL y on the underside of the central whorl leaves in evening hours. The tricho-cards should not be applied on rainy days.

Soybean

Seed Inoculation: Moisten the seed recommended for one acre with minimum amount of water and mix throughly one packet of *Bradyrhizobium* sp. (LSBR 3) with it and let it dry in shade. Sow the seed immediately.

Organic Manures: Incorporate the residues of previous wheat crop in the field. Apply well rotten farm yard manure on dry weight basis @ 4 tonnes per acre during the first five years of the start of organic farming and later on reduce it by 50 per cent. The green manure crop like sunnhemp/dhaincha should be sown @ 20 kg seed per acre in the third week of April or immediately after harvesting wheat. Incorporate 40-45 days old green manure crop at 5 to 7 days before sowing the soybean.

Weed Control: Apply 24 quintals per acre rice straw mulch at the time of sowing and if needed, give one hand weeding to remove the emerged weeds. Paddy straw bale shredder cum mulcher can be used for mulching of paddy straw (See Annexure V). If paddy straw mulch has not been applied then give need based 2-3 weedings.

Insect-Pest Control: For controlling white fly and other insects, apply bio-insecticides like 120 mL per acre Neemazal (1%).

Wheat

Method of Sowing: Wheat may be sown with any one of the conventional methods as given in wheat chapter. Prefer raised bed sowing with bed planter (2 rows on 37.5 cm wide bed with 30 cm furrow between two beds) for better weed control.

Seed Inoculation: Inoculate recommended quantity of seed for one acre with 500 g consortium or 250 g each of *Azotobacter* and *Streptomyces* (Azo-S) biofertilizer and one litre of water on pucca floor. Let it dry in shade and sow immediately.

Organic Manures: Incorporate the residues of previous maize or soybean crop in the field. Apply well rotten farm yard manure on dry weight basis @ 8 tonnes per acre during the first five years of the start of organic farming and later on reduce it by 25 per cent.

Weed Control: Give need based 2-3 weedings.

Insect-Pest Control: There is no serious problem of insect-pests. The natural predators (*Coccinella septempunctata*) become active on the appearance of the aphid. In case aphid infestation exceeds economic threshold level of 5 aphids per earheads (recorded from 10 randomly selected ear heads in each of the 4 quarters of one acre field), spray 2 litre per acre PAU homemade neem extract* at weekly interval in 80-100 litres of water per acre using knap sack sprayer.

*Method of preparation is same as given under cotton chapter

For the management of yellow rust of wheat in organic farming spray 20% fermented buttermilk (For one acre, dissolve 40 litres of fermented buttermilk in 200 litres of water) after one month of wheat sowing followed by three more spray after the appearance of yellow rust at an interval of ten days on moderately resistant varieties.

3. Maize-Potato-Onion

This cropping system enables to harvest the comparable yield with the chemical farming in the very first year if potato is intercropped with radish and onion with coriander. Sow maize in 1st fortnight of June, potato in the 1st fortnight of October and transplant onion in the 1st fortnight of January.

Maize

Seed Inoculation: Inoculate the seed as given under maize/soybean-wheat system in this chapter.

Organic Manures: The nutritional requirement of 50 kg nitrogen per acre to maize can be supplied through 1.7 tonnes FYM (1% N) + 1.1 tonnes vermicompost (1.5% N) + 0.7 tonnes castor cake (2.5% N).

Weeds and Insect-Pest Control: Control pests as given under maize/soybean-wheat system in this chapter.

Potato

Biofertilizers: Apply consortium biofertilizer @ 4 kg per acre as soil application at planting.

Organic Manures: The nutritional requirement of 75 kg nitrogen per acre to potato can be supplied through 2.5 tonnes FYM (1% N) + 1.7 tonnes vermicompost (1.5% N) + 1.0 tonnes castor cake (2.5% N).

Weed Control: Give need based mechanical or manual weedings.

Intercropping: Radish can be intercropped in potato in the first fortnight of October on the southern side of each potato ridge and can be dugout in December after 50-70 days after sowing.

Onion

Biofertilizers: Apply consortium biofertilizer @ 4 kg per acre as soil application at the time of transplanting or mix two packets (0.5 kg each) of biofertilizer (*Azotobacter* sp. + *Sphingobacterium* sp. + *Burkholderia* sp.) in 80-100 litres of water. Dip the roots of rabi onion seedlings for one acre in this mixture for 30 minutes and transplant immediately.

Organic Manures: The nutritional requirement of 40 kg nitrogen per acre to onion can be supplied through 1.3 tonnes FYM (1% N) + 0.9 tonnes vermicompost (1.5% N) + 0.5 tonnes castor cake (2.5% N).

Intercropping: Coriander can be intercropped in transplanted onion by sowing one row of coriander after every five rows of onion in the first fortnight of January and can be harvested as green coriander 40 days after sowing and as seed crop in the second week of May.

4. Maize-Potato-Summer *Moong*

Maize

Seed Inoculation: Inoculate the seed as given under maize/soybean-wheat system in this chapter.

Organic Manures: The nutritional requirement of 50 kg nitrogen per acre of maize

can be met through 5.0 tonnes dry FYM (1% N) or 3.3 tonnes dry FYM and 1.1 tonnes vermicompost (1.5% N).

Weeds and Insect-Pest Control: Control pests as given under maize/soybean-wheat system in this chapter.

Potato

Biofertilizers: Apply consortium biofertilizer @ 4 kg per acre as soil application at the time of planting.

Organic Manures: The nutritional requirement of 75 kg nitrogen per acre of potato can be met through 7.5 tonnes dry FYM (1% N) or 5.0 tonnes dry FYM and 1.7 tonnes vermicompost (1.5% N).

Weed Control: Give need based mechanical or manual weedings.

Summer *moong*

Seed Inoculation: Inoculate the seed with single packet of consortium biofertilizer (*Rhizobium* sp. LSMR-1 and Rhizobacterium RB-3) at the time of sowing. Moisten the seed using one packet per acre with about 300 mL of water. Mix the seed thoroughly with culture and let it dry in the shade. Sow the seed within one hour of application of biofertilizer.

Organic Manures: The nutritional requirement of 5 kg nitrogen per acre of summer moong can be met through 0.5 tonnes dry FYM (1% N) or 0.3 tonnes dry FYM and 0.1 tonnes vermicompost (1.5% N).

Weed Control: Give need based manual weedings.

5. Maize-*Durum* Wheat-Cowpea (fodder)

Maize

Seed Inoculation: Inoculate the seed as given under maize/soybean-wheat system in this chapter.

Organic Manures: The nutritional requirement of 50 kg nitrogen per acre to maize can be supplied through FYM, vermicompost and castor cake each supplying 1/3 of the total nitrogen requirement. Apply 1.7 tonnes per acre FYM (1% N) + 1.1 tonnes per acre vermicompost (1.5% N) + 0.7 tonnes per acre castor cake (2.5% N).

Weeds and Insect-pest Control: Control pests as given under maize/soybean-wheat system in this chapter.

Durum wheat

Seed Inoculation: Inoculate recommended quantity of seed for one acre with 500 g consortium or 250 g each of Azotobacter and Streptomyces (Azo-S) biofertilizer and one litre of water on pucca floor. Let it dry in shade and sow immediately.

Organic Manures: The nutritional requirement of 50 kg nitrogen per acre to durum wheat can be supplied through FYM, vermicompost and castor cake each supplying 1/3 of the total nitrogen requirement. Apply 1.7 tonnes per acre FYM (1% N) + 1.1 tonnes per acre vermicompost (1.5% N) + 0.7 tonnes per acre castor cake (2.5% N).

Weed Control: Integrated cultural practices should be adopted to reduce the incidence of weeds and the emerged weeds should be removed manually or mechanically twice or thrice depending upon the weed intensity.

Cowpea Fodder

Organic Manures: There is no need to apply any nutritional input to the cowpea fodder in this system as it grows well on the residual fertility of soil.

6. Turmeric-Onion

Turmeric

Biofertilizers: Apply consortium biofertilizer @ 4 kg per acre as soil application at the time of planting.

Organic Manures: The nutrition requirement of turmeric can be met by applying 6 trolleys of farmyard manure (6 tonnes of fully dried farmyard manure having 1% N) per acre. In case of non-availability of required farmyard manure, apply 4 trolleys of farmyard manure (4 tonnes of fully dried farmyard manure) supplemented with 1.3 tonnes of vermicompost (1.5% N).

Weed Control: Apply 40 quintals per acre paddy straw mulch at the time of planting and if needed, give one hand weeding at 3 months after planting. Paddy straw bale shredder cum mulcher can be used for mulching of paddy straw (See Annexure V). If straw mulch is not applied then give three hand weedings at 1, 2 and 3 months after planting the crop.

Onion

Biofertilizers: Apply consortium biofertilizer @ 4 kg per acre as soil application at the time of transplanting or mix two packets (0.5 kg each) of biofertilizer (*Azotobacter* sp. + *Sphingobacterium* sp. + *Burkholderia* sp.) in 80-100 litres of water. Dip the roots of *rabi* onion seedlings for one acre in this mixture for 30 minutes and transplant immediately.

Organic Manures: The nutritional requirement of onion can be met by applying 4 trolleys of farmyard manure (4 tonne of fully dried farmyard manure having 1% N). In case of non availability of required farmyard manure, apply 3 trolleys of farmyard manure (2.7 tonnes of fully dried farmyard) supplemented with 0.9 tonnes vermicompost (1.5% N). Apply consortium biofertilizer @ 4 kg per acre as soil application at the time of transplanting.

Weed Control: Weeds should be controlled by manual hoeing.

7. *Gobhi Sarson*

Sowing Method: Use 1.5 kg seed per acre. Sow the crop in rows 67.5 cm apart with plant to plant spacing of 10 cm.

Organic Manures: Apply 4 tonnes well rotten FYM (1.0% N) per acre at the time of sowing followed by three sprays of neem enriched FYM extract at 15 days interval starting at 50 days after sowing. The quantity of FYM may be increased or decreased depending upon its N content.

Preparation of neem enriched FYM extract: Take 30 liters of water in a plastic drum and put 10 kg well rotten FYM in it. Add 3 kg fresh neem leaves to it. Keep this solution

for 15-20 days under shade and keep stirring this after every 2 days. After 15-20 days, filter this solution and use the filtrate for spraying by using extract and water in 1:2 ratio.

Weed Control: Weeds can be managed by mechanical weeding with tractor or power weeder at 25 and 45 days after sowing. The escaped weeds, if any, can be removed by hand weeding.

Mustard aphid (*Lipaphis erysimi*)**:** Cold and cloudy weather is very favourable for the development of mustard aphid. The green plant lice become innumerable, covering the inflorescence and siliquae. They suck the plant sap in huge quantities and as a result, the plants remain stunted, siliquae shrivel up and seeds do not develop. The following integrated pest management programme is recommended for its effective control under organic farming conditions:

i. Sow the crop at recommended time preferably up to 3rd week of October
ii. Apply recommended dose of organic manures
iii. Spray any of the following biopesticides using 80-125 litres of water per acre at initiation of aphid attack, and repeat application at weekly interval, if required

Homemade neem extract - 4 litres

Modified *Brahmastra* - 4 litres

Preparation:

a) Homemade neem extract: Boil 4.0 kg terminal parts of the shoots of neem trees including leaves, green branches and fruits in 10 litres of water for 30 minutes. Then, filter this material through muslin cloth and use the filtrate for spraying at the recommended dose.

b) Modified *Brahmastra*: Put 2 kg leaves of guava, papaya, karanj and castor each, and 5 kg leaves of neem after grinding (paste form with little bit water) into 10 litres of dairy cattle urine. Boil the extract for 30 mintues and keep under shade for 48 hours followed by filtration. Use the filtrate as per recommended dose. This extract can be stored up to 5 months.

8. *Kharif moong*-Wheat-Summer *moong*

Kharif moong

Seed Inoculation: Moisten the seed recommended for one acre with minimum amount of water and mix it thoroughly with one packet of recommended Rhizobium culture and let it dry in shade. Sow the seed immediately.

Organic Manures: Apply 1.1 tonnes per acre farmyard manure (1.0% N) on dry weight basis at the time of sowing.

Weed Control: Give need based hand weedings.

Insect-Pest Control: If needed, neem based biopesticides may be used to control insect-pests.

Wheat

Method of Sowing: Wheat may be sown with any one of the conventional methods as given in wheat chapter of *Rabi* package, 2024-25. Prefer raised bed sowing with bed

planter (2 rows on 37.5 cm wide bed with 30 cm furrow between two beds) for better weed control.

Seed Inoculation: Inoculate recommended seed for one acre with 500 g consortium or 250 g each of Azotobacter and Streptomyces (Azo-S) biofertilizer and one litre of water on pucca floor. Let it dry in shade and sow immediately.

Organic Manures: Apply 5 tonnes per acre well decomposed farmyard manure on dry weight basis at the time of sowing.

Weed Control: Give need based 2-3 weedings.

Insect-Pest Control: The natural predators (*Coccinella septempunctata*) become active on appearance of the aphids. In case of aphid infestation, spray 2 litre per acre PAU homemade neem extract* at weekly interval in 80-100 litres of water using knap sack sprayer.

*Method of preparation is same as given under cotton chapter.

For the management of yellow rust of wheat in organic farming spray 20% fermented buttermilk (For one acre, dissolve 40 litres of fermented buttermilk in 200 litres of water) after one month of wheat sowing followed by three more spray after the appearance of yellow rust at an interval of ten days on moderately resistant varieties.

Summer *Moong*

Seed Inoculation: Inoculate the recommended seed for one acre with single packet of consortium biofertilizer (*Rhizobium* sp. LSMR-1 and *Rhizobacterium* RB-3) at the time of sowing. Moisten the seed with about 300 mL of water and mix thoroughly with culture and let it dry in the shade. Sow the seed within one hour of application of biofertilizer.

Organic Manures: Apply 0.5 tonnes per acre farmyard manure (1.0% N) on dry weight basis at the time of sowing.

Weed Control: Give need based hand weedings.

9. Okra-Radish-Pea

Okra

Organic Manures: Apply 3.6 tonnes farm yard manure per acre (1.0 % N) on dry weight basis at the time of sowing.

Mulching: Immediately after sowing, apply 3.6 tonnes per acre paddy straw mulch.

Weed Control: Use of mulch effectively manages weeds. Escaped weeds, if any, can be removed by hand weeding.

Insect-Pest Control: If needed, neem based biopesticides may be used to control insect-pests. For the management of jassid and whitefly, spray 80 mL Ecotin 5% (neem-based insecticide) or 2.0 litre PAU Homemade Neem Extract*. Method of preparation of neem extract is same as given earlier.

Radish

Organic Manures: Apply 2.5 tonnes farm yard manure per acre (1.0% N) on dry weight basis at the time of sowing.

Mulching: Apply 3.2 tonnes per acre paddy straw mulch immediately after sowing.

Weed Control: Use of mulch effectively manages weeds. Escaped weeds, if any, can be removed by hand weeding.

Insect-Pest Control: If needed, neem based biopesticides may be used to control insect-pests.

Pea

Seed Inoculation: Treat the seed with bacterial culture (*Rhizobium leguminosarum*). One acre culture packet should be mixed with half litre of water. Rub the mixture thoroughly on seed to give a fine covering of the culture to every seed. Thereafter, spread the seed in shade for drying and sow it immediately afterwards.

Seed Treatment: Treat the seed with 15 g Talc based formulation of *Pseudomonas fluorescens* per kg seed before sowing to control wilt, root rot and collar rot (*Fusarium oxysporum* and *Rhizoctonia solani*) diseases.

Organic Manures: Apply 2.0 tonnes farm yard manure per acre (1.0% N) on dry weight basis at the time of sowing.

Mulching: Immediately after sowing, apply 4.0 tonnes per acre of paddy straw mulch. Paddy straw bale shredder cum mulcher can be used for mulching of paddy straw (See Annexure V).

Weed Control: Use of mulch effectively manages weeds. Escaped weeds, if any, can be removed by hand weeding.

Insect-Pest Control: If needed, neem based biopesticides may be used to control insect-pests.

10. Brinjal-Pea

Brinjal

Organic manures: Apply 5 tonnes farmyard manure per acre (1.0% N on dry weight basis) at the time of seed bed preparation. The quantity of FYM may be increased or decreased depending upon its N content.

Weed management: Apply 4.8 tonnes per acre paddy straw mulch immediately after transplanting. Use of mulch effectively manages weeds. Paddy straw bale shredder cum mulcher can be used for mulching of paddy straw (see Annexure V). The escaped weeds, if any, can be removed by hand weeding.

Insect-pest management: For management of whitefly, spray 1200 mL PAU Neem Extract* or 1500 mL maize/sorghum/bajra juice per acre.

*Method of preparation: Boil 4.0 kg terminal parts of the shoots of neem trees including leaves, green branches and fruits in 10 liters of water for 30 minutes. Then filter this material through muslin cloth and use the filtrate for spraying at the recommended dose.

Pea

Seed treatment: Treat the seed with 15 g Talc based formulation of *Pseudomonas fluorescens* per kg seed before sowing to control wilt, root rot and collar rot **(***Fusarium oxysporum* and *Rhizoctonia solani***)** diseases.

Seed inoculation: Treat the seed with bacterial culture (*Rhizobium leguminosarum*) to ensure nodule formation and quick growth. One acre culture packet should be mixed with half litre of water. Rub the mixture thoroughly on seed to give a fine covering of the culture to every seed. Thereafter, spread the seed in shade for drying and sow it immediately afterwards.

Organic manures: Apply 2 tonnes farmyard manure per acre (1.0% N on dry weight basis) at the time of seed bed preparation. The quantity of FYM may be increased or decreased depending upon its N content.

Weed management: Apply 4 tonnes per acre paddy straw mulch immediately after sowing. Use of mulch effectively manages weeds. The escaped weeds, if any, can be removed by hand weeding.

Insect-pest management: If needed, neem based biopesticides may be used to control insect-pests.

11. Maize-Pea-Summer *moong*

Maize

Seed Inoculation: Mix half kg packet of recommended consortium bio-fertilizer with one litre of water and then thoroughly mix it with maize seed on clean pucca floor. Let it dry in shade and sow the seed immediately.

Organic Manures: The nutritional requirement of 50 kg nitrogen per acre to maize can be supplied through 1.7 tonnes FYM (1% N) + 1.1 tonnes vermicompost (1.5% N) + 0.7 tonnes castor cake (2.5% N).

Weeds and Insect-Pest Control: Control pests as given under maize/soybean-wheat system in this chapter.

Pea

Seed inoculation: Treat the seed of one acre with half kg packet having consortium of three bacterial cultures (*Rhizobium leguminosarum* + PSB+ PGPR) to ensure nodule formation and quick growth. Rub the mixture thoroughly on seed to give a fine covering of the culture to every seed. Thereafter, spread the seed in shade for drying and sow it immediately afterwards.

Seed Treatment: Treat the seed with 15 g Talc based formulation of *Pseudomonas fluorescens* per kg seed before sowing to control wilt, root rot and collar rot (*Fusarium oxysporum* and *Rhizoctonia solani*) diseases.

Organic Manures: Apply 2.0 tonnes farm yard manure per acre (1.0% N) on dry weight basis at the time of sowing. The nutritional requirement of 20 kg nitrogen per acre to pea can also be met through 0.7 tonnes FYM (1% N), 0.44 tonnes vermicompost (1.5% N) and 0.28 tonnes castor cake (2.5% N) each supplying 1/3 of the total nitrogen requirement.

Mulching: Immediately after sowing, apply 4.0 tonnes per acre of paddy straw mulch. Paddy straw bale shredder cum mulcher can be used for mulching of paddy straw (See Annexure V).

Weed Control: Use of mulch effectively manages weeds. Escaped weeds, if any, can be removed by hand weeding.

Insect-Pest Control: If needed, neem based biopesticides may be used to control insect-pests.

Summer *Moong*

Seed Inoculation: Inoculate the seed with single packet of consortium biofertilizer (*Rhizobium* sp. LSMR-1 and *Rhizobacterium* RB-3) at the time of sowing. Moisten the seed

using one packet per acre with about 300 mL of water. Mix the seed thoroughly with culture and let it dry in the shade. Sow the seed within one hour of application of biofertilizer.

Organic Manures: The nutritional requirement of 5 kg nitrogen per acre of summer moong can be met through 0.5 tonnes dry FYM (1% N) or 0.3 tonnes dry FYM and 0.1 tonnes vermicompost (1.5% N). The nutritional requirement of 5 kg nitrogen per acre of summer moong can also be met through through 0.17 tonnes FYM (1% N), 0.11 tonnes vermicompost (1.5% N) and 0.07 tonnes castor cake (2.5% N) each supplying 1/3 of the total nitrogen requirement.

