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The Package of Practices for the Crops of Punjab Kharif 2021 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 Extension Specialists Workshop held on 25 February, 2021. 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
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Director of Extension Education

Dr Simerjeet Kaur
Principal Agronomist

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.

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Cover Photo: PMH 13
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NEW RECOMMENDATIONS

CROP VARIETIES

Punjab Basmati 7 (Basmati): This semi-dwarf Basmati variety matures in about 101 days after transplanting. Its' average yield is 19.0 quintals per acre.

PMH 13 (Maize): This single cross hybrid matures in 97 days. Its' average yield is 24.0 quintals per acre.

ADV 9293 (Maize): This single cross hybrid matures in 97 days. Its' average yield is 24.5 quintals per acre.

JC 4 (Maize): This composite variety is recommended for irrigated and kandi areas. It matures in about 90 days and its' average yield is 13.0 quintals per acre. This variety is also recommended for organic farming.

CoPb 95 (Sugarcane): The average cane yield of this early maturing variety is 425 quintals per acre. Its' juice contains 17% sucrose in the month of December.

CoPb 96 (Sugarcane): The average cane yield of this early maturing variety is about 382 quintals per acre. Its' juice contains 16-17% and 18% sucrose in the months of November and December, respectively.

Co 15023 (Sugarcane): The average cane yield of this early maturing variety is about 310 quintals per acre. Its' juice contains 16-17 and 18% sucrose in the month of November and December, respectively.

CoPb 98 (Sugarcane): The average cane yield of this mid-late maturing variety is about 400 quintals per acre. Its' juice contains 17% and 19% sucrose in the months of January and March, respectively.

ML 1808 (Moong): It matures in about 71 days and its' average grain yield is 4.8 quintals per acre. It is resistant to mungbean yellow mosaic virus, cercospora leaf spot and bacterial leaf spot diseases.

PRODUCTION TECHNIQUES

Rice: Direct seeding in tar-wattar fields is recommended.

To tackle the problem of krand formation and to conserves soil profile moisture, direct seeding with Lucky Seed Drill fitted with press wheels is recommended.

Basmati rice: Punjab Basmati 7 and Pusa Basmati 1718 varieties are suitable for direct seeding.

Cotton: To minimize loss of cotton yield owing to water stress due to no rainfall or sudden canal closures, spray Salicylic acid on stress appearance.

Soybean: Spray the crop with 0.5% ferrous sulphate at 30 and 60 days after sowing to ameliorate iron deficiency.

Groundnut: Apply 10 kg nitrogen, 12 kg P₂O₅ and 90 kg gypsum in spring season groundnut.
PROTECTION TECHNIQUES

**Rice:** Post-emergence application of Vivaya 6 OD and Council activ 30 WG are recommended for control of weeds in direct seeded rice.

- Spray 60 ml Coragen 18.5 SC or 80 ml per acre Ecotin (neem based biopesticide) to manage rice stem borers and leaf folder.
- Spray 80 g per acre Osheen 20 SG to manage planthoppers.
- Spray 150 ml Pulsor 24 SC or 26.8 g per acre Epic 75 WG as soon as disease appears to control sheath blight.
- Spray 26.8 g per acre Epic 75 WG (hexaconazole) at boot stage to control sheath rot.

**Basmati rice:** Spray neem based biopesticide, 1.0 litre Neem Kavach or 80 ml per acre Ecotin to manage stem borers and leaf folder.

**Organic rice/basmati rice:** Spray neem based biopesticide, 1.0 litre Neem Kavach or 80 ml per acre Ecotin to manage stem borers and leaf folder.

**Maize:** Spread uniformly 30 quintals per acre of paddy straw mulch at the time of sowing to control annual weeds.

- In case of attack of fall armyworm in patches, do whorl application of soil-insecticide mixture for its management.

**Cotton:** Spray 900 ml per acre Sweep Power 13.5 SL as a directed spray to control weeds.

- Spray recommended insecticides to manage thrips at economic threshold level of 12 thrips per leaf.
- Spray 150 ml per acre Transform 21.8 SC to manage mealy bug.
- Spray 400 ml per acre Sefina 50 DC to manage whitefly.
- Spray 300 ml per acre Neon 5 EC to manage jassid.

**Sugarcane:** Integration of use of pheromone traps in combination with Trichocards for the management of early shoot borer and top borer.

**Groundnut:** Treat the seed with 2 ml Neonix 20 FS per kg seed before sowing to control Collar-rot and seed-rot. It will also controls white grub and termite.

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

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

#### b. Pesticides banned for use in agriculture in India

<table>
<thead>
<tr>
<th></th>
<th>Pesticide</th>
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<tbody>
<tr>
<td>1</td>
<td>Aldicarb</td>
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<tr>
<td>2</td>
<td>Aldrin</td>
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<tr>
<td>3</td>
<td>Benomyl</td>
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</tr>
<tr>
<td>4</td>
<td>Benzene Hexachloride</td>
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</tr>
<tr>
<td>5</td>
<td>Calcium Cyanide</td>
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<tr>
<td>6</td>
<td>Carbaryl</td>
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</tr>
<tr>
<td>7</td>
<td>Chlorbenzilate</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Chlordane</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Chlorofenvinphos</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Copper Acetoarsenite</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>DDT</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Diazinon</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Dibromochloropropane (DBCB)</td>
<td></td>
</tr>
</tbody>
</table>
14. Dieldrin  
15. Endrin  
16. Ethyl Mercury Chloride  
17. Ethyl Parathion  
18. Ethylene Dibromide  
19. Fenarimol  
20. Fenthion  
21. Heptachlor

35. Sodium Cyanide  
36. Sodium Methane Arsonate  
37. Tetradoxon  
38. Thiometon  
39. Toxaphene  
40. Trichloro acetic acid (TCA)  
41. Tridemorph

c. Pesticide formulations banned for use

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Carbofuran 50% SP</td>
</tr>
<tr>
<td>2.</td>
<td>Methomyl 24% L</td>
</tr>
<tr>
<td>3.</td>
<td>Methomyl 12.5% L</td>
</tr>
<tr>
<td>4.</td>
<td>Phoshamidan 85% L</td>
</tr>
</tbody>
</table>

**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. MAJOR CROPS

RICE

Rice crop occupied 31.42 lakh hectares in Punjab with total paddy production of 189.18 lakh tonnes (126.75 lakh tonnes of rice) during 2019-20. The average yield of paddy was 60.21 quintals per hectare (24.37 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-5 June) and timely transplanting (20 June-5 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 and PR 124, transplant 25-30 days old nursery.

• For higher savings in irrigation water, adopt direct seeding of rice in tar-wattar field from June 1 onwards.

• 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.

• 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. A temperature range of 20 to 37.5°C is required for its optimum growth. The crop requires a higher temperature at tillering but temperature requirement for blossoming ranges between 26.5 and 29.5°C.
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.

Improved Varieties/Hybrids

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. This variety is susceptible to brown leaf spot. For its management use recommended fungicides. Its’ average paddy yield is 30.5 quintals per acre. Transplant 25-30 days old nursery.

PR 124 (2015): Its’ average plant height is 107 cm and matures in about 105 days after transplanting. It possesses long slender, clear translucent grains. It is resistant to all the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab state. This variety is susceptible to brown leaf spot. For its management use recommended fungicides. Its’ average paddy yield is 30.5 quintals per acre. Transplant 25-30 days old nursery.

- Sow nursery of various varieties as per recommended schedule.
- Transplant 25-30 days nursery of PR 126 and PR 124.
- 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.
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: 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.

HKR 127: It is a medium duration variety and susceptible to most of the prevalent pathotypes of bacterial blight in the state.

Agronomic Practices

Unpuddled Direct Seeded Rice

Direct seeded rice (DSR) has been recommended with the adoption of following practices to make this technology a success:

- **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 and field preparation:** Laser levelling improves irrigation water use efficiency and ensures better germination. Plough the field twice with disc harrow followed by cultivation with cultivator and planking, then level the field with laser leveller. After laser levelling, irrigate the field followed by cultivation with cultivator and planking.