Weed Control: Give need based manual weedings.

12. Mentha (*Pudina*)

Seed Rate: About 2 quintals of freshly dug 5-8 cm long suckers are enough for one acre. This quantity can be had from half *kanal* (10 *marla)* of mentha.

Bio-fertilizers: Apply consortium bio-fertilizer @ 4 kg per acre as soil application before planting along with recommended fertilizer.

Organic Manures: Mentha responds favourably to organic manuring. Apply 6 tonnes FYM per acre (1.0 % N) on dry weight basis before planting. The quantity of FYM can be increased or decreased depending upon its N content.

Weed Control: To obtain good yield and high-quality oil, the crop should be kept free from weeds at all the stages of growth. For higher yield, apply paddy straw mulch @ 24 quintals per acre. Paddy straw bale shredder cum mulcher can be used for mulching of paddy straw (See Annexure V).

Irrigation: Mentha requires frequent but light irrigations. Irrigate at 10 days interval till the end of March and at five or six days interval till the onset of the monsoon. During the rainy season, irrigate according to the need.

13. Organic Fodder Production

The production technology for organic fodders is similar to that of conventional fodder crops except that chemical fertilizers, herbicides, insecticides and fungicides are not to be used on organic crops. The quantity of farmyard manure may be adjusted as per the nitrogen content of the farmyard manure.

Maize-Berseem-*Bajra*: Apply 3.5 tonnes of dry farmyard manure (1% N) per acre and sow maize in 2nd week of August. Harvest it after 50-60 days after sowing between milk ripe and dough stage of grain development. Then apply 1.0 tonnes of dry farmyard manure and sow berseem in the 2nd week of October which gives 4-5 cuttings. After berseem harvesting, apply 2.0 tonnes of dry farmyard manure and sow bajra in the 2nd week of June. Harvest it after 45-55 days after sowing at the ear initiation stage.

Maize-Berseem-Maize+Cowpea: Apply 3.5 tonne of dry farmyard manure (1%N) per acre and sow maize in 2nd week of August. Harvest it after 50-60 days after sowing between milk ripe and dough stage of grain development. Then apply 1.0 tonne of dry farmyard manure and sow berseem in the 2nd week of October which gives 4-5 cuttings. After berseem harvesting, apply 3.5 tonnes of dry farmyard manure and sow maize+cowpea mixture in 2nd week of June by using 15 kg seed of maize and 15 kg of Cowpea 88 variety

or 6 kg of CL 367. Harvest the mixture after 50-60 days after sowing at milk ripe to dough stage of grain development in maize.

Management of Maize Borer: The maize borer can be controlled by using tricho-cards twice having 50,000 eggs of *Corcyra cephalonica* per acre parasitized by *Trichogramma chilonis*; first release on 10 days old crop and second one week after first release. Cut tricho-cards into 50 strips, each having approximately 1000 parasitized eggs. Place these strips in the central whorl uniformL y at 50 spots per acre during evening hours. These tricho-cards are available at the Biocontrol Labs, Department of Entomology, PAU Ludhiana and Regional Station, Gurdaspur.

Note: The bio-fertilizer cultures are available with the PAU Seed Shop at Gate No. 1, *Krishi Vigyan Kendras* and Farm Advisory Service Centres in different districts.

Certification of Organic Produce

The Government of India has formulated organic standards for certified organic production and accredited inspection and certification agencies to certify organic farms based on these organic standards. The farmers who want to get their farms certified as organic can contact these agencies. The addresses of these inspection and certification agencies can be had from the APEDA website www.apeda.gov.in

Method of Preparing Phospho-compost

Collect rice-straw from fields and bring it to the composting site near the tubewell on the farm to have easy water availability. It can be made into bundles of convenient size (about 10-15 kilograms). Prepare large quantity of a "soaking solution" by thoroughly mixing one kg cow dung for every 1000 litre of water in a big tank. (The volume of the tank can be calculated by measuring Length x Breadth x Height of the tank in metres. One cubic metre is equal to 1000 Litres of water). Dip the bundles one by one into the "soaking solution" for 2-3 minutes.

Drain the excess solution by placing the bundles on a slope lined with a plastic sheet. The drip should be collected and recycled into the tank again. Make 15 cm raised beds 5 metre long and 1.5 metre wide on the ground. This will help in assessing the exact watering of the heap later. Draining of water out of bed is a visual indication of excess watering.

Take the wet rice-straw to the location of the compost heap. Line the bed with 2-6 centimetre diameter tree branches/sticks. This helps in aeration in the heaped rice-straw. The wet rice straw will generally have 70 per cent moisture. Place the wet rice straw on the beds uniformly until 500 kilograms has been stacked. Powdered low-grade rock phosphate (low grade rock phosphate can be had from Rajasthan State Mines and Minerals Ltd 4, Meera Marg, Udaipur 313004) should be mixed @ 6 per cent on dry weight basis of the rice straw approximately. For 500 kilogram of the rice straw, 30 kg of the rock phosphate should be sprinkled uniformly while making the heap after wetting. This will give approximately 1% phosphorus in the final decomposed product. The height of 500 kg rice-straw stack is 1.5 metre approximately. Any quantity of rice-straw can be composted in multiple heaps of 500 kg at one time leaving a passage of 1.0 metre between the beds.

Cover the heap with a 20-30 centimetre thick layer of unsoaked rice-straw. This will minimize water loss while providing the necessary aeration. The major key to success is the ability to maintain about 70 per cent moisture in the heap. Any major error in this step will delay composting. Water the heaps using watering lance with the help of Tullu Pump. (Note: watering heaps with sprinklers does not work because water generally runs down the sides, instead of going inside the heap. Ensure that the water penetrates the heap by using a lance with a sharp point to pierce the heap of rice-straw. Pierce the lance deepest possible with an aim to water uniformly). Composting can be terminated after 80-90 days by which time it is ready for processing or for field application. By this time its carbon and nitrogen ratio changes to 15:1. At this stage, strands of the rice straw are weak and twisting can readily break a hand-full of it.

Method for preparation of Vermicompost from paddy straw/ waste maize silage

1. For making vermicompost, cemented beds of dimensions 6' (length)×3' (breadth)×2' (height) should be constructed on leveled ground. The length of the bed may vary depending upon the space and resources.
2. The floor of the bed must be pucca floor to avoid seepage of vermin wash, faeces and urine of earthworms.
3. Firstly, lay the beds with one feet layer of paddy straw (chopped/unchopped)/waste maize silage. Paddy straw/waste maize silage is well moistened by sprinkling water to maintain moisture up to 60-70%.
4. Then second layer of 4-5 days old animal dung is applied up to 2 feet depth.
5. Introduce one kg earthworms of species (*Eisenia foetida*) per 6 feet length. The quantity of worms may vary if the bed size varied from standard dimensions.
6. Two inch layer of soaked paddy straw is applied on the beds to avoid water loss through evaporation.
7. Turning after every week is required to maintain aeration for earthworms and decomposition of paddy straw.
8. Water spray is applied two times a day in summer and 2-3 days interval in winter.
9. Vermicompost will be ready after 60-70 days and 45 days of composting of paddy straw and waste maize silage, respectively.

Precautions:

1. Fresh animal dung should be avoided as it has high temperature and high amount of gases which can be harmful to the earthworms.
2. The bed must be kept under the shed to protect the earthworms from direct sunlight, heat, cold and heavy rains.
3. The moisture in the beds must be 60-70%.

9. MULTIPLE CROPPING

Multiple cropping is a system in which more than two crops are grown one after the other on the same piece of land in quick succession during a year. The success of this system depends upon the selection of suitable crops/varieties, availability of labour, farm machinery, irrigation, fertilizers, pesticides, finance, etc. in addition to the required technical know-how. Timely cultural operations, alertness and managerial capability of the farmer are highly critical factors in the success of multiple cropping. The objective is to grow one or two additional crops in between the main season crops. This can be made possible through selection of short duration high yielding varieties, older nursery seedlings under delayed rice transplanting, adoption of minimum tillage and inter-relay cropping and harvesting of wheat and maize by about 5-7 days earlier than the dead ripe stage.

Some of the important high intensity rotations for multiple cropping systems are:

1. Green manuring (*Dhaincha*/Cowpea/Sunnhemp)-Rice-Wheat: After harvesting wheat apply *rauni* and sow 20 kg seed per acre of *dhaincha* (pre-soaked in water for about 8 hours) or sunhemp or 12 kg seed per acre of cowpea upto the end of April. Bury 6-7 weeks old *dhaincha*/sunhemp/cowpea, 1-2 days before transplanting of paddy. This will help in saving of about 25 kg N per acre for rice besides maintaining the soil health. However, for getting higher productivity of rice, practise green manuring and apply recommended dose of nitrogen (50 kg N per acre) in sandy to sandy loam soil. Likewise sowing of summer moong immediately after the harvesting of wheat in April end, after picking of pods, burying of its stover a day before transplanting of rice also helps to increase the paddy yield and in reducing the nitrogen dose of rice by one-third.

2. Cowpea/Bajra/Maize (fodder) - Maize/Rice-Wheat: Grow summer fodder crop (Cowpea/Bajra/Maize) with recommended seed rate and other practices, immediately after the harvest of wheat in the last week of April. These fodder crops will vacate field for timely sowing of the succeeding maize/rice crop. These fodder crops provide green fodder during the lean period in summer in the months of June. A fodder crop of 45-55 days old generally provides 80-100 quintals per acre of green fodder.

3. Green manuring-Maize-Wheat: Sow a green manure crop of *daincha*/sunhemp/cowpea with recommended practices in the last week of April and burry it after 6-8 weeks stage. Allow it to decompose for about 10-12 days before sowing maize in the end of June. This practice will help in maintaining the soil fertility. In green manured field maize crop does not require any more application of organic manure (FYM etc.)

4. Maize/Rice-Potato-Wheat: Grow a short duration variety of maize/rice in mid of June. The short duration crop varieties shall vacate the field in the mid of September for timely sowing of succeeding crop of potato. Sow early maturing varieties of potato like Kufri Chandermukhi with recommended practices in the end of September. Harvest 12

weeks old crop of potato and later on sow late sown wheat variety (PBW 752) with 50% recommended N/acre without P and K application.

5. Maize/Rice-Potato-Summer *Moong*: Summer moong sown after wheat is liable to caught up in early monsoon rains. For getting successful crop of summer moong, it should preferably be sown after seed crop of potato in the second or third week of March. In these cropping sequences maize/rice could be planted in mid June to vacate the field for timely sowing of potato crop in the second fortnight of September. Further, the summer mung after potato do not require any fertilizer application if the preceding potato crop received recommended dose of NPK and FYM.

6. Rice-Potato/*Toria*-Sunflower: Transplant short duration variety of rice (PR 126) in mid June. This will vacate the field in mid-September. Potato (Kufri chandermukhi) can be sown in the 3rd week of September and harvested in end of December. Alternatively, *toria* (TL-15) can also be grown after rice. Thereafter sow short duration variety of sunflower in the early January on southern slope of East-Westerly drawn ridges. Apply 12 kg N per acre to sunflower after potato, if the potato crop received recommended level of NPK alongwith 20 tonnes of FYM per acre. Sunflower crop will vacate the field in mid May for timely transplanting of rice.

7. Maize-Potato/*Toria*-Sunflower: In this cropping system, maize could be sown in early June to vacate the field for timely sowing of potato crop in second fortnight of September. Potato can be harvested after twelve weeks in end December. Alternatively short duration variety of *toria* (TL-15) can be grown after maize. Thereafter sunflower (short duration variety) can be grown successfully in early January southern slope of East-Westerly drawn ridges. Apply 12 kg N per acre after potato, if potato crop received recommended level of NPK alongwith 20 tonnes of FYM per acre. The sunflower crop will vacate the field in mid May for timely sowing of maize.

8. Groundnut-Potato/*Toria*/Pea/late *Kharif* fodder-Wheat: In groundnut-wheat cropping system, a crop of potato/*toria*/pea/late *kharif* maize fodder could be raised successfully. For this sow groundnut (variety SG 99 and M-522) during end of April and first week of May after the harvest of wheat. Further, as groundnut, crop vacates the field in early September, an additional crop of potato or early Pea (Ageta-6 or Arkel) or *Toria* (TL 15) or late sown maize fodder could be taken during the second fortnight of September. Toria/Pea/late sown fodder and potato vacate the field during December then the late sown wheat could be sown. Such a groudnut based cropping system has been found remunerative.

9. Maize-Potato-Onion: This cropping system gives highest net returns with substantial saving of water and gave almost double the productivity than rice-wheat system. For this system sow maize in mid-June, potato (Kufri Chandermukhi) in first week of October and onion (Punjab Naroya) from 10-15 January for high yield realization. The soil fertility in relation to OC, available N, P and K also improve over time.

10. Groundnut-Potato-*Bajra* (fodder): This cropping system gives better productivity levels than rice-wheat system with sizeable saving of water and also ensures improvement

in soil fertility. For this system sow groundnut (SG-99, M-522) in first week of May, potato in first week of October and bajra fodder in the first fortnight of March.

11. Basmati Rice-Celery-*Bajra* (fodder): This cropping system is more remunerative and productive than the existing basmati rice-wheat system. Transplant basmati rice in mid July which will vacate the field in mid November. Then grow celery in December which vacates the field in first fortnight of May and after this grow bajra crop for fodder.

12. Basmati Rice-Berseem (fodder and seed): This cropping system provides substaintial net returns than the existing basmati rice-wheat system. Transplant basmati rice in mid July which will vacate the field in mid November. A successful crop of berseem for seed production can be grown in end November after the harvest of basmati rice. It provides three cuttings of green fodder before leaving the crop for seed production.

13. Maize-Potato-Mentha: This cropping system is doubly profitable than rice-wheat system and provides considerable saving of irrigation water. In this system sow maize in mid June which will vacate the field in second fortnight of September. Then grow potato (Kufri Chandramukhi) in the first week of October which will vacate the field in mid January and after this grow mentha crop in the second fortnight of January. The soil fertility in relation to OC, available P & K also improves over time.

14. Maize/Rice-*Gobhi sarson*-Summer *Moong*: These cropping systems produce more yield and economic returns than the maize-wheat and rice-wheat systems. Therefore, maize should be sown in the first fortnight of June, rice in second fortnight of June, *gobhi sarson* from 10-30 October and summer moongbean in the first fortnight of April. The summer moongbean can be sown without tillage after applying pre-sowing irrigation.

15. Rice-Gram-Summer *Moong*: This cropping system produces more yield and economic returns than the rice-wheat system. Therefore, the rice should be transplanted in the second fortnight of June, gram should be sown from 25 October to 10 November in two lines per bed prepared by wheat bed planter and sow summer moongbean in the 2-3 week of April. This system also improves the soil fertility, soil micro flora and fauna over rice-wheat system.

16. Maize/Summer groundnut-Green Onion-Onion: These cropping systems produce higher yield and economic returns than the rice-wheat system. The groundnut should be sown in the second fortnight of May and maize in the first fortnight of June. The bulbs of onion sown in March should be uprooted in the month of June and stored in an airy place. These onion bulbs should be sown in the field after uprooting/harvesting of summer groundnut/maize in second fortnight of September. The green onions are uprooted in the second fortnight of December. For *rabi* onions, nursery should be transplanted in the first fortnight of January. These onions are ready for harvesting in mid May.

17. Maize-Vegetable pea/Potato-Spring maize: These cropping systems produce more yield and economic returns than the rice-wheat system. The maize should be sown in the first fort night of June. The vegetable pea/potato can be sown in the second fortnight of September and spring maize during first fortnight of February. Preferably grow spring maize under drip irrigation system.

Apply 2.5 tonnes per acre of crop residue mulch to each crop grown under surface and sub surface drip irrigation in *kharif* maize-potato-spring maize cropping system for water saving and higher productivity.

18. DSR-Potato-Mentha/Onion: These cropping systems produce more yield and economic returns than the rice-wheat system. Direct seeded rice should be sown in the first fortnight of June, potato can be sown in the second fortnight of October, mentha in second fortnight of January or onion can be transplanted in second fortnight of January.

19. DSBR-Potato-Mentha: This cropping system produce more yield and economic returns than the rice-wheat system. Direct seeded basmati rice should be sown in the second fortnight of June, potato can be sown in the first fortnight of November and mentha in first fortnight of February.

20. Soybean-Peas-Summer *moong*: This pulse based cropping system gives higher productivity and profitability as compared to rice-wheat system along with the improvement in the soil health. Soybean should be sown during first fortnight of June; Peas can be sown in the first fortnight of November and summer moong during second fortnight of March.

21. Groundnut-Peas-Sunflower: This cropping system gives higher productivity and profitability as compared to rice-wheat cropping system along with the improvement in the soil health. Groundnut should be sown during second fortnight of May, peas can be sown in the second fortnight of October and sunflower during first fortnight of February.

22. Spring Groundnut-Maize-Potato/Peas: These systems give higher productivity and economic returns than the rice-wheat cropping system along with improvement in soil fertility and soil microbial diversity. Spring Groundnut can be sown up to first fortnight of March, maize during first fortnight of July and sow potato and peas during mid of October.

23. Spring Groundnut-*Moong*-Potato/Peas: These systems give higher productivity and economic returns than the rice-wheat cropping system along with improvement in soil fertility and soil microbial diversity. Spring Groundnut can be sown up to first fortnight of March, moong during first fortnight of July and sow potato and peas during mid of October.

24. Summer *moong*-DSR-Wheat cropping system: This cropping system gives higher productivity and economic returns than DSR-wheat system. Summer *moong* can be sown in second week of April followed by DSR in the first fortnight of June. Incorporation of summer moong residue after picking of pods helps to increase the rice yield and also saves nitrogen. This system also improves soil fertility and soil micro flora and fauna over DSR-wheat.

25. Maize (Green cobs/fodder) Potato-Onion cropping system: This cropping system gives highest net returns with substantial saving of water and higher rice equivalent yield than rice-wheat system. For this system sow maize in the last week of May to end of June and pick green cobs after 55 days of sowing for table purpose and green fodder can be used for milch animals, potato (Kufri Pukhraj) in first week of October and onion (Punjab Naroya) from 10-15 January for high yield realization. The soil fertility in relation to OC, available N, P and K also improve over time.

26. Summer *moong*-DSBR-Wheat cropping system: This system gives more yield and economic returns than the DSBR-wheat cropping system. Summer *moong* can be sown upto 20th April, followed by DSBR in the second fortnight of June and wheat in second fortnight of November. Incorporation of summer *moong* residue after picking of pods helps to increase the basmati yield and also saves nitrogen. This system also improves soil fertility and soil micro flora and fauna over DSBR-wheat.

Fodder cropping system

27. Maize-Berseem-Bajra: In this cropping system, sow maize in 2nd week of August and harvest it after 50-60 days after sowing when the crop is between milkripe and dough stage of grain development. Sow berseem in the first or second week of October and take 4-5 cuttings. Then sow bajra in second week of June and harvest it after 45 to 55 days after sowing at the start of ear initiation stage.

28. Maize-Berseem-Maize+Cowpea: In this cropping system, sow maize in second week of August and harvest it after 50-60 days after sowing when the crop is between milkripe and dough stage of grain development. Sow berseem in the first or second week of October and take 4-5 cuttings. Then sow maize+cowpea mixture in second week of June and harvest it after 50 to 60 days after sowing when the maize crop is between milkripe and dough stage of grain development.

29. Sorghum multicut-Berseem cropping system: In this cropping system, sow multicut forage sorghum hybrid (Punjab Sudax Chari 4) in first week of May in rows 30 cm apart. The first cutting is ready in 55-65 days after sowing. Subsequently, cuttings can be taken after an interval of about 35-40 days. Sow berseem in the first or second week of October and take 4-5 cuttings.

SUB SURFACE DRIP IRRIGATION AND FERTIGATION

30. Maize-Wheat-Summer *moong*: Place drip inline having dripper having 20 cm spacing at 20 cm depth with lateral to lateral spacing of 67.5 cm spacing for sub surface drip fertigation in maize-wheat-summer moong cropping system. Sow one row of maize, two rows of wheat and two rows of summer moong on each drip inline during respective season.

Apply sub surface drip irrigation at 3 days interval for maize and summer moong with fertigation of 80 % recommended dose of NPK. In maize, apply 1/5 dose of NPK at sowing and fertigate remaining P and K in 5 splits and N in 7 splits at 9 days interval starting from 15 DAS. Apply sub surface drip irrigation at 7 days interval up to mid February and thereafter at 5 days interval to wheat with fertigation of 80 % recommended dose of NPK.

In wheat, apply 1/5th dose of NPK at sowing and fertigated the remaining NPK in 8 splits at seven days interval starting from crown root initiation. In summer moong fertigated NPK dose in 5 equal splits at 6 days interval starting from 10 DAS. Use urea, mono ammonium phosphate and muraite of potash as source of N, P and K, respectively. If dripper discharge is 2.2 litre per hour, the following schedule should be adopted for sub surface drip irrigation in maize-wheat-summer *moong* cropping system:

Crop	Month	Time of irrigation (Minutes)*
Maize	July	35
	Aug	35
	Sept	50
	Oct	30
Wheat	Dec	30
	Jan	65
	Feb	70
	March	50
Summer Moong	May	60
	June	45

If discharge rate is different then time of irrigation may be adjusted proportionally by the formula

= (2.2 x time of irrigation (min)*) ÷ Discharge of dripper (litre per hour)

In field experiments, sub surface drip irrigation and fertigation resulted in 18.4% higher system productivity with saving of 28.5 % applied irrigation water and 20% nutrients than control.

31. Zero till direct seeded rice-Wheat: Place dripline having inline emitter with discharge rate of 2 litre per hour having 30 cm spacing at 15 cm depth with lateral to lateral spacing of 67.5 cm. Sow rice in dry soil without rauni but just after sowing apply irrigation on alternate days up to 21 days for proper establishment of the crop. Fertigate with 80 % recommended dose of nitrogen in five equal splits starting from 15 days of sowing at 12 days interval.

Sow the wheat crop without pre sowing irrigation. Fertigate with 80 % recommended dose of nitrogen in five equal splits starting from 21 days of sowing at 10 days interval. The following schedule should be adopted for rice and wheat crops:

Crop	Month	Time of irrigation (Minutes)*	Interval (days)
Rice	June	65	2
	July	65	2
	August	65	2
	September	65	2
	October	65	2

Wheat	November	45	21
	December	45	10
	January	45	10
	February	45	7
	March	45	5
	April	45	5

If the discharge rate is different, then time of irrigation may be adjusted proportionally by the formula

= (2.0 x time of irrigation (min)*) ÷ Discharge of dripper (litre per hour)

This system improves the system productivity about 2.3 % with saving of 47% applied irrigation water and 20% nitrogen over conventional rice-wheat system.

32. Maize-Wheat raised on permanent beds: Place drip line having inline emitter with discharge rate of 1.6 litre per hour having 30 cm spacing in the center of permanent beds of 37.5 cm bed top with 30 cm wide furrow at 20 cm depth. Apply pre-sowing irrigation and sow one row of maize on the centre of the bed with double disc planter for better crop emergence.

For wheat, apply pre-sowing irrigation for 40 minutes about one week prior to sowing and sow two rows of wheat on the bed. Fertigate with 80 % recommended dose of nitrogen in five equal splits starting from 21 days of sowing at 10 days interval in both crops. The following schedule should be adopted for maize and wheat crops:

Crop	**Month**	**Time of irrigation (Minutes)***	**Interval (days)**
Maize	June	45	20
	July	45	10
	August	45	10
	September	45	7
Wheat	November	40	21
	December	40	10
	January	40	10
	February	40	10
	March	40	7
	April	40	5

If the discharge rate is different, then time of irrigation may be adjusted proportionally by the formula

= (1.6 x time of irrigation (min)*) ÷ Discharge of dripper (litre per hour)

This system improves system productivity about 9% with saving of 53% applied irrigation water and 20% nitrogen over conventional maize-wheat system.

33. Cotton-Wheat: Place drip inline having emitter spacing of 20 cm at 20 cm depth keeping lateral to lateral spacing of 67.5 cm. Sow one row of cotton at 67.5 cm spacing and three rows of wheat at 22.5 cm spacing on each drip inline during respective season. In cotton, apply irrigation at 5 days interval starting from 30-35 days after sowing (DAS). Fertigate100 kg urea (45 kg N) per acre in 10 equal splits at 10 days interval starting from 30-35 DAS.

In wheat, apply irrigation at 7 days interval up to mid-February and thereafter at 5 days interval with fertigation of 80% recommended dose of NPK. Apply 1/5 dose of NPK at sowing and fertigate the remaining NPK in eight equal splits at 7 days interval starting from crown root initiation stage. If emitter discharge is 2.2 litre per hour, the following schedule should be adopted:

Crop	**Month**	**Time of irrigation (Minutes)***
Cotton	May	40
	June	40
	July	35
	August	30
	September	25
Wheat	December	30
	January	65
	February	70
	March	50
	April	50

If the discharge rate is different, then time of irrigation may be adjusted proportionally by the formula

= (2.2 x time of irrigation (min)*) ÷ Discharge of dripper (litre per hour)

34. *Kharif* maize-Peas-Spring maize: Install drip inlines having emitter spacing of 30 cm at 20 cm depth keeping lateral to lateral spacing of 60 cm. One drip lateral will serve one row of *kharif* maize, two rows of peas and one row of spring maize during respective seasons. Use 80% of the recommended dose of nutrients in all the crops. Irrigate the *kharif* maize at 3 days interval. Apply 1/5 dose of NPK at sowing and fertigate the remaining P and K in 5 splits, and N in 7 splits at 9 days interval starting from 15 DAS.

For peas, apply irrigation at 3 days interval. Apply 1/5 dose of N and P at sowing as basal and fertigate the remaining N and P in 9 splits at 6 days interval starting from 25 DAS. Use SSP fertilizer for basal application of P.

Irrigate the spring maize at 3 days interval starting from 12 DAS. Apply 1/5th dose of N and P at sowing and fertigate the remaining amount in 10 equal splits at 6 days interval starting from 30 DAS. Use urea, MAP and MOP as a source of N, P_2O_5 and K_2O, respectively for fertigation. If emitter discharge is 2.2 litre per hour, the following schedule should be adopted:

Crop	**Month**	**Time of irrigation (Minutes)***
Kharif Maize	June	40
	July	35
	August	35
	September	50
Peas	October	20
	November	25
	December	25
	January	30
Spring Maize	February	25
	March	35
	April	65
	May	65

If discharge rate is different, then time of irrigation may be adjusted proportionally by the formula

= (2.2 × time of irrigation (min)*) ÷ Discharge of dripper (litre per hour)

35. Cotton-*Gobhi sarson* (transplanted) cropping system: Place drip inline having emitter spacing of 20 cm at 20 cm depth keeping lateral to lateral spacing of 67.5 cm and sow one row of cotton at 67.5 cm spacing. Apply irrigation at 5 days interval starting from 30-35 days after sowing (DAS). Fertigate 85 kg urea and 20 kg mono-ammonium phosphate (12-61-0) per acre in 10 equal splits at 10 days interval starting from 30-35 DAS.

Transplant the succeeding *gobhi sarson* as per the recommended technology and apply irrigation immediately. Initiate drip irrigation at 15 days after transplanting at 7 days interval as per the given schedule. Fertigation should be started at 15 days after transplanting and

all fertilizers should be applied in 10 equal splits at 7 days interval. Fertigate 70 kg urea, 16 kg mono-ammonium phosphate and 9 kg elemental sulphur, respectively. If emitter discharge is 2.2 litre per hour, the following schedule should be adopted:

Crop	Month	Time of irrigation (Minutes)*
Cotton	May	40
	June	40
	July	35
	August	30
	September	25
Gobhi sarson (transplanted)	December	60
	January	50
	February	50
	March	60

If discharge rate is different, then time of irrigation may be adjusted proportionally by the formula

= (2.2 x time of irrigation (min)*) ÷ Discharge of dripper (litre per hour)

CONSERVATION AGRICULTURE

36. Rice-Wheat: Retention or incorporation of both paddy and wheat residue for 12 year continuously in rice-wheat cropping system gives more wheat yield (22.68 q per acre) and rice-wheat system productivity (50.88 q per acre) over only paddy straw incorporation or retention. Retention or incorporation of both paddy and wheat residues also improved soil health which is desirable for sustainable rice-wheat production.

10. INTEGRATED FARMING SYSTEM

'Integrated Farming System' is an economically viable option to enhance the farm productivity, reduce the environmental degradation, nutritional security and upliftment of resource poor farmers. Integrated farming system is the favourable and adequate combination of crops, livestock, aquaculture, agro-forestry, agri-horticulture so as to ensure sustainability, profitability, balanced food availability and employment generation. In addition, integrated farming system is the resource management strategy for sustained production and to meet diverse requirements of farm households to make the agriculture cost-effective, remunerative and above all to ensure livelihood security of the farming community.

The Punjab Agricultural University, Ludhiana based on long-term research, has come out with 2.5 acre model of integrated farming system for small farmers with the following components:

Component	**Area (*kanal*)**
Field crops	7.0
Fodder	4.0
Oilseeds/pulses	1.0
Fruit trees with intercropping of seasonal vegetables	4.0
Agro-forestry	1.0
Dairy(2 cows/buffaloes) shed with composting/vermicomposting unit	0.5
Fishery (with high density boundary planting of fruit trees and Napier *bajra*)	2.0
Kitchen gardening	0.5
Planting of turmeric on bunds around field crops	-
Boundary plantation of *karonda* and *galgal* (optional)	-

The integrated farming system involving crop + dairy + kitchen gardening and other secondary components alongwith location. Specific agri-based enterprises can be included after acquiring proper training. The integrated farming system is highly remunerative as compared to conventional rice-wheat cropping system.

11. SOIL TEST BASED FERTILIZER APPLICATION

Soil testing is the best tool to ensure optimum and balanced use of nutrients. Improper use of fertilizers leads not only to imbalanced nutrition but also deterioration of the environment. Soil testing comprises determination of organic carbon content and the amount of available nutrients besides, the basic characteristics such as soil reaction (pH) and soil salinity (electrical conductivity). Based on the soil test values, the soils are categorized as low, medium and high with respect to the status of available nutrients. Fertilizer recommendations are made for each category, depending upon the crop/cropping sequence in question. General fertilizer recommendations, given in the package of practices , pertain to normal soils of medium category.

Nitrogen: Organic carbon content of the soil is considered as an index of available nitrogen and is thus used to make fertilizer recommendations for nitrogen. Based on its content, the soils are categorized as low (less than 0.40%), medium (0.40-0.75%) and high (more than 0.75%). Since the soils low in organic carbon are poor in supplying nitrogen, increase the dose of nitrogenous fertilizer by 25 per cent over the general recommended dose for medium organic carbon soils, whereas, in high organic carbon soils, lower this dose by 25 per cent (Table 1).

Phosphorus: Based on available phosphorus content, soils with less than 5 kg phosphorus per acre are rated as low, those with 5-9 kg phosphorus per acre as medium, with 9-20 kg phosphorus per acre as high and with more than 20 kg phosphorus per acre as very high. In soils testing low in phosphorus, apply 25 per cent more fertilizer than the recommended dose, whereas in high phosphorus soils reduce it by 25 per cent (Table 1). In soils testing very high in available phosphorus, omit application of phosphatic fertilizer application for 2-3 years and then get the soil tested to know if the repeat application of phosphorus is required. However, in maize-wheat cropping system, when soil test phosphorus level is more than 16 kg per per acre, there is no need to add any phosphorus fertilizer to both the crops.

In *kharif* crops e.g. Rice, Maize and Cotton following Wheat that received the recommended dose of phosphatic fertilizer, omit its application. In Soybean-Wheat rotation, if recommended dose of phosphatic fertilizer has been applied to Wheat, apply only 150 kg super phosphate instead of 200 kg per acre. However, in soils where wheat did not receive the recommended dose, apply phosphatic fertilizer on soil test basis. In Sugarcane too, the phosphatic fertilizer should be applied only if the soil tests low in available phosphorus.

Table 1. Fertilizer recommendations (kg per acre) for major crops grown on different fertility category soils

Crops	Soil test category											
	Nitrogen			Phosphorus								
	Low	Medium	High	Low		Medium		High		Very high		
	Urea			SSP	*DAP	SSP	*DAP	SSP	*DAP	SSP	*DAP	
Rice	110	90	70	75	27	--	--	--	--	--	--	
Maize	130	110	90	190	65	155	55	125	45	--	--	
Cotton (Bt and non-Bt hybrids	110	90	70	95	35	75	25	55	20	--	--	
Cotton (varieties)	80	65	50	95	35	75	25	55	20	--	--	
Sugarcane (plant crop)	165	130	100	75	25	--	--	--	--	--	--	

* For every 50 kg Diammonium phosphate, reduce the dose of Urea by 20 kg

Since the organic carbon content also influences the amount of fertilizer phosphorus required, the dose of phosphatic fertilizer should be decided based on both the soil organic carbon and available phosphorus content as shown in table 2. As such, if the soil organic carbon content is 0.4 to 0.6 per cent, reduce the phosphatic fertilizer dose by 25 per cent in medium phosphorus soils, by 50 per cent in high phosphorus soils and omit its application in very high phosphorus soils. If organic carbon content of the soil is more than 0.6 per cent and available phosphorus is 5-9 kg per acre, reduce the dose by 50 per cent. However, if soil phosphorus status is more than 9 kg per acre, omit the application of phosphatic fertilizers. In all other categories viz. soil with less than 5 kg phosphorus/acre irrespective of organic carbon content and soils with less than 0.4 per cent organic carbon irrespective of soil phosphorus status, apply the recommended dose of phosphatic fertilizer.

Table 2. Recommendations for fertilizer phosphorus based on available phosphorus and organic carbon content in soils

Soil organic carbon (%)	Available Phosphorus (kg per acre)			
	Low (below 5)	Medium (5-9)	High (9-20)	Very High (above 20)
Below 0.4	25% more than Recommended	Recommended*	25% less than Recommended	Nil
0.4-0.6	25% more than Recommended	25% less than Recommended	50% less than Recommended	Nil
Above 0.6	25% more than Recommended	50% less than Recommended	Nil	Nil

* Fertilizer dose for medium soils as given in table 1.

Potassium: Based on the available potassium status, soils are grouped into two categorizes viz. deficient (less than 55 kg K_2O/acre) and sufficient (more than 55 kg

K_2O/acre). Application of potassium is recommended only in soils deficient in available potassium. Since the farmers mostly omit potassium application, it is important to get the soil tested in order to ensure that potassium deficiency does not limit crop yields. Deficiency of potassium is generally confied to the soils in the districs of Gurdaspur, Hoshiarpur, Nawanshahar, Jalandhar and Ropar.

Micronutrients: Micronutrient deficiencies are becoming important yield limiting factors, particularly, in *kharif* crops due to intensive cropping, cultivation of fertilizer responsive high yielding crop varieties and the use of high analysis fertilizers. Based on the critical deficiency levels of micronutrients, the soils are categorized as deficient or adequate in respect of different micronutrients.

- In zinc-deficient soils (available zinc content less than 0.6 kg per acre), soil application of 25 kg zinc sulphate heptahydrate or 16 kg zinc sulphate monohydrate per acre is recommended for rice as well as groundnut.
- Application of 10 kg zinc sulphate heptahydrate or 6.5 kg zinc sulphate monohydrate per acre is recommended for maize and cotton. In case of maize, if zinc deficiency symptoms appear late in the season when interculture is not possible, it is advised to spray the crop with a solution prepared by dissolving 1.2 kg zinc sulphate heptahydrate and 600 gram of unslaked lime (or 750 g zinc sulphate monohydrate and 375 gram of unslaked lime) in 200 litre of water per acre.
- Since *kharif* crops, particularly rice and maize are more susceptible to zinc deficiency, application of zinc sulphate should be made preferably to *kharif* crop in the cropping sequence in order to get maximum benefit.
- Iron deficiency is a common problem of rice grown on highly permeable coarse textured soils and that of sugarcane on highly alkaline soils. It is, therefore, recommended to spray the crops with 1.0 per cent solution of ferrous sulphate initiating at the appearance of deficiency symptoms. Generally, 2-3 sprays carried out at weekly intervals are sufficient.
- Regular green manuring with *dhaincha* before rice transplanting, also helps in reducing the occurrence of iron deficiency in the rice crop.

Salt affected soils: Apart from the nutrient content, the soil texture, its reaction,and degree of salinity or alkalinity also influence the efficiency of applied fertilizers.

For proper reclamation of the alkali (sodic) soils (pH more than 9.3), gypsum application must be accompanied with other management practices. In these soils, it is recommended to apply 25 per cent higher fertilizer nitrogen over that for the normal soils. Crops grown on alkali soils generally show zinc deficiency and require application of zinc sulphate at rates higher than those recommended for normal soils.

Saline soils (electrical conductivity more than 0.8 millimhos/cm) require 25 per cent extra fertilizer nitrogen. In these soils, addition of organic manures/green manures/crop residues is beneficial. Farmers are advised not to apply gypsum to saline soils.

Collection of soil sample

For making fertilizer recommendations in field crops: Scrap away surface litter and make a V-shaped cut with a spade or a *khurpa* to a depth of 6 inches. Remove about 1" thick uniform slice of soil from one side of the cut. Similarly, collect samples from 7 to 8 places in the field of uniform texture and uniform fertility. Put the samples in a clean bucket, tray or cloth and mix it thoroughly. Take approximately half kg of soil in a cloth bag and label it with information such as field number, name of the farmer, address, date of sampling etc. The soil samples are usually collected from fallow fields after the harvest of crops. However, except for rice, soil samples in other crops can also be taken during the standing crops from the area between the rows.

For *kallar* reclamation: Dig three feet deep pit with one side vertically straight and the other slanting. From the vertically straight side, remove with the help of *khurpa* about 1" thick soil layer to collect about half kg soil from 0-6, 6-12, 12-24 and 24-36 inch depth. Put the soil samples collected from each depth in a separate clean cloth bag and label with the information such as field number, depth of sample, name of the farmer, address, date of sampling etc.

For orchard plantation: Dig a 6 feet deep pit in the centre of the field with one side-vertically straight and the other slanting. From the vertically straight side, remove with the help of khurpa about 1" thick soil layer to collect about half kg soil from 0-6, 6-12, 12-24, 24-36, 36-48, 48-60 and 60-72 inch depth. Collect and process samples from different depths as described above for kallar reclamation. If there is any concretion layer, sample it separately and note down its depth and width.

If the samples are wet, dry them in shade before putting into the cloth bag.

Soil Testing Laboratories

Soil and water samples are tested by the following laboratories in Punjab:

1. Soil Testing Laboratory, Deptt. of Soil Science, Punjab Agricultural University, Ludhiana.
2. Soil Testing Laboratory, Regional Station (Punjab Agricultural University), Gurdaspur and Bathinda.
3. Soil Testing Laboratory, KVK's, Amritsar, Bathinda, Faridkot, Ferozepur, Gurdaspur, Bahowal (Hoshiarpur), Langroya (Shaheed Bhagat Singh Nagar), Patiala, Ropar, Kheri (Sangrur), Noormahal (Jalandhar), Samrala (Ludhiana), Kapurthala, Goneana (Sri Muktsar Sahib), Budhsinghwala (Moga) and Fatehgarh Sahib.
4. MARKFED and the Department of Agriculture and Farmer Welfare, Punjab have also established Soil-Testing Laboratories in the state.

12. RATIONAL USE OF POOR QUALITY IRRIGATION WATER

In about 42% of the total area of Punjab, the underground tubewell waters contain high concentration of salts and their sustained use adversely affects soil health and agricultural production. These waters are either saline (containing chlorides and sulphates of sodium) or sodic (containing carbonates and bicarbonates of sodium). Some of these waters may also contain toxic elements like boron and flouride. It is, therefore, important that the underground tubewell waters must be got tested from a soil and water testing laboratory so as to know the kind and extent of the problem. Irrigation with waters having very high concentration of salts is not recommended. But waters having low to moderate salinity or sodicity can be used by following specific management practices. In Punjab, the problem is mainly due to high sodicity (expressed in terms of residual sodium carbonates, RSC) in ground waters and the following guidelines are recommended for their safe use:

1. Ensure adequate drainage: In areas receiving poor quality irrigation waters, leaching of excess soluble salts and water from the root zone depth of the soil has to be ensured so as to maintain a favourable salt and water balance. In poorly drained areas and in soils having hard pan at some depth, long term irrigation with poor quality waters results in the build up of salts in the soil much more rapidly than that under well drained soil conditions. Provision of proper drainage is, therefore, a pre-requisite when poor quality waters are to be used for irrigation. Surface drains are cheaper than the sub-surface drains.