- **Suitable varieties:** Short and medium duration varieties

- **Sowing time:** 1-15 June

- **Seed rate:** Use 8-10 kg seed per acre.

- **Method of sowing:** Rice can be direct seeded by two methods:

  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 planking twice and sow immediately. Field preparation and sowing should preferably be done during evening hours and it should never be done during noon hours.

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.

Imbibe rice seed in water for 8 to 12 hours, dry in shade and treat with 3 g Sprint 75 WS (mencozeb + carbendazim) per kg seed. Seed should be placed at 3-4 cm depth in 20 cm spaced rows. This *tar-wattar* method results in i) more saving in irrigation water ii) lesser weed problem iii) reduced iron deficiency owing to deeper root development as compared to sowing in dry fields.

**2. Direct seeding in dry fields:** Treat the dry seed with 3 g Sprint 75 WS (mencozeb + carbendazim) per kg seed. Seed should be placed 2-3 cm deep in rows spaced at 20 cm. Dry seed of rice is sown in a dry field and irrigation is applied immediately after sowing.

- **Weed control:** Spray 1.0 litre per acre Stomp/Bunker 30 EC (pendimethalin) in 200 litres of water for control of annual grass weeds and some broadleaf weeds. 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.

The choice of post-emergence herbicide will depend on the presence of weed flora in the field. Spray any of the following herbicides by dissolving in 150 litres of water at 15-25 days of sowing when weed plants are at 2 to 4 leaf stages (see page 177).

In case of *swank* and *paddy mothas*, spray 100 ml per acre Nominee gold 10 SC (bispyribac-sodium).

If *chini gha* is there along with *swank*, *paddy motha* and broadleaf weeds, spray 900 ml per acre Vivaya 6 OD (penoxsulam 1.02%+cyhalofop butyl 5.1%*).

If *swank, madhana, makra, chini gha, gandi wala motha, paddy motha* and broadleaf weeds like *itsit* are present, spray 90 g per acre Council activ 30 WG (triafamone 20%+ ethoxysulfuron 10%).

- 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 per acre in moist soil immediately after sowing and thereafter use other herbicides as per recommendation.
if there is only grass weeds like madhana, leptochloa (chini) gha and chiri gha, spray 400 ml per acre Ricestar 6.7 EC (fenoxaprop-p-ethyl).
Spray 8 g per acre Almix 20 WP (metsulfuron methyl+chlorimuron ethyl) if field is infested with broadleaf weeds and mothas including gandi wala motha.
The left over weeds may be uprooted before they produce seeds.

• **Fertilizers:** Apply 130 kg urea/acre in three equal splits at 4, 6 and 9 weeks of sowing. 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 11-12).

**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 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 10 “Management of Rodents and Birds.”
**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 - 5 June is the optimum time of sowing:

<table>
<thead>
<tr>
<th>Variety</th>
<th>Sowing Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>PR 121, PR 122, PR 128, PR 129, PR 114, PR 113</td>
<td>May 20-25</td>
</tr>
<tr>
<td>PR 127, PR 124, HKR 47</td>
<td>May 25-31</td>
</tr>
<tr>
<td>PR 126</td>
<td>May 25-June 5</td>
</tr>
</tbody>
</table>

**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.

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 (pretiachlor + 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/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 to 150 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.

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 preferred 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.

**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 5 July. Under late sown conditions, prefer transplanting of PR 126.

**Age of Seedlings at Transplanting:** Use 30-35 days old seedlings for medium duration varieties. However, for short duration varieties (PR 126 and PR 124), 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 and 15 x 15 cm (44 hills/sq m) for the late transplanting. 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/Bed transplanting:** In heavy textured soils, rice can be transplanted on ridges (60 cm)/beds (67.5 cm) to save irrigation water. After field preparation (without puddling), apply basal dose of fertilizer and prepare ridges/beds with ridger/wheat bed planter. Irrigate the furrows and immediately transplant seedlings on the middle of the slopes (both sides) of ridges/beds by maintaining a plant to plant distance of 9 cm on beds and 10 cm on ridges.

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 rice transplanter at spacing of 30x12 cm.
**Weed Control**

**Inter-culture** with a Paddy Weeder (Appendix IV), 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 swank and other weeds:** Use of any of the following pre-emergence, early post-emergence and 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/acre in standing water within 2 to 3 days of transplanting.