2. Level the land properly: For uniform distribution of irrigation water in the field, the land should be properly levelled. Proper land levelling also ensures uniform leaching of soluble salts and waters from the soil. Even with small changes of microrelief in the field, unequal distribution of water and salts takes place.

3. Use poor quality waters on light textured soils: These soils facilitate leaching of salts applied through irrigation water because of their high infiltration rates. Infiltration rates of the heavy textured soils are low and water applied through irrigation tends to stagnate at the surface for longer periods and after evaporation salinity/sodicity builds up at faster rates in these soils, it is, therefore, recommended that poor quality waters should preferably be used on light textured soils.

4. Make proper crop selection: It is always preferable to grow crops and varieties capable of producing high yields even when irrigated with saline or sodic waters. Only salt tolerant and semi-tolerant crops like barley, wheat, mustard, guar, senji, spinach, turnip, sugarbeet, raya and millets should be grown. Cotton is sensitive at the germination stage but can be grown if proper germination is ensured by pre-sowing irrigation with good quality water. Pulse crops are sensitive to salinity and sodicity and, therefore, should not be irrigated with poor quality waters. The crops having high water requirements such as

rice, sugarcane and berseem should preferably not be grown particularly when drainage is very poor.

5. Apply gypsum: Poor permeability of soils is commonly observed where irrigation waters containing high bicarbonates of sodium (testing high in RSC) are used. High saturation of the soil with sodium, deteriorates soil structure and results in poor aeration and poor nutrient and water availability to plant roots. The adverse effects of high soil sodium saturation can be offset by gypsum application. Application of gypsum is recommended when RSC of irrigation water exceeds 2.5 me/l. The quantity of gypsum should be got calculated from a soil and water testing laboratory. For each me/l of RSC, the quantity of gypsum (70% purity) works out to be 1.50 quintals per acre for four irrigations of 7.5 cm each. Gypsum should be applied on cumulative basis (calculated on the basis of number of irrigations) in one dose after the harvest of previous crop. If the soil is already sodic gypsum should be applied on soil test basis. After mixing gypsum in the surface (0-10 cm) soil, heavy irrigation should be given to leach down soluble salts before sowing of the next crop.

In soils irrigated with sodic water, yellow gypsum was found as effective as mined gypsum for mitigating the adverse effect of sodicity on crop yields (rice, cotton-canola and cotton-wheat systems). Thus, if mined gypsum is unavailable or its quality is inconsistent, yellow gypsum can be used as an effective alternate source for reducing the adverse effects of sodic water irrigation.

6. Use organic amendments: In calcareous soils with more than 2% calcium carbonate, use organic manures viz. farmyard manure @ 8 tonnes per acre or green manure or wheat straw @ 2.5 tonnes per acre per year for reducing harmful effects of sodic irrigation water.

7. Irrigate alternate furrows: In cotton growing areas where underground irrigation water is of poor quality, prefer ridge planting of cotton using pre-sowing irrigation with canal water and subsequent irrigations with poor quality tube well water in alternate furrows for sustainable yields. The alternate furrow irrigation with poor quality tube well water also results in saving of irrigation water and check deterioration of soil health.

8. Use of saline water for irrigating cotton: Under scarcity of good quality irrigation water, alternate use of good quality canal water and saline tubewell water through surface drip irrigation is recommended in light-textured soil for obtaining sustainable seed cotton yield with a minimal adverse effect on soil quality.

In soils irrigated with saline water (EC upto 10 dS/m), application of 16 quintal per acre rice-residue biochar reduces adverse affect of salinity and increases seed cotton yield.

9. Use poor and good waters conjunctively: This practice assumes importance particularly when supplies of good quality canal water are inadequate. The poor quality waters should preferably be used to supplement the good quality canal waters. The poor and good quality waters can be used together, either alternatively or by mixing with each

other. It is also advisable to use good quality waters in early stages of crop growth and poor quality waters during later stages when the crop can tolerate higher salinity/sodicity levels.

10. Watch the build up of the salinity and sodicity in the soil: When poor quality waters are used on a long term basis the farmers should keep a watch on the build up of salts in the soil by getting the soil samples tested at regular intervals. This will help them in keeping a check on soil deterioration.

11. Use of village pond water for irrigation: Water in village ponds contains essential plant nutrients like nitrogen, phosphorus and potassium. However, it may also contain salts such as carbonates, bicarbonates and chlorides of calcium, magnesium, sodium and pathogenic microorganisms in undesirable amounts. Therefore, this water should be got tested from the Soil and Water Testing Laboratory, Department of Soil Science for physiochemical parameters and from Department of Microbiology for microbiological quality. After that, watermay be used for irrigation as per recommendation.

13. SPRAY TECHNOLOGY

The success of insect-pests, diseases and weed control depends upon use of proper spraying technology. Adopt following recommendations for efficient and effective management of weeds, insect-pests and diseases:

Selection of pesticide: Correct identification of insect-pest, disease and weed is very essential for proper selection of pesticides. Always use the recommended brand of herbicide, pesticide and fungicide.

Selection of spray pump and nozzle: Spraying of pesticides can be done with knapsack sprayer (manually or battery operated) or tractor operated sprayer (See Appendix V). For spray of pre-emergence herbicides at the time of sowing, use flat fan or flood jet nozzles. Always use flat fan nozzles for spraying post emergence herbicides. Use cone type nozzle for the control of insect-pests and diseases.

Quantity of water: Always use 200 litres of water for pre-emergence herbicides at the time of sowing and 150 litres of water per acre for post emergence application. Use 200 litres of water for control of diseases and 100-150 litres of water per acre for control of insect pests. To estimate the water required for spraying, fill the spray pump with measured quantity of water and spray in the field. After spraying, measure the area sprayed and calculates the required quantity of water per acre by the following formula:

$$\text{Quantity of water (l/acre)} = \frac{\text{Volume of water consumed (litre)} \times 4000}{\text{Sprayed Area } (m^2)}$$

Preparation of spray fluid: According to the quantity of water needed for an acre as calculated above, calculate the number of spray pumps required for spraying one acre. For example, if water required for spraying in one acre is 150 litres and capacity of spray pump is 15 litre. It means 10 pumps are required for spraying one acre area. In this case dissolve the quantity of pesticide required for one acre in less quantity of water and make the volume to 10 litre. Now, pour one litre of this pesticide solution in one spray pump. For tractor operated sprayer, prepare the pesticides solution as per the capacity of spray tank.

Method of spray: Nozzle height at the time of spraying is very important. Maintain nozzle height around 1.5 feet from the crop canopy during spraying of herbicides, insecticides and fungicides on the crop. Similarly in case of pre-emergence herbicides, maintain the nozzle height at 1.5 feet from ground surface. Always spray in strips by keeping the spray lance straight. Do not move the spray lance to and fro. Use multiboom nozzles for uniform spray. In case of backpack type electrostatic sprayer, electrostatic nozzle should not be lifted above the shoulder height. Maintain the distance of the electrostatic nozzle tip about 1 to 1.5 feet above the crop canopy. Only 15 litres of water per acre is required for spraying with electrostatic sprayer.

Precautions during spraying

- Always purchase recommended brands of pesticides and obtain bill from the shopkeeper.
- Read carefully instructions given on pesticide label and follow the same.
- Clean the spray pump with washing soda/surf solution before and after spray. If possible, keep separate pumps for spraying herbicide and other pesticides.
- Do not tear open the pesticide packet but use scissor or knife for this purpose.
- Use recommended dose of pesticides and apply at appropriate time.
- The preparation of spray solutions from concentrated pesticides should be done in drums using long sticks to protect the operation from splashings and to permit stirring from a standing position.
- Always use clean water for spraying to avoid clogging in the nozzles.
- Wear hand gloves for preparation of spray fluid, and gas mask, full sleeve shirt and trousers during spraying.
- Only healthy person without any wound on body should be engaged for spraying.
- Do not spray on an empty stomach.
- Never spray accross the direction of the wind flow. Spray should be done on calm days.
- Do not blow the clogged nozzle. If nozzle clogs, remove and disassemble the nozzle assembly. Clean the openings/filter and nozzle tips of any obstructions and reassemble.
- If the discharge rate of the nozzle exceeds by 10-15% than the initial discharge rate, the nozzle is considered as worn out. Replace the worn out nozzle.
- Do not touch the nozzle tip while operating the backpack type air-assisted electrostatic sprayer.
- Operator should not work for more than 8 hours a day. Those engaged in handling pesticides should be checked by a physician regularly.
- The worker should not smoke, chew, eat or drink while spraying and must wash hands and feet thoroughly with soap and water after handling or use of pesticide.
- Keep pesticides in labelled containers only.
- Store pesticides in a safe and locked place, out of the reach of children, irresponsible persons and pets.
- Never store pesticides near foodstuffs or medicines.
- Do not use the empty containers of pesticides for any purpose. Destroy them by making holes.

14. MANAGEMENT OF RODENTS AND BIRDS

A. Management of Rodents

Rats and mice are the most serious pests of crops and must be controlled. By virtue of their extremely adaptable nature, highly intelligent patterns of behaviour and tremendous potential to multiply, they maintain their large populations which cause extensive damage in crop fields and other premises. They cause more damage at seedling and ripening stages of the crops. The performance of different control methods vary in different situations and at different stages of the crop. The best control success can only be achieved if these methods are adopted properly at appropriate timings.

Methods of Control

i. Mechanical Control

- **Killing:** During irrigation of vacant harvested fields, rats coming out of flooded burrows may be killed with sticks.
- **Trapping:** In crop fields place 16 traps/acre covering runways, damage and activity sites of rodents. In houses, godowns, poultry farms etc., set traps (1 trap/4-8 m^2 area) along the walls, in corners, behind the storage bins and boxes etc. Kill the trapped rats by drowning in water and the interval between two trappings at the same location should not be less than 30 days. Do not place the traps at the same place again and again.

ii. Cultural Control

Weeds, grasses and bushes should be removed from the fields as these provide shelter and food to rats and mice. Highly infested bunds, water channels and field pavements should be periodically rebuilt to destroy permanent rat burrows. Keep the height and width of bunds to minimum and avoid crop lodging.

iii) Biological Control

Owls, kites, hawks, falcons, eagles, snakes, monitor lizards, cats, mongoose etc. are the natural predators of rats and mice. These should be protected.

iv. Chemical Control

Poison Bait Preparation

The acceptance of poison baits by rats and mice depends upon the quality, texture, taste and odour of the baiting materials, therefore, bait should be prepared as under:

- **Zinc phosphide bait (2%):** Take 1 kg of bajra or sorghum or cracked wheat or their mixture and mix it thoroughly with 20 g of edible vegetable oil, 20 g of powdered sugar and 25 g of 80% zinc phosphide powder.

Caution: Never allow water to mix in zinc phosphide bait and always use freshly prepared bait. Minimum interval between two baitings of zinc phosphide must be 2 months. To increase the acceptance and efficacy of zinc phosphide bait, do pre-baiting. For this place bajra or sorghum or cracked wheat or their mixture smeared with oil and powdered sugar @ 400g per acre at 40 bait points on pieces of paper for 2-3 days.

- **Bromadiolone bait (0.005%):** Take 1 kg of bajra or sorghum or cracked wheat or their mixture or flour and mix it thoroughly with 20 g of edible vegetable oil, 20 g of powdered sugar and 20 g of 0.25% bromadiolone powder.

Poison bait placement and timings

Baiting in lean period (May-June)

This period is most suitable for rodent control campaign in large areas. During this period, the rat burrows can easily be located in the fields, on bunds, water channels and surrounding waste lands. Close all the burrows in the evening and in the reopened burrows on the next day, insert a paper boat containing about 10 g of zinc phosphide or bromadiolone bait about 6 inches deep in each burrow. In case of burrows of the lesser bandicoot rat, gently remove the fresh soil from the burrow opening to locate the tunnel and then put the poison bait deep inside it.

Baiting in different crops

For baiting in crop fields keep 10-10 g of poison bait on pieces of paper at 40 bait points per acre on dry sites and inside the crop throughout the field along bunds, covering runways and activity sites of rodents.

Transplanted rice: Do poison baiting in the month of August-September using 400 g per acre zinc phosphide or bromadiolone bait. The baiting must be done during dry days and before milky grain stage. Otherwise, if delayed, the rats would avoid poison bait due to the availability of fresh grains in the crop.

Direct seeded rice: Do burrow baiting after crop sowing followed by burrow/crop baiting at dough stage in crop fields when the number of rodent burrows is >10/ acre with zinc phosphide or bromadiolone bait along with weed management. If the number of rodent burrows is high (>20/acre), double burrow baiting after sowing or double burrow/crop baiting at the dough stage can be done using zinc phosphide followed by bromadiolone or bromadiolone followed by bromadiolone.

Sugarcane: Since sugarcane crop harbours high rodent population, poison baiting should be done first in July (after paddy transplantation) and second in October-November (after paddy harvest). At each of these two timings do baiting with zinc phosphide or bromadiolone followed by another baiting after 15 days with bromadiolone @400 g per acre each. If the crop is to be harvested after January-February, third baiting should be done with bromadiolone @800 g per acre on 40 bait papers in January.

Groundnut: Do double rodenticidal baiting with 2% zinc phosphide bait followed by bait of 0.005% bromadiolone bait or vice-versa @ 400 g per acre each. The first baiting should be done at the start of pod formation (when the crop is of 60-65 days). The second baiting should be done after an interval of one month i.e. before the maturation of pods (90-95 days of crop).

Note: In crop fields, the rodenticide baiting should be done when the number of live rodent burrows is more than 10/acre.

Safety Measures:

- Keep the rodenticides and poison baits away from reach of children, domestic animals and pets.
- Mixing of rodenticides in the baiting material should be done with a stick, spade or by wearing gloves. Avoid contact of poison with mouth, nose and eyes.
- Household utensils should never be used for preparation of the poison bait.
- Collect and burry the left over poison bait and dead rats.
- Zinc phosphide is toxic and there is no antidote for it. In case of its accidental ingestion induce vomiting by inserting fingers in the throat and rush to a doctor.
- Vitamin K is the antidote for bromadiolone which can be given to the patient under medical supervision.

v. Integrated Approach

No single method is 100% effective in controlling rats and mice. Left over population reproduce reaching the orginal size in a short time. Therefore, adopt an integrated approach by using different methods at different stages of the crop. After harvesting Rabi crops, rats must be killed during irrigation and apply chemical measures at appropriate timings in the crop as given above. The left over rats after zinc phosphide baiting should be tackled with bromadiolone. Due to bait shyness, zinc phosphide cannot be used in follow up baiting but bromadiolone can be used. Do not repeat zinc phosphide bait before two months.

Village Level Campaign

Control of rats and mice in smaller areas usually becomes ineffective due to their migration from the surrounding untreated fields. Therefore, for better results village level antirat campaigns, to cover maximum possible area, both cultivated and uncultivated, should be organized.

Rodent Proof Storage Structure

For rodent proofing of cover and plinth (CAP) storage structure under outdoor bulk grain storage conditions, built plinth at a height of 2.5 feet from ground level and extend platform by one foot in all the four sides of a plinth.

B. Management of Birds

Birds, in general, are both useful and harmful to agriculture. Even the same species may be beneficial or problematic in different situations. Only a few of about 300 species of birds of Punjab cause problems in crop fields and granaries. Rose-ringed Parakeet is the only bird that seems to be exclusively harmful to farmers' interests.

Harmful Birds: Parakeet is the major bird pest causing serious damage to almost all cereal and fruit crops. It is particularly harmful to sunflower. House Crows damage sprouting wheat, maize and sunflower. House Crows also damage maturing maize and sunflower. Doves and pigeons damage pulses. Sparrow and weaver birds damage stored grains at shellers and godowns. Sparrows and weaver birds also damage rice nurseries and maturing bajra and sorghum.

Management Techniques for Harmful Birds

I. Mechanical Control

- Use crackers to scare the birds at different intervals.
- Fixing of scare crows i.e. a discarded earthen pot painted to stimulate human like head supported with wooden sticks and clothed in human dress to give a human like appearance is one of the most effective traditional techniques to keep the birds away. Position, direction and the dress of the scare crow should be changed at least at 10 days interval. The height of the scare crow should be 1 meter above from the crop height.
- Use automatic bird scarers by shifting their position periodically. The other simplest method is the use of rope crackers. It involves tying of sets of small fire crackers at a distance of 6-8 inches apart and igniting it from the lower end. The explosions caused by the fire crackers on catching fire at different intervals scare the birds feeding on sproutings. Fix up the rope crackers in the centre of the field during sprouting stage whereas in maturing crops fix the rope on a stick in the periphery of the field.
- To reduce bird damage to maize, reflective ribbons of polyester strips with metallic coating of red color on one side and silver on the other having 1.5 cm width should be used. Reflective ribbons should be installed about 30 cm above the crop canopy in parallel rows at 5 m distance in north-south direction at the milky stage of the crop. If there are resting sites for birds nearby the fields then one strip of reflective ribbon should also be installed on the boundary of the field. Reflective ribbons for bird scaring is an effective, easy to use and eco-friendly technique for bird management in maize crop.

II. Cultural Practices

- The traditional practices of planting 2-3 border rows of less costly crops like millet, maize and daincha equally preferred by birds will reduce the bird pressure to the inside sown cash crops particularly sunflower and maize etc. Moreover, planting of these crops also act as physical barriers/ wind breakers and help in preventing lodging of crops during stormy/rainy days.
- As far as possible sowing of maize and sunflower crop should be avoided at sites most frequently visited by birds or where there are more resting sites like trees, electric wires, buildings etc.
- To prevent parakeet damage in sunflower and maize crops sowing should be discouraged in small block areas, at least 2-3 acre block area is more suitable, for lessening bird damage pressure because parakeet avoid feeding /venturing in the core of the field.

III. Alarming Calls

Playing of CD available with Centre of Communication and International Linkages, PAU of distress or flock calls of parakeets and crows respectively at peak volume for ½ hr twice each in the morning between 7.00 to 9.00 a.m. and in the evening at 5.00 to 7.00 p.m. respectively, with a pause of 1 hour, scare the birds or halt their activities for full day in the freshly sown, emerging or maturing crop fields and in orchards. Use of distress or flock calls remain effective for 15-20 days. Better result can be obtained by using this technique in sequence or in combination with other methods as an integrated pest management. For covering larger area use of amplifier and additional speakers as per requirement can be done.

Conservation of useful Birds: Predatory birds like owls, falcons, hawks, eagles, kites etc. eat large number of rats and mice. A single owl normally eats 4-5 rats a day. Insect eating birds like drongo, babblers, shrikes, lapwings, mynas and many other small birds eat away numerous insect pests. Even granivorous birds like Sparrows and Weaver birds feed a large number of insects to their young ones. A single pair of House Sparrows feed insects to their young ones about 250 times a day. Therefore, the useful birds should not be killed. Rather they can be attracted to crop fields in several different ways.

ANNEXURE - I

Minimum Support Price of Different Crops

(Rs. per quintal)

Crop	Crop Year				
	2020-21	**2021-22**	**2022-23**	**2023-24**	**2024-25**
Paddy (Common)	1868	1940	2040	2183	2300
Paddy (Grade 'A')	1888	1960	2060	2203	2320
Jowar (Hybrid)	2620	2738	2970	3180	3371
Bajra	2150	2250	2350	2500	2625
Maize	1850	1870	1962	2090	2225
Tur (Arhar)	6000	6300	6600	7000	7550
Moong	7196	7275	7755	8558	8682
Mash (Urad)	6000	6300	6600	6950	7400
Groundnut	5275	5550	5850	6377	6783
Sunflower Seed	5885	6015	6400	6760	7280
Soybean	3880	3950	4300	4600	4892
Sesamum	6855	7307	7830	8635	9267
Cotton (Medium staple)	5515	5726	6080	6620	7121
Cotton (Long staple)	5825	6025	6380	7020	7521
Wheat	1975	2015	2125	2275	2425
Barley	1600	1635	1735	1850	1980
Gram	5100	5230	5335	5440	5650
Lentil (Masur)	5100	5500	6000	6425	6700
Rapseed/ Mustard	4650	5050	5450	5650	5950
Sugarcane (SAP)#	310/300/295	360/350/345	380/370/365	391/381/381	401/391/391

#State-agreed price for early, mid and late sugarcane varieties

ANNEXURE - II

District-wise Area, Production and Yield of Various *Kharif* Crops in Punjab during 2023-24

District	Paddy			Maize			Bajra			Total Kharif Cereals	
	A	P	Y	A	P	Y	A	P	Y	A	P
Amritsar	181.0	864	4772	1.7	3.1	1832	-	-	-	182.7	581.8
Barnala	114.5	910	7952	-	-	-	-	-	-	114.5	610.1
Bathinda	199.9	1416	7084	0.5	1.9	3827	0.1	0.1	590	200.5	950.8
Faridkot	117.0	806	6893	-	-	-	-	-	-	117.0	540.3
Fatehgarh Sahib	87.4	624	7142	0.2	0.8	3827	-	-	-	87.6	419.0
Fazilka	116.4	568	4882	-	-	-	-	-	-	116.4	380.7
Ferozepur	187.3	1273	6796	-	-	-	-	-	-	187.3	852.7
Gurdaspur	173.6	1040	5990	1	3.0	2972	0.3	0.2	785	174.9	699.8
Hoshiarpur	78.5	469	5975	45.3	172.9	3817	-	-	-	123.8	487.2
Jalandhar	173.6	1163	6703	3.9	17.6	4508	-	-	-	177.5	797.1
Kapurthala	119.1	824	6916	1.0	2.6	2553	-	-	-	120.1	554.4
Ludhiana	258.8	1961	7578	0.9	2.8	3112	-	-	-	259.7	1316.8
Malerkotla	52.9	445	8422	0.2	0.8	3827	-	-	-	53.1	298.8
Mansa	133.6	919	6878	0.1	0.4	3827	0.3	0.3	850	134.0	615.6
Moga	183.2	1412	7707	0.2	0.8	3827	-	-	-	183.4	946.8
Pathankot	30.1	177	5899	7.0	22.4	3199	-	-	-	37.1	141.4
Patiala	233.6	1574	6737	0.7	1.9	2746	-	-	-	234.3	1056.4
Rupnagar	40.7	251	6184	20.3	82.5	4066	-	-	-	61.0	250.5
Sangrur	238.6	1844	7728	0.2	0.8	3827	-	-	-	238.8	1236.2
SAS Nagar	33.6	202	6015	4.5	15.9	3531	-	-	-	38.1	151.3
SBS Nagar	63.1	435	6899	6.5	30.4	4684	-	-	-	69.6	322.1
Sri Muktsar Sahib	187.5	1140	6082	-	-	-	-	-	-	187.5	764.0
Tarn Taran	175	1109	6339	0.3	1.1	3827	-	-	-	175.3	744.5
State	**3179**	**21426**	**6740**	**94.5**	**361.7**	**3827**	**0.7**	**0.6**	**785**	**3274.2**	**14718.2**

A= Area in thousand ha, P= Production in thousand tonnes, Y= Average yield in kg/ha
Source: Department of Agriculture and Farmers' Welfare, Punjab

District-wise Area, Production and Yield of Various *Kharif* Crops in Punjab during 2023-24

District	Moong			Mash			Arhar			Total Kharif Pulses	
	A	P	Y	A	P	Y	A	P	Y	A	P
Amritsar	0.3	0.3	1079	-	-	-	0.1	0.1	1158	0.4	0.4
Barnala	0.4	0.3	759	-	-	-	-	-	-	0.4	0.3
Bathinda	0.5	0.5	1007	-	-	-	-	-	-	0.5	0.5
Faridkot	0.1	0.1	1214	-	-	-	-	-	-	0.1	0.1
Fatehgarh Sahib	-	-	-	-	-	-	-	-	-	-	-
Fazilka	0.6	0.6	996	-	-	-	-	-	-	0.6	0.6
Ferozepur	0.4	0.4	996	-	-	-	-	-	-	0.4	0.4
Gurdaspur	-	-	-	0.1	0.1	816	-	-	-	0.1	0.1
Hoshiarpur	-	-	-	0.1	0.1	527	-	-	-	0.1	0.1
Jalandhar	-	-	-	-	-	-	0.3	0.4	1169	0.3	0.4
Kapurthala	-	-	-	-	-	-	-	-	-	-	-
Ludhiana	0.1	0.1	870	-	-	-	0.3	0.4	1188	0.4	0.5
Malerkotla	-	-	-	-	-	-	0.1	0.1	915	0.1	0.1
Mansa	0.4	0.4	996	-	-	-	-	-	-	0.4	0.4
Moga	-	-	-	-	-	-	0.2	0.2	1061	0.2	0.2
Pathankot	-	-	-	1.0	0.4	393	-	-	-	1.0	0.4
Patiala	-	-	-	-	-	-	-	-	-	-	-
Rupnagar	-	-	-	0.1	(b)	440	-	-	-	0.1	(b)
Sangrur	0.1	0.2	1545	-	-	-	-	-	-	0.1	0.2
SAS Nagar	-	-	-	-	-	-	0.1	0.1	1127	0.1	0.1
SBS Nagar	-	-	-	-	-	-	-	-	-	-	-
Sri Muktsar Sahib	0.2	0.2	996	-	-	-	-	-	-	0.2	0.2
Tarn Taran	0.2	0.2	996	-	-	-	0.1	0.1	1127	0.3	0.3
State	**3.3**	**3.3**	**996**	**1.3**	**0.6**	**440.0**	**1.2**	**1.4**	**1127**	**5.8**	**5.2**

A= Area in thousand ha, P= Production in thousand tonnes Y= Average yield in kg/ha

(b): Less than 50 tonnes.

Source: Department of Agriculture and Farmers' Welfare, Punjab

District-wise Area, Production and Yield of Various *Kharif* Crops in Punjab during 2023-24

District	Desi Cotton			American Cotton			Total Cotton		
	A	P*	Y*	A	P*	Y*	A	P*	Y*
Amritsar	-	-	-	-	-	-	-	-	-
Barnala	0.1	0.3	430	1.6	6.8	720	1.7	7.0	703
Bathinda	0.4	1.0	430	57.2	175.0	520	57.6	175.9	519
Faridkot	-	-	-	0.9	1.7	328	0.9	1.7	328
Fatehgarh Sahib	-	-	-	-	-	-	-	-	-
Fazilka	1.0	2.5	431	82.1	218.3	452	83.1	220.5	452
Ferozepur	-	-	-	-	-	-	-	-	-
Gurdaspur	-	-	-	-	-	-	-	-	-
Hoshiarpur	-	-	-	-	-	-	-	-	-
Jalandhar	-	-	-	-	-	-	-	-	-
Kapurthala	-	-	-	-	-	-	-	-	-
Ludhiana	-	-	-	-	-	-	-	-	-
Malerkotla	-	-	-	0.1	0.3	500	0.1	0.3	500
Mansa	-	-	-	40.2	151.8	642	40.2	151.8	642
Moga	-	-	-	0.1	0.3	500	0.1	0.3	500
Pathankot	-	-	-	-	-	-	-	-	-
Patiala	-	-	-	-	-	-	-	-	-
Rupnagar	-	-	-	-	-	-	-	-	-
Sangrur	0.1	0.3	430	1.7	5.3	535	1.8	5.6	529
SAS Nagar	-	-	-	-	-	-	-	-	-
SBS Nagar	-	-	-	-	-	-	-	-	-
Sri Muktsar Sahib	-	-	-	28.3	65.3	392	28.3	65.3	392
Tarn Taran	-	-	-	-	-	-	-	-	-
State	**1.6**	**4.1**	**431**	**212.2**	**624.1**	**500**	**213.8**	**628**	**500**

A= Area in thousand ha, P= Production in thousand bales (one bale of 170 kg lint) , Y= Average yield in kg/ha

*in terms of lint

Source: Department of Agriculture and Farmers' Welfare, Punjab

District-wise Area, Production and Yield of Various *Kharif* Crops in Punjab during 2023-24

District	Groundnut			Sesamum			Total Kharif Oilseeds	
	A	P	Y	A	P	Y	A	P
Amritsar	-	-	-	0.6	0.2	407	0.6	0.2
Barnala	-	-	-	-	-	-	-	-
Bathinda	-	-	-	-	-	-	-	-
Faridkot	-	-	-	-	-	-	-	-
Fatehgarh Sahib	-	-	-	-	-	-	-	-
Fazilka	-	-	-	-	-	-	-	-
Ferozepur	-	-	-	0.2	0.1	380	0.2	0.1
Gurdaspur	-	-	-	-	-	-	-	-
Hoshiarpur	1.6	2.8	1740	0.3	0.1	367	1.9	2.9
Jalandhar	-	-	-	0.1	0.1	671	0.1	0.1
Kapurthala	-	-	-	-	-	-	-	-
Ludhiana	-	-	-	-	-	-	-	-
Malerkotla	-	-	-	-	-	-	-	-
Mansa	-	-	-	-	-	-	-	-
Moga	-	-	-	-	-	-	-	-
Pathankot	-	-	-	0.4	0.1	306	0.4	0.1
Patiala	-	-	-	-	-	-	-	-
Rupnagar	-	-	-	0.1	(b)	258	0.1	(b)
Sangrur	-	-	-	-	-	-	-	-
SAS Nagar	-	-	-	-	-	-	-	-
SBS Nagar	-	-	-	-	-	-	-	-
Sri Muktsar Sahib	-	-	-	-	-	-	-	-
Tarn Taran	-	-	-	0.2	0.1	380	0.2	0.1
State	**1.6**	**2.8**	**1740**	**1.7**	**0.6**	**380**	**3.3**	**3.4**

A= Area in thousand ha, P= Production in thousand tonnes, Y= Average yield in kg/ha, (b): Less than 50 tonnes.
Source: Department of Agriculture and Farmers' Welfare Punjab

District-wise Area, Production and Yield of Various *Kharif* Crops in Punjab during 2023-24

District	Sugarcane (Cane)			Guara Seed		
	A	P	Y	A	P	Y
Amritsar	6.6	551	83430	-	-	-
Barnala	0.2	18	88080	-	-	-
Bathinda	0.1	8	83254	3.4	1.5	440
Faridkot	-	-	-	-	-	-
Fatehgarh Sahib	2.3	182	78994	-	-	-
Fazilka	1.0	43	42673	-	-	-
Ferozepur	0.1	6	63940	3.9	3.5	900
Gurdaspur	22	1996	90724	-	-	-
Hoshiarpur	25.1	1989	79246	-	-	-
Jalandhar	9.6	796	82931	-	-	-
Kapurthala	3.7	318	86000	-	-	-
Ludhiana	2.4	214	89035	-	-	-
Malerkotla	0.6	54	90175	-	-	-
Mansa	-	-	-	1.1	1.6	1450
Moga	0.1	8	83254	-	-	-
Pathankot	3.7	271	73345	-	-	-
Patiala	1.5	141	93931	-	-	-
Rupnagar	2.6	189	72517	-	-	-
Sangrur	1	99	99261	-	-	-
SAS Nagar	1.6	122	76451	-	-	-
SBS Nagar	5.3	452	85196	-	-	-
Sri Muktsar Sahib	0.2	17	83254	0.5	0.5	910
Tarn Taran	0.5	36	72260	-	-	-
State	**90.2**	**7510**	**83254**	**8.9**	**7.1**	**793**

A= Area in thousand ha, P= Production in thousand tonnes, Y= Average yield in kg/ha

Source: Department of Agriculture and Farmers' Welfare, Punjab

ANNEXURE-III

Table A: List of Bt cotton hybrids recommended for cultivation in Punjab state during *Kharif* 2025 only as evaluated by Interstate Committee for cotton.

S. No.	Hybrid	S. No.	Hybrid	S. No.	Hybrid
1	ACH 133-2 BG II	21	NCS 9024BG II	41	MH 5302BG II
2	ACH 177-2BG II	22	PRCH 333BG II	42	MRC 7041BG II
3	ACH33-2BG II	23	RCH 314BG II	43	NCS 459BG II
4	ANKUR 3224BG II	24	RCH 650BG II	44	NCS 495BG II
5	ANKUR 3228BG II	25	RCH 653BG II	45	NCS 855BG II
6	ANKUR 3244BG II	26	RCH 776BG II	46	NCS 857BG II
7	ANKUR 5642BG II	27	SHAKTI 9BG II	47	NCS 9013BG II
8	ANKUR JASSIBG II	28	SOLAR 77BG II	48	PCH 225BG II
9	Bio 841-2BG II	29	SUPER 544BG II	49	PCH 879BG II
10	Bio 846-2BG II	30	SUPER 721BG II	50	PCH 9611BG II
11	KCH 172BG II	31	SUPER 965BG II	51	RCH 773BG II
12	KCH 999BG II	32	SUPER 971BG II	52	SOLAR 75BG II
13	KDCH 441BG II	33	SWCH 4735BG II	53	SO7H878BG II
14	KDCH 641BG II	34	SWCH 4750BG II	54	SWCH 4744BG II
15	KSCH 207BG II	35	SWCH 4768BG II	55	SWCH 4755BG II
16	MRC 7301BG II	36	VICH 308BG II	56	ACH777-2BG II
17	MRC 7361BG II	37	VICH 309BG II	57	PRCH 7799BG II
18	MRC 7365BG II	38	VICH 310BG II	58	ANKUR 999BG II
19	NCS 4455BG II	39	ACH 155-2BG II	59	GBCH 85BG II
20	NCS 9002BG II	40	KDCHH 621BG II		

Table B: List of Bt cotton hybrids released & notified by Central Sub-Committee on Crop Standards, Notification & Release of Varieties for Agricultural Crops for North Zone of India on the basis of evaluation under ICAR-AICRP on Cotton.

S. No.	Hybrid	S. No.	Hybrid	S. No.	Hybrid
1	Raghuvir	11	KCH 307 BG II	21	RCH 997 BG II
2	ACH 945-2 BG II	12	C 9313 BG II	22	RCH 1103 BG II
3	ACH 955-2 BG II	13	C 352 BG II	23	KCH 9355 BG II
4	RCH 938-2 BG II	14	KCH 9323 BG II	24	ARCH 220 BG II
5	RCH 951 BG II	15	KCH 9333 BG II	25	ACH 999-2 BG II
6	RCH 846 BG II	16	RCH 960 BG II	26	ACH 559-2 BG II
7	RCH 926 BG II	17	RCH 983 BG II	27	ACH 902-2 BG II
8	MC 5403 BG II	18	RCH 1136 BG II	28	C 9314 BG II
9	MC 5408 BG II	19	RCH 1101 BG II		
10	MC 5410 BG II	20	RCH 1139 BG II		

ANNEXURE - IV (A)

Field Standards for the Production of Foundation and Certified Seeds

Crop	Isolation (in metre)		Pollen shedders		Off type Plants/ Earheads		Objection-able weed		Plants/ Earheads affected by seed borne diseases		Remarks
	F	C	F	C	F	C	F	C	F	C	
Rice	3	3	-	-	0.05	0.2	0.01	0.02	-	-	Wild rice or red rice
Maize Varieties hybrids	400	200	1.0	1.0	0.1	-	-	-	-	-	With same colour and texture
	-	300	0.5	1.0	-	-	-	-	-	-	With different kernel colour
	-	200	-	-	-	-	-	-	-	-	With same kernel colour
Bajra (hybrid)	1000	200	0.05	0.1	0.01	0.05	-	-	0.05	0.1	Grain ear and grain smut
Bajra (Composite)	400	200	-	-	0.05	0.1	-	-	0.05	0.1	
Mash	10	5	-	-	0.1	0.2	-	-	-	-	At final inspection
Moong	10	5	-	-	0.1	0.2	-	-	0.1	0.2	For disease
Arhar	200	100	-	-	0.1	0.2	-	-	-	-	Permitted at final inspection
Soybean	3	3	-	-	0.1	0.2	-	-	-	-	At final inspection
Cotton	50	30	-	-	0.1	0.2	-	-	-	-	Same species, permitted at flowering
	5	5	-	-	-	-	-	-	-	-	Different species, permitted at flowering
Groundnut	3	3	-	-	0.1	0.2	-	-	-	-	-
Sesamum	100	50	-	-	0.1	0.2	-	-	0.5*	1.0*	-
Sunflower (hybrid)	600	400	0.05	1.0	0.2	0.5	-	-	-	-	-

Standards are in percentage unless indicated otherwise

F: Foundation C: Certified

* Cercospora leaf spot disease

ANNEXURE - IV (B)
Seed Standards for Foundation and Certified Seed

Crops	% Pure seed (Minimum)		% Inert matter (Maximum)		No. of seeds per kg (Maximum)						Germination % (Minimum)		Moisture % (Maximum)	
					Other crop Seed		Weed seeds		Objectionable Weed Seeds					
	F	C	F	C	F	C	F	C	F	C	F	C	F	C
Rice	98.0	98.0	2.0	2.0	10	20	10	20	2	5	80	80	13.0	13.0
Maize														
(i) Hybrids	–	98.0	–	2.0	–	10	–	None	–	–	–	90	–	12.0
(ii) Composite and open pollinated varities	98.0	98.0	2.0	2.0	5	10	None	None	–	–	90	90	12.0	12.0
Bajra (Hybs. & Vtys.)	98.0	98.0	2.0	2.0	10	20	10	20	–	–	75	75	12.0	12.0
Mash	98.0	98.0	2.0	2.0	5	10	5	10	–	–	75	75	9.0	9.0
Moong	98.0	98.0	2.0	2.0	5	10	5	10	–	–	75	75	9.0	9.0
Arhar	98.0	98.0	2.0	2.0	5	10	5	10	–	–	75	75	9.0	9.0
Soybean	98.0	98.0	2.0	2.0	None	10	5	10	–	–	70	70	12.0	12.0
Cotton (Hybs. & Vtys.)	98.0	98.0	2.0	2.0	5	10	5	10	–	–	65	65	10.0	10.0
Groundnut	796.0	96.0	4.0	4.0	None	None	None	None	–	–	70	70	9.0	9.0
Sesamum	97.0	97.0	3.0	3.0	10	20	10	20	–	–	80	80	9.0	9.0
Sunfloweer (Hybs. & Vtys.)	98.0	98.0	2.0	2.0	None	None	5	10	–	–	70	70	9.0	9.0
F: Foundation C: Certified.														

ANNEXURE - V

Agricultural Engineering

I) Recommendations for Implements/Machines

General recommendations in respect of implements and machines used in agriculture are given below:

- The selection of the implements or machinery should be made on the basis of size and draft requirements which should match with the power available on the farm.
- Design, field capacity, materials, availability of spare parts and cost of operation per hour or per acre are important criteria to be considered in order to arrive at the decision to own a machine or any implement.
- Implements and machines including tractor involve a lot of investment. Periodic maintenance before and after the use of machinery is therefore, very necessary. In most cases, owner's manuals will provides safe guide-lines. On following these guidelines, machinery is expected to give un-interrupted service throughout its life.
- The seed-cum-fertilizer drill and the tractor mounted sprayer should be calibrated before they are used.
- Safety rules must be followed and adhered to strictly while operating tractors and high-speed agricultural machinery to avoid the loss of life and property.

Seed-cum-Fertilizer Drill

In selecting a seed-cum-fertilizer drill, the following points should be considered:

- It must have provision for varying line-to-line distance.
- The machine must have provision to control the depth of seed placement.
- The metering system of the drill should not damage the seeds which pass through the system.
- All furrow openers must deliver the same quantity of seed and fertilizer.
- A good agitator in the fertilizer box is desirable to avoid bridging.
- There should be provision for disengaging the seed and fertilizer distribution system.

For proper selection of seed-cum-fertilizer drills, the Test Reports issued by the Farm Machinery Testing Centre of the Punjab Agricultural University must be considered.

Calibration of Drill

Calibration means such a setting of the metering mechanism that ensures the dropping of the right quantity of seed and fertilizer in the field. The drills are already calibrated by the manufacturers, but the calibration may become defective during transportation. Further, the same calibration may not be found appropriate for all varieties of seed. The method of calibration is given below:

- Jack-up the seed-cum-fertilizer drill and check the free rotation of the driving wheel and the grain and fertilizer feed-shafts.
- Place the container or bag under each seed tube.

- Measure the circumference of the wheel. The circumference gives the distance covered in one revolution of the wheel.
- Find out the size of the drill by multiplying the number of furrow-openers by the distance between the furrow openers.
- Find out the number of revolutions required to sow one acre area as follows:

$$\text{Number of revolutions} = \frac{\text{Area of an acre (4000 sq. m.)}}{\text{Size of drill (m) X Circumference of wheel (m)}}$$

- Multiply this figure by 9/10 to take care of the wheel-slippage in the field.
- Mark a point on the rim of the wheel. Rotate the wheel by 1/10th of the number of revolutions required to sow one acre as above. Collect the seed quantity from each container separately and weigh.
- For getting seed rate per acre, multiply by 10.
- If the quantity collected from each container is not uniform, then check for a defect in the seed-dropping mechanism.
- Adjust the shift-lever on the feed box for grain rate accordingly, i.e. if the seed rate seems to be less than the actual quantity required per acre and then move the indicator a little to the higher side and vice-versa.
- Repeat this process twice to get the correct setting of the seed rate.
- Calibrate in the same manner for fertilizer rate.