<table>
<thead>
<tr>
<th>Brands (Herbicide)</th>
<th>Dose per acre</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machete/Delchlor/Rasayanchlor/Exachlor/Punch/Hiltachlor/Thunder/Teer/­Capchlor/Trapp/Milchlor/Narmadachlor/Fychlor/Arochlor/Arochlor/Megachlor/Butachlor-Sunbeam/Markchlor/Paklor/Banweed/Butacid/Jabutachlor 50 EC (butachlor)</td>
<td>1200 ml</td>
<td>These herbicides are highly effective against swank give moderate control of other weeds.</td>
</tr>
<tr>
<td>Fast-mix 50 EW (butachlor)</td>
<td>1200 ml</td>
<td></td>
</tr>
<tr>
<td>Arozin 18 EC (anilofos)</td>
<td>850 ml</td>
<td>For control of <em>kanki</em>, Arozin/Aniloguard/Libra/Control H-30/Pestoanilofos/Markanil/Jaifos/Haragro-anilfos/Padigard 30 EC (anilofos)</td>
</tr>
<tr>
<td>Arozin/Aniloguard/Libra/Control H-30/Pestoanilofos/Markanil/Jaifos/Haragro-anilfos/Padigard 30 EC (anilofos)</td>
<td>500 ml</td>
<td>Arozin/Aniloguard/Libra/Control H-30/Jaifos/Pestoanilofos/Markanil/Haragro-anilfos/Padigard have an edge over other herbicides.</td>
</tr>
<tr>
<td>Stomp 30 EC (pendimethalin)</td>
<td>1000 to 1200 ml</td>
<td>In case of Stomp, use lower dose on light textured soils and higher dose on medium to heavy textured soils.</td>
</tr>
<tr>
<td>Rifit/Eraze/Markpretia/Revenge/Mif Pretia/Sokusai 50 EC (pretilachlor*)</td>
<td>600 ml</td>
<td></td>
</tr>
<tr>
<td>Rifit Plus 37 EW (pretilachlor*)</td>
<td>750 ml</td>
<td></td>
</tr>
<tr>
<td>Sathi 10 WP (pyrazosulfuron ethyl)</td>
<td>60 g</td>
<td></td>
</tr>
<tr>
<td>Topstar 80 WP (oxadiargyl*)</td>
<td>45 g</td>
<td></td>
</tr>
</tbody>
</table>

   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.
iii. **Post-emergence (within 20-25 days of transplanting):** For the effective control of *swank* and *paddy mothas*, spray 100 ml per acre Nominee Gold/Wash out/Macho/Taarak 10 SC (bispyribac) using 150 litres of water, at 20-25 days of transplanting. In crop infested with *Leptochloa (chini) gha and kanki*, apply 400 ml per acre Ricestar 6.7 EC (fenoxaprop) at 20-25 days of transplanting in 150 litres of water. Do not spray the herbicide in standing water and irrigation may be applied one day after spray.

2. **Control of sedges and broadleaf weeds:** For control of sedges (paddy mothas like *chhatri wala dila*) and broadleaf weeds including *ghrilla, sanni* etc, spray 30 g per acre Algrip 20 WG (metsulfuron*) or 50 g Sunrice15 WG (ethoxysulfuron) or 40 g Londex 60 DF (bensulfuron methyl) or 16 g Segment 50 DF (azimsulfuron*) or 8 g per acre Almix 20 WP (metsulfuron methyl +chlorimuron ethyl) if the crop is infested with paddy mothas including *gandi wala motha* in 150 litres of water at 20 days of transplanting. Do not spray the herbicide in standing water and irrigation may be applied one day after spray. The spray should be done on a clear and calm day for getting good efficacy from herbicides.