Weight of Seeds Dropped in Five Revolutions of ground wheel

(For each seed tube of seed-cum-fertilizer drill)

Distance between rows	Size of Wheel			
	45 cm/18”	**60 cm/24”**	**75 cm/30”**	**90 cm/36”**
20 cm/8’’	15-18 grams	20-22 grams	25-28 grams	32-34 grams
22 cm/9’’	18-20 grams	24-26 grams	30-33 grams	37-39 grams

Combine Harvester

Some farmers own combines while some other get this facility on custom hire basis from the other agencies. There have been reports that in several instances the combine did a poor job, resulting in considerable loss of grain. The loss of grains as loose grains or ear heads can occur at the following points in a combine:

(i) At the cutter bar: These losses can be seen on the ground if all the discharge from behind the machine is collected in a bag and then the machine performance is observed for some distance. These can be avoided or reduced by setting the proper height of cutter-bar-reel and forward speed.

(ii) Behind the Machine: These losses will be either in the form of unthreshed heads or loose grains. Too many unthreshed heads mean that the cylinder-speed and the cylinder-

concave clearance are not properly adjusted. Too many loose grains may be due to many chocked sieves or excessive air blasts or both. Proper machine adjustment including running at speed according to the plant density can reduce such losses.

(iii) Grain Delivery: Unclean grain or broken grain or both will result from excessive cylinder speed or improper sieve-chaffer setting or improper forward speed.

Combine is very sensitive to adjustments which are required to be made at turning or according to the varying plant density, crop conditions (lodged etc.) and ground level (bunds) etc.

To get a rough estimate of losses, measure one metre square area and collect the grain and loose material fallen on it behind a combine. Separate the grains and weigh in grams. Multiply this by 10 to get the loss in kilograms per hectare. Alternatively, estimate the loss by counting the number of grains collected from one square metre area. One hundred grains per sq. metre mean about 40 kg per hectare for wheat.

Tips for efficient use of combine for paddy harvesting

- Paddy should be harvested between 9.00 A.M. to 9.00 P.M. due to fog/dew and excessive moisture in air.
- Self-propelled combine should be operated between 2.5 to 3.5 km/h whereas tractor operated combine should be operated between 2.0 to 3.0 km/h depending upon the field condition. Further in case of lodged crop the maximum speeds are 2.5 and 1.5 km/h for self-propelled and tractor operated combines respectively.
- Paddy should be harvested below 22% moisture.
- Replace cutter bar blades if it has become blunt.
- Reduce air-blast if grain damage as thrower losses is above 1%. If still, the problem persists, open the chaff sieve further.
- If grain breakage is more than 2% in the grain tank then reduce cylinder speed or increase concave clearance at the rear.
- If the amount of un-threshed grain in the thrower loss is more than 1%, then reduce the cylinder concave clearance.
- If combine gets over-loaded, then reduce the forward speed or cut the crop little higher.
- If crop is wet, i.e. more than 22 percent grain moisture then it should not be harvested otherwise it can cause fire.

Guidelines for adjusting the combine for maize threshing with husk

- The drive to the cutter bar should be disconnected and the reel should be removed for easier feeding of the maize ears. This can be done very easily by removing a belt and opening only a few nuts and bolts. Arrangements should be made to put the maize ears at a distance from the auger and allow these ears to flow by gravity directly to the auger. This will make the feeding proper and safe. The feeding platform should be lifted about one foot above ground for proper feeding.

- Raspbar cylinder used for threshing wheat should be used for threshing maize. The speed of cylinder should be kept between 500 to 600 rpm as compared to about 900 rpms for wheat. This could be achieved by mounting a 12 inches pulley on the cylinder shaft and 6 inches pulley on the drive shaft (stripping beater shaft).
- Cylinder-concave clearance should be maximum (approx. one inch) for maize threshing. This could be achieved by setting concaveshaft on one of the last three notches.
- The sieve in the cleaning shoe should be replaced by the large hole size sieve (approx. 1/2 inch) generally provided with the combine by manufacturers.
- If the combine does not have a grain tank, the grains should directly by taken from the chaffer to avoid possible grain damage. However, if a grain tank is provided, no such change is necessary.
- There should be least two canvas screens on the straw/rack/walkers. One screen is normally provided at 1/3rd distance in the first portion. The second screen should be provided at 1/3rd distance from the rear. This is necessary to avoid grain losses.

Effective Utilization of Threshers

Presently, about 3,00,000 threshers are being used for threshing of wheat crop in the Punjab. In order to utilize these threshers efficiently and economically, the following points are to be kept in mind:

The farmer's decision on owning a particular type of thresher should be based upon:

- Output of threshed crop in quintals per horse-power/hour.
- Speed of the threshing cylinder in rpm recommended by the manufacturer.
- Power required to operate the thresher.

This information should be gathered from the manufacturer and check with the test report from the Farm Machinery Testing Centre, Department of Farm Machinery and Power Engineering, PAU, Ludhiana, if available.

With the above-mentioned information in hand, the farmer will be able to use his thresher economically and efficiently provided the following guidelines are observed:

- The thresher should be kept in level position.
- The power required by the thresher should match with that of the power source which should not be overloaded.
- It should be operated at the recommended rpm with due adjustment made in the thresher for the crop variety, moisture content and cleanliness of the grain.

Tips to Save Diesel

- Badly maintained tractor wastes upto 25 per cent of the diesel used.
- Prevent leakage of diesel as it is a direct wastage.
- Wrong gear selection can increase fuel consumption upto 30 per cent and reduce output upto 50 per cent.

- A smoky tractor wastes diesel upto 20 per cent.
- Unfiltered air wears out cylinder bore 45 times faster and piston rings 115 times faster than normal which results in loss of power and wastage of diesel.
- Avoid unnecessary slippage of tractor wheels with the help of water ballast and/or cast iron weights in case of sandy soils and use cage wheel in wet land condition to avoid slippage.
- Relug worn out tyres.
- Operate the tractor at the correct throttle setting to give the recommended p.t.o. speed for operating pumping set or thresher.
- Keep the correct inflation pressure in tyres.

Farm Equipment/Implements Recommended for Various Operations for *Kharif* Crops

Operation	Name of the implement/ machine	Size	Power required	Capacity (acre/day)	Remarks
Straw Management	Stubble Shaver	1.35 m	Tractor (35 hp)	12-14	For cutting standing stubbles
	Paddy straw cutter sum spreader	1.2 m	Tractor (35 hp)	9-10	It improves the efficiency (20%) of PAU Happy Seeder by chopping and spreading of straw after combine harvesting of paddy.
	Straw baler	1.4 m	Tractor (50 hp)	8.0	It collects the straw and compress in the form of bales.
	Paddy straw chopper cum spreader	2.0 m	Tractor (50 hp)	6.0-7.0	The paddy straw chopper cum spreader chop the straw into small pieces and spread it on the surface.
	Combine harvester with SMS attachment	4-5 m	Tractor mounted (50-60 hp) Self-propelled (80-120 hp)	8-10 15-20	SMS attached at rear of combine below the straw walkers and behind the chaffer sieves for uniform distributions of loose straw. SMS is to be operated with following considerations; • V-belts and pulley arrangement used for power transmission should be appropriately covered against paddy residues. • Counter rotating discs should remain in motion during harvesting operation in the field for uniform spreading of residues.
	Combine harvester with PAU Super SMS attachment	4-5 m	Self-propelled (80-120 hp)	13-16	Super SMS attached at rear of combine harvester for chopping and even distribution of loose straw.

Tillage	Mould board plough	30 cm (2 bottom)	Tractor 30 hp & above	3.75-5.0	Field capacity will depend upon size of implement and soil conditions.
	Mould board plough	30-35 cm (3 bottom)	Tractor 40 hp & above	5-6	
	Sub-soiler	single tine	Tractor 45 hp & above	6-8	
	Cultivator	7 to 11 tined	Tractor 25-45 hp	8-15	
	Disc harrow				
	(a) Trailing type	1.35 m	Tractor 30 hp & above	8-10	
		1.85 m	Tractor above 40 hp	12-16	
	(b) Mounted type	0.9 m	Tractor 20-30 hp	5-7	
		1.35 m	Tractor 30-35 hp	10-12	
		1.85 m	Tractor above40 hp	12-16	
Levelling	Leveller	2.3 m	Tractor 35 hp & above	17.5	The field capacity will depend upon the soil type and the extent of undulation in the field.
	Super leveller	3.0 m	-ditto-	25	
	Laser land leveller	2.0 m	Tractor 50 hp and above	4-6	
Puddling	Straight-angular blade puddler	2.5 m	Tractor 35 hp and above	12.5	For puddling of fields before paddy transplanting
	Paddy-disc-harrow	1.8 m	Tractor 30 hp and above	10-12	
	Cultivator with pulverizing roller	2.7 m	Tractor above 35 hp	15-20	
Mat type paddy nursery sowing	Tractor operated seeder for mat type paddy nursery	1.0 m	Tractor (40 hp or above)	Mat type rice nursery for 150 acre/ day	Machine is used to sow mat type paddy nursery for mechanical paddy transplanters.
Cutting of mat-type paddy nursery	PAU nursery cutter	280 mm x 1205 mm	One person	It could cut mat type paddy nursery for 25-30 acre/ day	Cutting of mats with this equipment results in increasing cutting capacity and reducing human fatigue compared to manual cutting with a knife, sickle, or local tools.
Trans-planting	Paddy transplanter	1.2 m	Manually Operated	0.6-0.8	Machine uses only mat type nursery. Three persons are required for machine operation including nursery uprooting and transportation.
	-do-	1.2 m (set the machine at spacing of 30x12 cm)	Engine operated machine (walk behind type)	2.5	Four persons are required for machine operation including nursery uprooting and transportation.
	-do-	-do-	Remote Controlled - Engine operated machine (walk behind type)	2.75	The machine is controlled by remote and operator need not to walk in puddled field behind the machine.
Sowing	Tractor operated pneumatic planter for maize crop	4-row	Tractor (45 hp or above)	12-15	For sowing Maize with provision for bed making.
	Seed-cum-fertilizer planter	Four rows	Tractor 35 hp & above	6.0	For Maize, groundnut, cotton, soybean, gram and peas.

Sowing	Seed-cum-fertilizer drill	9-11 rows	Tractor 35 hp & above	9-11	-
	Lucky seed drill	9-11 rows	Tractor 35 hp & above	6.0-8.0	For simultaneous spray of herbicide and sowing
	Zero till drill	9 rows	Tractor 35 hp & above	7-8	For sowing maize
	Ridger	Two rows	Tractor 35 hp & above	6-7	For making ridges
	Ridger planter	-ditto-	-ditto-	5-6	For sowing cotton, maize on ridges.
	Sugarcane planter	2 rows	Tractor 30-45 hp	4.0	Use setts of 20" length.
	Sugarcane cutter planter	Two rows, (row spacing 60-90cm adjustable	35 hp and above	2.5-3.0	The machine cuts sugarcane sets, applies fungicide insecticides automatically
	Sugarcane trench digger	Paired two row spacing (30cm)	-ditto-	6-8	Machine makes trenches and a bed for paired row sugarcane planting
Inter-culture	Wheel hand hoe	9-30 cm	Manually operated (1-2 persons)	0.75-1.25	For soyabean, Maize etc crops
	Paddy weeder (cono weeder)	10-15 cm	Manually operated	0.3	For paddy crop only
	Self propelled power weeder	Single row	5.0 hp diesel engine	1.5-2.0	For wide row crops like sugarcane, maize, cotton etc.
	Tractor operated rotary weeder	2/ 3 row	Tractor 35 hp and above	8-10	-do-
Spraying and dusting	Knapsack sprayer	500 mL / min.	Manually operated	1.5-1.75	For spraying on different crops
	Foot sprayer	1200 mL / min.	Foot-operated	2.5	-do-
	Shoulder mounted power-sprayer-cum-duster	8 l/min.	1.5 hp diesel engine	4.5	For maize and cotton
	Self propelled boom sprayer	6.0 m	5 hp diesel engine	15-20	For spraying weedicides and insecticides
	Tractor-mounted boom sprayer	12 m	30-35 hp Tractor	30-40	Multipurpose
	Self-propelled high clearance sprayer	13.5 m	20 hp diesel engine	30-40	It can be used for even sprays without any damage to crop
Spraying and dusting	Backpack type air-assisted electrostatic sprayer	0.67-0.90	6.5 hp (Petrol engine)	3.0	For efficient control of sucking pests, bollworms and tobacco caterpillar of cotton crop by increasing the deposition of sprayon the top side and underside of leaves.

	Auto Rotate gun type sprayer	15.0 - 20.0	Tractor ≥ 35 hp	24-30	For effective spraying on crops especially for the control of whitefly at the initial stage of cotton crop.
	PAU multipurpose high clearance sprayer	10.0 (without gun)	High clearance tractor ≥ 35 hp	20	For increasing deposition of spray especially at top,middle and bottom of the canopy.
		20.0 (with gun)		40	
	4 WD- Paddy transplanter with boom sprayer mounting	7.0 m	17 hp engine	18-26	More annual use of paddy transplanter and judicious spraying in row crops such as wheat and paddy etc.
	Hexacopter Drone fitted with a standard/extended flat fan nozzle or anti-drift/air induction nozzles	Hexacopter Drone (small category with payload capacity 10 kg)	Battery (Lithium Polymer)	2.5 acre / hour	A hexacopter drone fitted with a flat fan nozzle or anti-drift/air induction nozzles to be operated (by a certified pilot) at a pressure of 1.38 kg cm-2 along with a forward speed of drone 2.0-3.0 m/s and at a height of 2.0-3.0 m above the crop.
Harvesting	Groundnut-digger shaker	1.22 m	35 hp Tractor-operated	6-8	For digging, shaking and winnowing of groundnut.
	Vertical conveyor reaper	1.9 m	35 hp Tractor-operated	5-8	For harvesting paddy 7 or 8 persons required for machine operation including the crop collection and transporation.
Threshing, Grading etc.	Japanese-type pedal Thresher	---	Manually operated	2.5-3.0 q/day	For small farmers and hilly regions.
	Power-operated thresher	---	20-30 hp	4-6 q/h (bajra)	In bajra, the threshing of heads is done only.
	Paddy-huller	---	2 men	2.0 q/day	For hulling rice.
	Groundnut thresher	---	25 hp Tractor	2.0 q/h	For threshing groundnut crop.
	Groundnut-decorticator	---	Manually operated	2.0 q/day	For shelling groundnut pods.
	Groundnut-decorticator	---	5-6 hp electric motor	1.0 q/h	-Ditto-
	Maize-sheller	---	Manually operated	1.2 q/day	For shelling maize cobs.
	Maize-sheller	---	Power-operated 7.5 hp electric motor or equivalent diesel engine/ tractor	2.6 q/h	-Ditto-
	Maize dehusker cum thresher	---	5 -20 hp electric motor or equivalentdiesel engine/tractor	15-20 q/h	Maize along with husk can be threshed

Threshing, Grading etc.	Multicrop thresher	Feeding width: 370 mm	5 hp electric motor or equivalent diesel engine/ tractor	Paddy: 4 q/h	Three persons are required for machine operation and transportation of the crop.
		Feeding width: 560 mm	10-15 hp electric motor or equivalent diesel engine/tractor	Paddy: 8 q/h	Four persons are required for machine operation and transportation of the crop.
	Moong Thresher	---	7.5 hp electric motor or equivalent diesel engine/ tractor	2.5 q/h	Spike tooth type power thresher for wheat can be used with following modifications: i) Keep only one spike on each row in spiral manner and remove additional spikes.
					ii) Increase concave clearance to 25 mm by reducing the spike length. iii) Operate the thresher at a cylinder peripheral speed of 19-21 m/s. This can be achieved by increasing the existing pulley size on thresher by a factor of 1.1 to 1.2.
Combine	Tractor mounted Combine	3.0 m	Tractor (55-60 hp)	8-10	-
	Self-propelled Combine	4.0 m	80-120 hp	15-20	-
	Self-propelled Combine (with Maize header)	3.6 m	-do-	5.0-8.0	1. Adjustment needed 2. Six persons are required for machine operation
Removal of sticks	Cotton stalk uprooter	Two row (135 cm)	45 hp & above	10-12	For uprooting of cotton sticks
Mulching for weed control and moisture conserva-tion	Paddy straw bale shredder cum mulcher	-	Tractor (35 hp or above	6.0-7.0 acre/day	It reduces straw size and spreads it uniformL y in the field to act as a mulch.
Sub-surface drip laying machine		Two row	-do-	1.6-2.24	For laying drip pipes under surface at 15-30 cm depth

II) Selection, Installation and Operation of Farm Pumps

Four types of pumps are used for irrigation in Punjab. They are centrifugal pumps, propeller pumps, turbine pumps and submersible pumps. Centrifugal pumps are widely used in pumping water. They are simple in construction, easy to operate, low in intial cost and produce a constant steady discharge. Generally they are used to lift water for a total head of 4 meters to 10 meters. Propeller pump is used for low head (generally less than 4 meters). It is used for lifting water from water course, drain, pond, river etc. It is also relatively simple in fabrication, care and repair. When the depth of water table is more than the practical reach of centrifugal pump or the water table is fluctuating, then submersible pump or turbine pump is used. Both turbine pumps as well as submersible pumps have high initial cost, difficult to install and difficult to repair as compard to centrifugal pumps.

(a) Selection

Total head and discharge expected from the pump to irrigate a particular area is calculated and then the pump is selected which has the best efficiency at the above head and discharge conditions. Reputed pump manufacturers furnish the characteristic, curves or catalogues giving summary of important characteristics of their pumps. Pumps made by different manufacturers may vary considerably in their prices, adaptibility and efficiency. The pumps have efficiencies from 50 to 70 per cent. Good pumps with the highest possible efficiency should, therefore, be chosen. Regarding efficiency, ISI and Punjab quality mark pump can be relied upon.

While purchasing the pump, the farmer should have the following information:

- Source of water supply (open well, tubewell, canal etc.)
- Water table depth in the area.
- Crops to be sown.
- Total area under crops.
- Discharge required.
- Type of Prime-mover (engine or motor). In case of electric motor, the hours of electric supply.
- Location of tubewell in the farm.
- Type of drive (Belt drive, direct coupled, monoblock).
- Water conveyance system (lined or unlined or underground pipeline).
- Ground water quality in the area.

(b) Instructions for Efficient Use of Pumps

- The centrifungal pump should be installed at 1 to 2 m above the water level.
- Select a proper pump by consulting the different performance tables or charts from the dealer.
- Use large radius bends.
- Keep the height of delivery pipe at the minimum possible height above the ground level.
  (a) Use proper material of joint dori.
  (b) Fix joint dori in such a way that it leaks about 15-20 drops per minute.
  (c) Put the joint dori in pieces equal to circumference of pump shaft. The ends of each piece should be staggered.
- Servicing and annual overhauling of the pump set should be done as per manufacturer's instructions.
- To avoid leakage in joints, tighten the joints properly using good quality gaskets.
- The pump must be run at the recommended revolutions.

- Use proper quality of driving belts, in case of belt driven pumps.
- Use proper size of suction and delivery pipes according to discharge.
- Use good quality reflax valve whose flap should open fully.
- Foundation should be pucca, levelled and with bolts embedded in it.
- Align the motor and pump pulley accurately.

(c) Gas Problem in Tubewell Pits

In some areas, accummulation of gas (mainly carbon dioxide gas) has been found in the lower portion of the tubewell pit. When one goes into the pit for repair of pump, he feels difficulty in respiration and becomes unconscious after a few minutes. If one experiences such conditions, he should immediately come out of the pit. For testing the gas, one can burn a kerosene lamp and slowly lower it in the pit, wherever it blows off means that below that point there is carbon dioxide gas. This can be removed by using the following measures:

- One can use an exhaust fan lowered up to bottom of the pit and keep the exhaust fan on the ground surface and attach a PVC pipe up to bottom of it.
- One can use an empty juite bag or bucket or umbrella and move it up and down in the pit to remove the gas.
- If the pump is loaded by belt, run the pump idle for 15 minutes and the gas is pushed out.
- After using these measures, one should re-test the gas accumulation with the kerosene lamp before going down in the pit for repairs, etc.

(d) Efficient use of Irrigation Water

Methods of irrigation are Flooding (Kiara), Furrow, Sprinkler and Drip method. Flooding (Kiara) method is most commonly used by the farmers for irrigating cereal crops. For proper utilisation of irrigation water, it is necessary that most water applied in the field should be stored in the root zone of the crop. This depends upon soil type, field slope, field size, discharge and crop. To have better use of applied water, irrigation method should be properly selected. At present, irrigation application efficiency is 30 to 40% which can be increased to 60 to 70% by adopting proper method of irrigation.

Furrow method of irrigation is suitable for sunflower, maize, soybean and sugarcane crop in all types of soils. Sprinkler method can be used on sand dunes, light soils and where water is scarce. However, the system has high initial cost. Drip method is suitable for row crops like cotton, sugarcane etc. on light soils, poor quality water and undulating lands but the initial cost is quite high. For light, medium and heavy soils, the recommended slopes are 0.4, 0.3 and 0.15 per cent respectively i.e., the difference in levels at the two ends of an acre field should be 9.6, 7.2 and 3.6 inches respectively. Further, for tubewell delivery size of 3"-4" (7.5-10 litres per sec) and 6" (20 litres per sec), the number of border strips (Kiara) per acre should be 16, 10, 8 and 10, 5, 4 respectively for light, medium and heavy

soils. For Mogha discharge of 30 litres per sec the number of border strips (Kiara) per acre should be 7, 4, 3 respectively for light, medium and heavy soils.

(e) Laser land leveling

Laser land leveling is one such important technology for using water efficiently as it reduces irrigation time and enhances productivity not only of water but also of other non-water farm inputs. Laser leveler is trailed type equipment used for achieving precise fine leveling with desired grade. This two meter wide automatic leveling operation can be successfully operated with 50 or above horse powered tractor. It has four basic units' viz. Laser emitter/transmitting unit, laser receiving unit with soil bucket having double actuating hydraulic valve and level control box. The laser beam signal with 360º laser reference upto a command radius of 300-400 m for auto-guidance of the receiving unit. This unit actuates the hydraulic control for moving up/down the leveling bucket for the desired cut/fill operation. Prior to operating the machine the area requiring fine leveling has to be surveyed using a grade rod. Then based on the survey observations a mean grade is found. The bucket blade is then placed at the average grade and synchronized with the control unit. After this the operator operates the machine and the necessary cuts and fills are automatically controlled by the machine to achieve the desired level in the field. The capacity of the machine depends upon the amount of soil cut and fill required in the field and field geometry. It has been observed that the field efficiency of the machine is more for regular sized fields. It generally takes 1.5-2.5 hr per acre if the mean cut and fill is with-in 8 to 10 cm.

Since the initial cost of the Laser leveler is quite high so this type of service should be available on custom hiring through Govt. agencies, cooperative societies and custom operators/Contractors for making this service available to all categories of farmers. This technology is proven a boon to farmer community and for state agriculture and will motivate other farmers for adopting proper water management measures to use water more efficiently and judiciously, thus saving the depleting natural resource (water).

III. Turmeric washing and Polishing Machine

Turmeric rhizomes can be mechanically washed as well as polished in a, portable, electric power (1 hp) operated, rotary drum type turmeric washing and polishing machine. The rotating drum, made of stainless steel is provided with an electronic device to regulate precisely the rotational speed of the drum. The machine operated at 40 rpm for 5 minutes can wash 2.5-3.0 quintals per hr of turmeric rhizomes. The same machine can be used to polish 1 quintals per hr of turmeric by increasing abrasiveness using three detachable abrasive screens along the inner side of the drum. The desirable olive yellow colour of turmeric having smooth surface and negligible microbial infestation can be achieved by polishing turmeric at 40 rpm for 20 minutes. Only one person is required to operate the machine. For more information Department of Processing and Food Engineering of Punjab Agricultural University can be contacted.

Annexure - VI
Grain Storage and Management of Stored Grain Insects

1. Storage of Wheat

(a) Home consumption: Improved storage structures of various capacities are now available. For indoor use, PAU metal bins of 1.6, 3.5, 7.5, 10 and 15 quintal capacity are available. The air-tight bin is so constructed that it does not allow entry of any outside insects and rodents and the insects present in the grain do not get favourable atmosphere to develop. It is also economical, portable and simple to fabricate.

For filling and using the PAU metal bin, the following storage practices are recommended:

(i) Clean the bin thoroughly and do not allow the left-overs of the previously-stored grains to remain in the bin. Inspect the covers to ensure that the gaskets are intact.

(ii) Clean and sort the grains of all impurities. Broken kernels and other impurities lead to insect attraction and, hence, should be separated.

(iii) Do not mix the new grains with old stock as the latter may be infested with insects.

(iv) Never store infested grains, or grains with high moisture content. Dry the grains out in the sun, cool it and fill in the bin later in the evening. The moisture content of the grains should not be higher than 9 per cent.

(v) Fill-in the bin to full capacity and tight the lid properly.

(vi) Do not open the bin for the first 30 days and thereafter open it fortnightly. The cover should be replaced immediately after use.

(vii) Inspect the grains frequently.

(b) Commercial Purposes: For storing wheat for commercial purposes, the farmers should make use of the facilities provided by the following agencies.

(i) State Warehousing Corporation in the State and its regional offices.

(ii) Central Warehousing Corporation and its regional offices.

2. Management of Stored Grain Insects

Pests and Symptoms of attack: Twenty species of insects infest grains in the Punjab. Khapra beetle (*Trogoderma granarium*), lesser grain-borer (*Rhizopertha dominica*) rice weevil (Sitophilus oryzae) and flour beetles (*Tribolium* spp.) are serious pests of wheat jowar, rice barley and maize. Mung dhora (*Callosobruchus analis*), gram dhora (*C. chinensis*) and cowpea dhora (*C. maculatus*) attack different pulses. Grain moth (*Sitotroga cerealella*) attacks wheat, maize, jowar, oats, barley grains which lose nutritive value and germinating capacity, besides loss in weight.

Recommendations

Preventive measures

1. Dry the grains properly before storage.
2. Plug all cracks, crevices and holes in the godowns thoroughly.
3. Store new grains in the clean godowns or receptacles.
4. Use new gunny bags.
5. Disinfect empty godowns or receptacles by spraying 0.05% malathion emulsion (100 mL Malathion 50 EC in 10 litres of water) on the floor, walls and ceiling or fumigate the godowns using 25 tablets of aluminium phosphide/100 cum of empty space before storing the grains. Exposure 7 days.
6. Against dhora, cover the pulses stored in bulk with 7 cm layer of sand or sawdust or dung ash.

Curative measures

1. Phostoxin or Delicia or Celphos (aluminium phosphide) one tablet of 3 g/tonne or 25 tablets/100 cum space. Exposure 7 days.

Caution/limitation

- Before storing, the metal bins should be cleaned and placed in the sun for 2-3 days.
- Grains stored in metal bin also get infested if not treated with any insecticide. Control this infestation by giving fumigation.
- Where there is infestation of Khapra, use double the dose of aluminium phosphide.
- The fumigant should be only used in air-tight stores or under tarpaulins in the open by specially trained persons because these fumigants are deadly poisonous.

ANNEXURE - VII

Fertilizer Sources for the supply of Plant Nutrients

(A) Nutrient contents of different fertilizers (Percent)

Fertilizer	N	P_2O_5	K_2O	Other
Ammonium Sulphate	20.5	..	..	
Ammonium Chloride	25.0	..	..	
Calcium Ammonium Nitrate	25.0	..	..	
Urea	46.0	..	..	
Superphosphate (single)	..	16.0	..	12 (S)
Diammonium Phosphate	18.0	46.0	..	
Urea-ammonium Phosphate	28.0	28.0	..	
Nitrophosphate	20.0	20.0		
Sulphated phosphate	13	33	..	15(S)
Sulphate of Potash	..	..	48.0	
Muriate of Potash	..	..	60.0	
Potassium Nitrate	13	..	45	
Manganese Sulphate	..	..	..	30 (Mn)
Zinc Sulphate (Heptahydrate)	..	..	..	21 (Zn)
Zinc Sulphate (Monohydrate)	..	..	..	33 (Zn)
Ferrous Sulphate	..	..	..	19 (Fe)
Copper Sulphate	..	..	..	24 (Cu)
Gypsum	..	..	..	16 (S)
FYM/Vermicompost	0.5 -1.5	1.2 - 1.8	1.2 - 2.0	Sufficient

(B) Quantity of the fertilizer to give 1 kg of nutrient

For 1 kg of N		**For 1 kg of P_2O_5**	
Calcium ammonium nitrate	4 kg	Superphosphate	6.2 kg
Ammonium chloride	4 kg	Diammonium phosphate	2.2 kg
Ammonium sulphate	5 kg	Urea-ammonium-phosphate	3.6 kg
Urea	2.2 kg	Nitrophosphate	5.0 kg
For 1 kg of K_2O			
Muriate of Potash	1.7 kg		

Note: Urea-ammonium phosphate (28-28), nitrophosphate (20-20) and diammonium phosphate (18-46) contain both nitrogen and phosphorus. By adding one kg of phosphorus (P_2O_5) through these fertilizers, one kg nitrogen (N) from urea-ammonium phosphate and nitrophosphate and 400 g of N from diammonium phosphate is also added. This point must be taken into account while using these fertilizers.

Well rotten FYM contains 40-50 % moisture. Each ton of such FYM supplies N, P and K equivalent to 4 kg Urea, 10 kg Superphosphate and 6 kg muriate of Potash. So reduce the fertilizer dose accordingly.

ANNEXURE - VIII

Agricultural Accidents - Preventive and Curative Measures

1. First-aid precautions during spraying accidents

In case of pesticide poisoning, call a physician immediately. Awaiting the physician's arrival apply the FIRST-AID.

a. Swallowed Poisons

- Remove poison from the patient's stomach immediately by inducing vomitting. Give one teaspoonful (15 g) common salt in a glass of warm water (emetic) and repeat until the vomit fluid is clear. Gentle stroking or touching the throat with a finger or placing the blunt end of a spoon will help induce vomitting when the stomach is full of fluid.
- If the patient is already vomitting, do not give common salt.
- Do not induce vomitting if the patient is in a coma.

b. Inhaled poisons

- Carry the patient (do not let him walk) to fresh air immediately.
- Open all doors and windows.
- Loosen all tight clothing.
- Apply artificial respiration if breathing has stopped or is irregular. Avoid vigorous application of pressure to the chest.
- Cover the patient with a blanket.
- Keep the patient as quiet as possible.
- If the patient is convulsing, keep him in bed in some dark room.
- Avoid any jarring noise.
- Do not give alcohol in any form.

c. Skin Contamination

- Drench the skin with water (giving shower with a hose or pump).
- Apply a stream of water to the skin while removing the clothing.
- Cleanse the skin thoroughly with soap and water.
- Rapid washing is most important for reducing the extent of injury.

d. Prevention of Collapse

- Cover the patient with a light blanket.
- Raise the feet of the patient on the bed.
- Apply elastic bands to arms and legs.
- Give strong tea or coffee.
- Give fluid administration of normal saline intravenously.
- Give blood or plasma transfusion.

e. Eye Contamination

- Hold eyelids open.
- Wash the eyes gently with stream of running water immediately.A delay of even a few seconds greatly increases the extent of injury.
- Continue washing until the physician arrives.
- Do not use chemicals. They may increase the extent of the injury.

2. Snake Bite Preventions

In snake infested regions long trousers, high shoes or leggings and gloves should be worn. Most important is to look where one steps while walking.

First Aid: Re-assurance and complete rest to the victim to retard the absorption of venom. A wide tournaquet (or any piece of cloth) should be placed a few centimeters above the site of bite. It should be tight to an extent that a finger should pass below it with difficulty. Suction of venom should be done by giving a 1 cm linear and 1/2 cm deep incision at the mark of the fangs after applying an antiseptic lotion. Suction should preferably be done with rubber bulb, breast pump or with mouth after ensuring that there is no oral lesion. It should be continued for about an hour. If done promptly 50% of the venom can be removed.

3. Honey Bee and Wasp Bites

- Cooling of the part with ice pads.
- Removal of stings.
- Cleaning with soap and water.
- Local and systemic anti allergics to be given.
- Perfumes and bright colours attract these insects and should be avoided.
- Sensitive person can have severe anaphyllatic shock with even a single bite.
- Every such patient must get the medical aid from a doctor.

4. Electric Injuries-Preventions

Education of electric hazards to everybody, proper installation of electric appliances, grounding of telephone lines, radio and television arials, use of rubber gloves and dry shoes when working with electric circuits.

First Aid: Prompt switching off the current, if possible. Immediate removal of the victim from the contact with the current without directly touching him. Rescurer should use a rubber sheet, a leather belt, a wooden pole or any other non conductive material to detach him.

5. Safety Precautions During Threshing

- Don’t wear loose clothes, wrist watch etc. while working on a thresher.
- Never operate thresher under the influence of intoxicants like opium, liquor, etc.
- For safety, the minimum length of the feeding chute should be kept 90 cm covered

upto a minimum of 45 cm and inclined to a horizontal at an angle of 5 to 10 degrees. The angle of the covered portion with the base length of feeding chute should be kept equal to 5 degrees.

- A person is advised not to work on a thresher for more than 10 hours a day.
- Do not indulge in talking or any other distraction while working on the thresher.
- Avoid feeding ear heads (ghundian) as it may lead to serious hand injuries. Wet crop should also not be fed as it is bound to lead to fire accident. Take special care while feeding the damaged or short stalked crop.
- The exhaust pipe of the tractor should be fixed vertically upward and not under the tractor.
- The main switch of the electrical motor should be within the reach of the operators to switch off the current at the time of emergency. At the same time it should be ensured that layout of electrical wiring should not hinder the operational movement of workers.
- Do not cross over the belt or move near it.
- Keep a fire control equipment and first aid box for use in the event of need.

6. Safely Precautions During Tractor-Trolley use

- Purchase tractor with driver's safety structure to make operator safe during roll back of tractor.
- Use Triangular Reflector (Slow Moving Vehicle Emblem) on tractors, trolleys, carts etc.
- Do not load trolleys to oversize (width) while transporting wheat straw (turi), cotton sticks etc. Use proper lighting system and reflectors (mirror) while transporting above said bulky materials.
- Tractor used for trailer should also be weight blasted at the front axle to make it stable to check rearward rolling.
- When tractor-trailer moving up the slope, do not disengage the gear otherwise trailer may pull back tractor during gear change.
- Be careful while crossing un-manned railway crossing.

7. Safety Precautions During Chaff Cutting

- Purchase chaff-cutter with safety features like flywheel lock and cover on blade, fly wheel, gearbox, shafts, pulleys and belts etc.
- Feeding chute of chaff cutter should be 90 cm long and 45 cm cover on top with a warning roller in it.
- A reversal gear mechanism should be provided and located near the worker to stop or reverse the speed in emergency.
- The chaff cutter should be installed with firm foundation, in shade with sufficient space and lighting arrangement.

8. Safety Precautions to Avoid Fire Accidents

- To avoid fire accident the silencer of tractor or engine should be up in vertical direction.
- Threshing and collection of crop should be away from high-tension electric wires. The wires should be high enough so that the combine harvester with hood may pass safely.

- The arrangement of water (tubewell or canal) or heap of sand should be available near the site to control fire.
- Do not burn wheat straw to vacate field and use straw combines to make turi (dry fodder).

MONETARY COMPENSATION FOR ACCIDENT VICTIMS

Punjab State Marketing Board (Mandi Board) provide financial help to all the farmers, their family members and labourers while

- Working on agricultural implements in the field.
- Digging of well or electrocution while operating tubewell on the farm.
- Using pesticides or due to snake bite in the field.
- Use of implements in the notified market committees in Punjab.

Mandi Board Rates of Monetary aid to Accident Victims:

Type of injury	Rate of monetary aid (Rs.)
Loss of life	2,00,000/-
Loss of two limbs i.e. hands, arms, legs, feet etc.	60,000/-
Loss of one limb i.e. hand, arm, leg, foot etc.	40,000/-
Loss of four fingers i.e. equivalent to amputation of one body part.	40,000/-
Loss of finger/finger parts equivalent to amputation of complete finger	10,000/-
Physical disability (more than 25%)	50,000/- to 1,00,000/-

Application Procedure for Monetary Help

In Mandi Board, victim or the nearest successor has to submit prescribed application within 30 days of accident or with a justification in case of delay. The performa includes personal detail of the victim, details of accident and level of injury. This performa is to be verified by the Sarpanch and two members of village Panchayat or by the Municipal Commissioner in case of jurisdiction of municipal committee. He/she has to submit a police report of the accident and also a verification report by the Sub-Divisional Magistrate, Patwari and Tehsildar. Regarding medical treatment and loss, verification is accepted only from registered or qualified doctor. The victim has to submit an affidavit mentioning that monetary relief is not being sought from any other agency.

ANNEXURE - IX

Antidotes for Pesticides for Human Beings

Signs and Symptoms of Toxicity

Inhalation	Usually appear within 1/2 hour of exposure, maximum after 6 hours. Nausea and vomiting, running nose, feeling of chest tightness, excessive salivation, difficulty in respiration, frothing from mouth, headache, giddiness, vertigo.
Oral intake	Nausea and vomiting, abdominal cramps, diarrhoea, muscle twitching, confusion and disorientation, salivation and frothing, profused sweating, diminished vision, pin-point pupils, respiratory difficulty, convulsions, coma, death.
I. Insecticides	
Organochlorines (lindane etc.)	No specific antidote. For convulsions: **Diazepam** 10 mg intravenous (I/V). Could be repeated upto 30-40 mg. **Phenobarbitone** 100-300 mg in drip.
Organophosphates (monocrotophos, chlorpyriphos, methyl parathion acephate,triazophos malathion, quinlphos, dimethoate etc)	**Atropine**: 2-4 mg intravenous as a first dose. If no effect double dose may be given every 10 minutes till atropinization. Maintain upto 24-48 hours. **2-PAM**: 1- 2 g I/V as 5% solution in dextrose to be given in 5-7 minutes or 150 mL of saline drip every 30 minute. If required it may be repeated every hour till the muscle weakness and fasiculation persists. To be continued every 6-8 hours for 1-2 days or 5% solution as infusion @ 1/2 g/ hr. **2 - PAMCL**: dose same as above. **Atropine + 2PAM**: should be given together as 2 PAM acts as synergist to atropine. + Glycopyrolate 7.5 mg in 200 mL saline in case of respiratory inf.
Carbamates (Carbaryl carbofuran etc.)	**Atropine**: 2-4 mg I/V as a test dose. If no effect double dose may be given every 10 minute till atropinization. Maintain upto 24-48 hours. Avoid 2 PAM. **Warning: Do not use oxime or morphine.**
Pyrethroids (cyper-methrin, fenvalerate, deltamethrin etc).	Only symptomatic treatment, antihistamine are of value, if large amounts are ingested to cause nervous infestation, pentabarbitone (0.7g/day)/diazepam 5-10 mg for convulsions be used. For diarrohoea treat by **atropine**.
Cartap hydrochloride (Padan, Caldan etc)	**Dimercaprol (BAL)** 3-4 mg/kg body weight. (Comes as 3 mL , 10% solution alongwith benzyl benzoate in arachis oil). Given deep intra muscular every 4 hours for 2 days and then twice for another 10 days.
Aluminium phosphide (celphos. phostoxin etc)	No specific antidote. Give activated charcoal slurry with sorbitol 50-100 g orally, diazepam 5-10 mg I/V slowly over 2-3 minutes. Phenobarbitone 600-1200 mg.diluted in 60 mL noral saline. Maximum dose 1-2 g. Dimercaprol (BAL). Magnesium sulphate 3g I/V bolus followed by 6 g in 12 hours for 5-7 days. Administering 5% glucose I/V can minimize liver and kidney damage. + Dopamine - 4.6 micrograms/kg/min i/v to treat Hypotension. Warning: Do not give water or water based drinks
Naturalyte (Spinosad)	No specific antidote. Treat symptomatically
Oxadiazine (Indoxacarb)	No specific antidote. Treat sympotmatically
Phenyl Parazole (fipronil)	No specific antidote. Treat symptomatically
Neonicotinoids (thiamethoxam etc.)	No specific antidote. Treat symptomatically
II Fungicides	
Carbendazim (Bavistin, Agrozim, Parazim, Derosal etc.)	**Atropine**: 2-4 mg I/V as a test dose. If no effect double dose may be given every 10 minute till atropinization. Maintain upto 24-48 hours.
Streptocycline	Injection of adrenalin, antihistamine and cartisone in case of acute anaphylactic shock, high or low blood pressure, profuse respiration and urticaria.