- 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:

<table>
<thead>
<tr>
<th>Organic manure</th>
<th>Dose (t/acre)</th>
<th>Fertilizer saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmyard manure</td>
<td>6</td>
<td>16 kg Nitrogen (35 kg urea)</td>
</tr>
<tr>
<td>Pressmud</td>
<td>6</td>
<td>25 kg Nitrogen (55 kg urea)</td>
</tr>
<tr>
<td>Poultry manure</td>
<td>2.5</td>
<td>25 kg Nitrogen (55 kg urea)</td>
</tr>
<tr>
<td>Gobar gas slurry</td>
<td>2.4</td>
<td>16 kg Nitrogen (35 kg urea)</td>
</tr>
<tr>
<td>Prali Char</td>
<td>2.0</td>
<td>16 kg Nitrogen (35 kg urea)#</td>
</tr>
<tr>
<td>Green manure</td>
<td>-</td>
<td>25 kg Nitrogen (55 kg urea)##</td>
</tr>
<tr>
<td>Summer moong crop residue incorporation</td>
<td>-</td>
<td>16 kg Nitrogen (35 kg urea)##</td>
</tr>
</tbody>
</table>

# In addition to saving of nitrogen, application of prali char @ 2.0 t/acre increase the crop yield by 10 %.
## In loamy sand to sandy loam soils incorporate green manure or summer moong residue and apply recommended dose of nitrogen (50 kg N/acre) to get higher yield.

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:
**Nutrients (kg per acre)**

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>P$_2$O$_5$</th>
<th>K$_2$O</th>
<th>Neem coated urea</th>
<th>DAP or single superphosphate</th>
<th>Muriate of potash</th>
</tr>
</thead>
<tbody>
<tr>
<td>42</td>
<td>12</td>
<td>12</td>
<td>90</td>
<td>27</td>
<td>75</td>
<td>20</td>
</tr>
</tbody>
</table>

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

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 Chapter 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 up to 7 days of transplanting and second split at 21 days of transplanting. The third split to short duration (PR 126 and PR 124) 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.

**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 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 178). 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 178). 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±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 (Appendix IV).

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

- 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 preceding 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.
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**
   - **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).

   - **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 wet 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:

   - **Power generation:** Seven bio mass 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.

   - **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 6-7 m³ biogas daily for 3-4 months.

   - **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°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**: Phospho-compost can be prepared from the paddy straw. (see details in Organic 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 178).

  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*) or 170 g of Mortar 75 SG (cartap hydrochloride) or 1 litre of 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.

- **Leaf folder**: The larvae fold the leaves, eat out the green tissue and produce whitestreaks (Plate No. 4, page 178). 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*) or 170 g of Mortar 75 SG (cartap hydrochloride) or 1 litre of 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 80 g Osheen 20 SG (dinotefuran) or 120 g Chess 50 WG (pyremozine) or 800 ml Ekalux/Quinguard/Quinalmass 25 EC (quinalphos) in 100 litres of water per acre. 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 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.

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**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
### 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 178). Its severe attack results in the poor filling of the grains. 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 150 ml 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 178). 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/acre. 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 129, PR 128, PR 127, PR 126, PR 124, PR 122, PR 121 and PR 113 which are resistant to most of the pathotypes of bacterial blight pathogen.
- Use disease 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 seedlings 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 10 “Management of Rodents and Birds”.

Rice Cultivation in Alkali Soils

- **Addition of Gypsum:** If the pH of soil is more than 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

**Improved Varieties**

**Photoperiod Sensitive Varieties (Short daylength initiates flowering)**

**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 and performs better when transplanted in the first fortnight of July. It is resistant to all the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab state.

**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 and are non-sticky & 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.

**Punjab Basmati 4 (2017):** It is high yielding, semi-dwarf, lodging tolerant Basmati variety which is about 96 cm tall. The grains are extra-long slender with excellent cooking and eating quality characteristics. The grains double upon cooking and are non-sticky & aromatic. It is resistant to all the ten pathotypes of bacterial blight pathogen presently prevalent in the State. It matures in about 116 days after transplanting. Its' average paddy yield is 17.0 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 3 (2013):** It is a semi-dwarf lodging tolerant variety which is about 105 cm tall. It is resistant to all the ten presently prevalent pathotypes of bacterial blight pathogen in the State. It possesses extra-long slender grains with tip awns which prevent bird damage. The grains are

- **Pusa Basmati 1637** is moderately resistant to blast.
- **Punjab Basmati 7, 5, 4, 3** and **Pusa Basmati 1718** are resistant to bacterial blight.
- 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.
- Direct seeding of Basmati should be done on medium to heavy soils only.
translucent with strong aroma, good cooking and eating quality characteristics. The cooked rice is non-sticky and soft to eat. It matures in about 109 days after transplanting. Its' average paddy yield is 16.0 quintals per acre.