Copper oxychloride Copper sulphate (Blitox etc.)	**Dimercaprol (BAL)** 3-4 mg/kg body weight. Comes as 3 mL , given deep intramuscular every 4 hours for 2 days and then twice for another 10 days. + Sod. Bicarbonate 44-88 meq/ lit. + D-penicillamine - 0.5 g 6 hrly before meals for 5 days.
Edifenphos (Hinosan)	**Atropine**: 2-4 mg I/V as a test dose. If no effect double dose may be given every 10 minutes till atropinization.
Iprobenphos (Kitazin)	Maintain upto 24-48 hours. 2-PAM: 1-2g I/V as 5% solution in dextrose to be given in 5-7 minutes or 150 mL of saline drip every 30 minutes. If required it may be repeated every hour if the muscle weakness and fasiculation persists. To be continued every 6-8 hours for 1-2 days or 5% solution as infusion @ 1/2 g/hr.
Methoxy ethyl mercuric chloride (MEMC), Agallol, Ceresan etc.	Activated charcoal, egg white or 5% sodium bicarbonate solution (gastric lavage). High colonic irritation: 5% sodium formaldehyde sulfoxylate (fresh 100 - 200 mL) intravenous. For f aster treatment sodium citrate, oral 1 - 4 g every 4 hours. For spasms 100 mL (10%) calcium gluconate intravenous. BAL - i/m Inj 2.5-3 mg/kg every 4 hours for 2 days then BD for 7-10 days.
Mancozeb, Thiram, Zineb	**Ascorbic acid** (vitamin C) intravenous @ 0.2 g/min.
Ridomil MZ (8% metalaxyl + 64% mancozeb)	No specific antidote for metalaxyl. Antidote for mancozeb as given above mancozeb) metalaxyl+64% may be recommended as this combination contains 64% mancozeb.
Triadimifon (beylton), **Dinocap** (karathane)	No specific antidote, gastric lavage with 5% sodium (Bayleton) bicarbonate. No specific antidote. Gastric lavage with Karathane) 5% sodium bicarbonate and medicinal charcoal suspension. Then give 15-30 g sodium sulphate in half litre of water.
Carboxin (Vitavax)	Treat symptomatically
Captan (Captaf)	If ingested, induce vomiting by administering a spoon-ful of salt in hot water.
Chlorothalonil (Kavach)	Treat symptomatically
Propiconazole (Tilt)	Treat symptomatically
Wettable sulphur (Sultaf)	If chemical has gotten into the victim's eyes, flush eyes with plenty of water for atleast 5 minutes
III. Herbicides	
Anilophos (Arozin, Libra, Anilguard)	**Atropine**: 2-4 mg I/V as a test dose. If no effect double dose may be given every 10 minute till atropinization. Maintain upto 24-48 hours. 2-PAM: 1-2 g intravenous as 5% solution in dextrose to be given in 5-7 minutes or 150 mL of Anilfos Padigard etc.) saline drip every 30 minutes. If required it may be repeated every hour if the muscle weakness and fasiculation persists. To be continued every 6-8 hours for 1-2 days or 5% solution as infusion @ 1/2g/hr. 2-PAMCL: dose same as above. Gastric lavage with 5% sodium bicarbonate.
2,4-D	**Ingestion:** Gastric lavage with activated charcoal slurry. For muscle and cardiac irritability give Lidocaine 50-100 mg intravenous, followed by 1-4 mg/minas needed. Alkalize urine by sodium bicarbonate 10-15 g daily intravenously.
Glyphosate	**Ingestion**: immediately dilute by swallowing milk (Roundup) or water.
Isoproturon (Arelon, Delron Milron etc.)	Flush eyes with soap. Wash skin with soap and water.
Paraquat (Gramoxone)	Induce vomiting unless unconscious. Give gastric lavage with one litre of 30% aqueous suspension with Fuller's earth together with magnesium sulphate. Repeat administration until Fuller's earth is seen in stool. + sorbitol - 1-3 gm/kg to maximum 150 gms.
IV. Rodenticides	
Zinc phosphide (Ratol, Zinc-Tox etc.)	As under aluminium phosphide

Coumatetralyl (Racumin)	Vitamin 'K' under medical supervision
Bromadiolone	Vitamin 'K' under medical supervision.

Some common trade names of antidotes	
Diazepam	Calmpose, Lori, Paciquil, Tenil, Valium
Phenobarbitone	Gardenal
Dimercaprol	Inj. BAL (Knoll Pharma)
PAM	Neopam, Pam, Pamplus, Pam-A-Korea
Atropinisation includes	
1.	Drying up of secretions i.e. dry mouth, no frothing, loss of sweating.
2.	Tachycardia: Pulse should be maintained at about 110/minute
3.	Dilated pupils
4.	Hyperthermia

Sources of Information	
(a)	Farm Chemicals Handbook, 1994
(b)	Health hazards of Pesticides and its management (1996) Voluntary Health Association of India
(c)	Essentials of Forensic Medicine and Toxicology (1999) by Narayan Reddy
(d)	National Poison Information Centre, AIIMS, New Delhi

Caution: Antidotes are to be used in case of poisoning only, for which a physician must be consulted immediately.

DISCLAIMER

The information given is only advisory. Actual selection of antidote, dose and manner of administration is to be decided by the qualified physician.

The Punjab Agricultural University, Ludhiana accepts no legal responsibility.

ANNEXURE - X
IMPORTANT TELEPHONE NUMBERS OF PUNJAB AGRICULTURAL UNIVERSITY, LUDHIANA (DIAL EXCHANGE 0161-2401960 TO 2401979 FOR EXTENSION NO.)

Name/Designation	Telephone Number	
	Office	Mobile
Dr. Makhan Singh Bhullar **Director Extension Education**	0161-2401644	98728-11350
Dr. G P S Sodhi **Additional Director Extension Education**	0161-2401960/418 0161-2400429	94176-26843
Dr. Tarsem Singh Dhillon **Additional Director Extension Education**	0161-2401644 0161-2401960/214	94640-37325
Dr. T S Riar **Additional Director Communication**	0161-2401960/373 0161-2405731	98142-10269
Dr. Rupinder Kaur **Associate Director (Skill Development)**	---	97797-00905

Help Line Numbers for the Farmers

Kisan Call Centre	1800-180-1551 (Toll Free)	
Dr. G S Makkar, Plant Clinic	417	81464-00248
Dr. B S Gill, Plant Breeding & Genetics	435	98721-63567
Dr. Amarjit Singh, Plant Pathology	505	94637-47280
Dr. R S Chandi, Entomology	504	81460-39400
Dr. Amit Kaul, Agronomy	401	81464-00233
Dr. Gobinder Singh, Soil Science	506	95011-92500
Dr. Ruma Devi, Vegetable Science	452	98783-99555
Dr. Jaswinder Singh Brar, Fruit Science	303	99158-33793
Dr. Mahesh Narang, Farm Machinery & Power Engineering	446	94173-83464
Dr. Arashdeep Singh, Food Science and Technology	305	98762-35555
Dr. Jugraj Singh, Soil & Water Engineering	284	98155-47607

Dr. Raj Kumar, Economics & Sociology	461	81460-96600
Dr. Tarsem Chand, Processing & Food Engineering	384	97790-00640
Dr. Simrat Singh, Landscaping & Floriculture	440	98157-93196
Dr. Dharminder Singh, Extension Education	321	98726-12124
Dr. Neena Singla, Rodent Management	382	93573-25446
Dr. Tejdeep Kaur Kler, Bird Management	382	99559-65904
Seed Shop	419	---

Phone Number of Heads of Various Departments

Plant Breeding & Genetics	224
Wheat Section	250
Cotton Section	334
Maize Section	437
Oilseed Section	433
Pulses Section	413
Fodder Section	443
Entomology	320
Plant Pathology	319
Agronomy	308
Soil Science	317
Vegetable Science	370
Fruit Science	303
Landscaping & Floriculture	440
Extension Education	321
Farm Machinery & Power Engineering	257
Economics & Sociology	301/461
Microbiology	330
Rats & Birds Control	429

Associate/Deputy Directors of *Krishi Vigyan Kendras*

Dr. Bikramjit Singh, Amritsar	0183-2505672	98723-54170
Dr. Gurdeep Singh, Bathinda	0164-2912011	88722-00121
Dr. Kamaldeep Singh, Faridkot	01639-253142	98882-05158
Dr. Vipan Kumar Rampal, Fatehgarh Sahib	01763-221217	81465-70699
Dr. Gurmail Singh, Ferozepur	01632-279517	81462-60400
Dr. Sarbjit Singh Aulakh, Gurdaspur	01874-220743	94640-70131
Dr. Maninder Singh Bons, Hoshiarpur	---	98157-51900
Dr. Sanjeev Kataria, Jalandhar	01826-292053	99889-01590
Dr. Vipan Kumar Rampal, Ludhiana (Addl. Charge)	01628-261597	81465-70699
Dr. Harinder Singh, Kapurthala	01822-233056	97800-90300
Dr. Gurdeep Singh, Mansa (Addl. Charge)	01652-280843	88722-00121
Dr. Amandeep Singh Brar, Moga	---	81465-00942
Dr. Karamjit Sharma, Sri Muktsar Sahib	---	98722-17368
Dr. Bikramjit Singh, Pathankot (Addl. Charge)	0186-2920895	98723-54170
Dr. Hardeep Singh, Patiala	0175-2225473	81688-60099
Dr. Satbir Singh, Ropar	01881-220460	99882-27872
Dr. Pardeep Kumar, SBS Nagar	01823-292314	95010-23334
Dr. Mandeep Singh, Sangrur	01672-245320	70097-84182

Senior Most Extension Specialists of Farm Advisory Services

Dr. Jagdish Arora, Abohar	01634-225326	81959-50560
Dr. Narinderpal Singh, Amritsar	0183-2501989	84270-07023
Dr. Navdeep Singh Gill, Barnala	---	81461-00796
Dr. Amarjit Singh Sandhu, Bathinda	0164-2212684	94633-71120
Dr. Raminder Singh Ghuman, Chandigarh/Mohali (Addl. Charge)	0172-2775348	98885-21200
Dr. Fatehjeet Singh Sekhon, Faridkot	01639-250143	82848-00299
Dr. Jagjot Singh Gill, Ferozepur	01632-242136	82839-32427
Dr. R.S. Bal, Gurdaspur	01874-220828	78883-56773

Dr. Charanjeet Kaur, Hoshiarpur	01882-222392	94172-87920
Dr. Maninder Singh, Jalandhar	---	81460-88488
Dr. Harinder Singh, Kapurthala (Addl. Charge)	01822-232543	97800-90300
Dr. Gurpreet Kaur, Patiala	0175-2200646	94633-69063
Dr. Raminder Singh Ghuman, Ropar	01881-222257	98885-21200
Dr. Ashok Kumar, Sangrur	01672-293098	95018-55223
Dr. Parvinder Singh, Tarntaran	---	81463-22553

Directorate Research

Dr. Ajmer Singh Dhatt **Director Research**	0161-2401221 216 (Ext. No.)	99151-35797
Dr. G. S. Mangat **Addl. Director Research (Agriculture)**	0161-2407309 341 (Ext. No.)	98145-16464
Dr. Mahesh Kumar Addl. Director Research **(Agricultural Engineering) (Addl. Charge)**	---	94786-40539
Dr. Rajinder Singh **Associate Director (Seed)**	438	94649-92257
Dr. Balkaran Singh Gill **Deputy Director (Farm)**	253	81469-00244

Regional Research Station/Seed Farm

Abohar	01634-225326
Bathinda	0164-212159, 97800-24223
Bahadurgarh (Patiala)	0175-2381473
Faridkot	01639-251244
Gurdaspur	01874-220825, 88720-03010
Gangian (Hoshiarpur)	01883-85075, 98772-52692
Ladhowal (Ludhiana)	0161-2801566, 81463-00510
Kheri (Sangrur)	70097-84182
Kapurthala	98722-04523
Amloh (Naraingarh)	94649-92257
Ballowal Saunkhri (SBS Nagar)	98880-14851
Jallowal (Lesriwal) Jalandhar	98141-37547
Usman (Tarntaran)	81463-22553
Dyal Bharang (Amritsar)	98723-54170

Major weeds of direct seeded rice


Swank


Swanki


Chini gha


Madhana


Takri gha


Chupati


Tandla


Chulai


Chatri wala motha


Gandi wala motha

A few problems of rice


Plate 1: Zinc deficiency


Plate 2: Iron deficiency


Plate 3: Attack of Stemborer


Plate 4: Attack of Leaf folder


Plate 5: Sheath blight


Plate 6: False smut

A few problems of cotton

Plate 1: Site of dollop application

Plate 2: Attack of whitefly

Plate 3: Attack of jassid

Plate 4: Attack of pink bollworm

Plate 5: Symptoms of leaf curl disease

Plate 6: Parawilt

IMPORTANT NATURAL RESOURCE CONSERVATION TECHNOLOGIES

Crop: Technology (Year)	Other Important Crops
Water Conservation	
Rice: Discontinuation of ponding water (1981)	-
Maize: Mulching (1989)	Sugarcane (1980), Potato (2007), Summer moong (2013)
Sunflower: Ridge/Bed Sowing (1992)	Wheat (2003-04), Soybean (2006), Rice (2007), Summer moong (2009-10), Spring maize (2012-13), Lentil (2024)
All crops: Laser Leveller (2005)	-
Rice: Tensiometer (2005)	-
Rice: Direct Seeding Normal wattar (2010) Tar wattar (2020)	-
Potato: Drip irrigation (2011)	Potato (2011), Wheat (2013), Spring maize (2015), Sunflower (2015), Peas (2016), Turmeric (2016), Cotton (2017), Gobhi sarson (2018), Raya (2018), Kinnow (2019), Sugarcane (2019), Guava (2020) **Sub surface drip irrigation system in cropping system:** Maize-wheat-summer moong (2018), Rice (DSR)-Wheat (2018), Cotton-wheat (2018), Maize-Pea-Spring maize (2022), Cotton-Gobhi sarson (transplanted) (2024)
Rice: Short duration variety PR 121 (2013)	PR 122 (2013), PR 123 (2014), PR 124 (2015), PR 126 (29017), PR 127 (2018), PR 128 (2020), PR 129 (2020), HKR 47 (2020), PR 130 (2022), PR 131 (2022), PR 132 (2025)
Rice, Wheat: Use of brackish water (1989)	Cotton (2010), Potato (2016), Eucalyptus (2016), Kinnow (2019)
Soil Health Management and Fertilizer Application	
All crops: Soil Test based fertilizer (1962)	-
All crops: Kallar reclamation (1969)	-
Rice: No P after wheat (1983)	Maize (1985), Cotton (2014)
Moong: Biofertilizer (1985)	Berseem (2011), Sugarcane (2011), Chickpea (2012), Arhar (2013), Lentil (2015), Wheat (2015), Maize (2015), Potato (2015), Turmeric (2015), Rice (2018), Mash (2018), Cowpea (2020), Rapeseed & Mustard (2024)
Rice: Green manuring (1983)	-
Rice: Leaf Colour Chart (2005)	Maize (2011), Wheat (2012), DSR (2018), Cotton (2018)
Wheat: Happy Seeder (2006), Surface seeding cum mulching (2023)	

PAU: At the Service of Farmers
Available on every Social Media Platform

Kindly Scan

PAU WEBSITE

FACEBOOK

TWITTER

PAU KISAN APP

INSTAGRAM

YOUTUBE

2401960-79 (Ext. 373,475)

PAU Portal

Lets connect with PAU via Social Media

ਮਾਰਕਫ਼ੈੱਡ ਪੰਜਾਬ

ਐਗਰੋ ਕੈਮੀਕਲਜ਼

ਫ਼ਸਲਾਂ ਦੀ ਜਾਨ, ਕਿਸਾਨਾਂ ਦਾ ਮਾਣ

ਮਾਰਕਫ਼ੈੱਡ ਪੰਜਾਬ
50 ਸਾਲਾਂ ਤੋਂ ਵੱਧ ਦਾ ਭਰੋਸਾ

ਪੰਜਾਬ ਦੇ
ਮਿਆਰੀ ਉਤਪਾਦ

ਝੋਨੇ ਦੀ ਫ਼ਸਲ ਲਈ

ਪੀ.ਏ.ਯੂ. ਲੁਧਿਆਣਾ ਵੱਲੋਂ
ਪ੍ਰਮਾਣਿਤ ਨਦੀਨ-ਨਾਸ਼ਕ ਅਤੇ
ਕੀਟ-ਨਾਸ਼ਕ।

✓ ਉੱਤਮ ਕੁਆਲਿਟੀ ✓ ਵਾਜ਼ਬ ਕੀਮਤ ✓ ਭਰੋਸੇ ਯੋਗ

ਇਹ ਦਵਾਈਆਂ ਮਾਰਕਫ਼ੈੱਡ ਦੀਆਂ ਸ਼ਾਖਾਵਾਂ ਅਤੇ ਖੇਤੀਬਾੜੀ ਸਹਿਕਾਰੀ ਸਭਾਵਾਂ ਤੋਂ ਮਿਲਦੀਆਂ ਹਨ।

ਮਾਰਕਫ਼ੈੱਡ ਐਗਰੋ ਕੈਮੀਕਲਜ਼, ਮੋਹਾਲੀ | ਫੋਨ ਨੰਬਰ: 0172 2220851, 2273247

Dr Balwant Singh Hunjan Wishing All a Very Happy New Year-2025

Govt. of India recognised Hunjan Hospital for (CGHS) Services to its Central Govt. Employees

Hunjan Hospital having best infrastructure, the Govt. of India has empanelled this International Branded Hospital for (CGHS) services which provides comprehensive health care services to Central Govt. Employees, Pensioners and their dependents. It offers medical facilities through a wide network of wellness centres and reputed Hospitals. Keeping in view the latest modern infrastructure and technology, covering consultants, treatments, diagnostics and medications assessable and affordable healthcare. Hunjan Hospital is 1st Hospital in this area empanelled by the Govt. of India for (CGHS) services. Hunjan Hospital has already been Awarded by Govt. of India for best infrastructure.

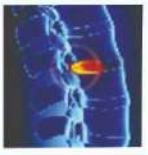
Dr. B.S. Hunjan
MBBS, MS, M.Ch (Ortho)
Director & Senior Orthopedics Consultant
Formerly at: (Fellowships)

- Hull Royal Hospital, U.K., Caste Hill Hospital, Hull, U.K.
- Liverpool Hospital, Sydeny, Australia
- Putnam Hospital Centre, New York, USA
- A.O. Fellow University Hospital, Zurich, Switzerland
- A.O. Fellowship, Kanto Rosai Hospital, Tokyo, Japan
- Stryker Fellow Branthurst Clinic, Johannesburg, SA
- B. Brown fellow- Grneral Hospital, Singapore.

Dr. Jaiveer S. Hunjan
MBBS, MS (Ortho)
Certified Robotic Surgeon
Fellowship in Knee & Shoulder Arthroscopy
Consultant Orthopedics Surgeon
Mob.: +91-95690-60630

Introduces for the First Time
Minimal Invasive
Surgical Treatment for Spine
with **LASER (PLDD)**

NO INCISION
NO STITCH
SHORT HOSPITAL STAY



First Hospital in North India to star
Robotic Joint Replacement

Robotic Knee & Hip Replacement Surgery to Get perfect Results

- Well Equipped ICU with Ventilators
- Endoscopic Surgeries & Bronchoscopy
- Modern C-Arm Image Intensifier
- Operative Arthroscope
- Laser Treatment for Disc (PLDD)
- Laser Treatment for Varicose Veins
- Joint Replacement Centre
- Trauma Centre
- Painless Delivery
- Psychotherapeutics & Diagnostics
- Digital X-Rays
- Physiotherapy
- Well Equipped Operation Theatres
- Laboratory Equipped with Fully Auto Cell Counter, Biochemistry Analyser
- Indoor Facility with General Ward, Private Rooms & Deluxe Rooms

Cashless Facility Available with most of Insurance Companies

NABH ACCREDITED AN ISO 9001-2015 Certified Hospital

HUNJAN HOSPITAL

HUNJAN HOSPITAL

111-South Model Gram, Kochar Market Road, Ludhiana-141 002
Mob.: 92175-92178, 98140-20234
E-mail: drbshunjan@gmail.com | **Website:** www.hunjanhospital.com