**Basmati 386 (1995):** This variety is about 180 cm tall and performs best under medium fertility conditions. Its' grains are extra-long, superfine and aromatic. Grains elongate almost double on cooking. The cooked rice is non-sticky and soft to eat. It matures in about 125 days after transplanting. It is susceptible to all the pathotypes of bacterial blight pathogen prevalent in the State. Its' average yield is 9.0 quintals paddy per acre.

**Basmati 370:** This variety is about 165 cm tall and lodge under high fertility conditions. It performs best on average fertility soils. Its' grains are superfine, highly aromatic and elongate almost double upon cooking. The cooked rice is non sticky and soft to eat. It matures in about 120 days after transplanting. It is susceptible to all the pathotypes of bacterial blight pathogen prevalent in the State. Its' average yield is 12.0 quintals paddy per acre.

**Photoperiod Insensitive Varieties (flowering unaffected by daylength)**

**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.

**Pusa Basmati 1637 (2018):** It is a new version of Pusa Basmati 1 which is moderately tolerant to blast disease. Its’ average plant height is 109 cm and matures in 108 days after transplanting. It possesses extra long slender grains. Its’ average paddy yield is 17.5 quintals per acre.

**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**

**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. 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 11-12).

**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 harzianum* @ 15 g per kg of seed immediately before sowing and seedling root dip for 6 hrs with *T. harzianum* @ 15 g per litre of water before transplanting.

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

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Time of Nursery Sowing</th>
<th>Time of Transplanting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Punjab Basmati 7, 5, 4 and 3, Pusa Basmati 1121, 1637 and 1718</td>
<td>First fortnight of June</td>
<td>First fortnight of July</td>
</tr>
<tr>
<td>CSR 30, Basmati 370, Basmati 386, Pusa Basmati 1509</td>
<td>Second fortnight of June</td>
<td>Second fortnight of July</td>
</tr>
</tbody>
</table>

Basmati 386 and Basmati 370 if transplanted too early in the season have a prolonged vegetative phase resulting into a tall and leafy crop. Such a crop is more prone to lodging because of excessive height and vegetative growth. To check lodging, lopping of the upper half of crop canopy (Basmati 386 and Basmati 370) after 45 days of transplanting may be done. Further it would also reduce stem borer damage.

**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 preceding 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, Basmati 386 and Basmati 370** - 18 kg urea per acre
- **Punjab Basmati 7, 5, 4 & 3 and Pusa Basmati 1121, 1637 & 1718** - 36 kg urea per acre
- **Pusa Basmati 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 Basmati 386, Basmati 370 and CSR 30) and LCC shade 4 (for Punjab Basmati 7, 5, 4, 3 and Pusa Basmati 1121, 1509, 1637 and 1708).
- 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:
Stem borers can be managed by spraying neem based biopesticide, 80 ml Ecotin (azadiracthin 5%) or 100 ml Achook/Neem Kavach (azadiracthin 0.15%) or 20 ml Fame 480 SC (flubendiamide*) or 170 g Mortar 75 SG (cartap hydrochloride) or 60 ml Coragen 18.5 SC (chlorantraniliprole*) 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 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.

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. Grow Pusa Basmati 1637, which is moderately tolerant to blast. 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.

Bacterial blight: Punjab Basmati 7, 5, 4, 3 and Pusa Basmati 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.
MAIZE

Maize occupied 144.6 thousand hectares, with a production of 410.5 thousand tonnes in the Punjab State during 2019-20. The average yield was 35.82 quintal per hectare (14.50 quintal per acre).

Climatic Requirements
Maize requires considerable moisture and warmth from germination to flowering. The most suitable temperature for germination is 21°C and for growth is 32°C. Extremely high temperature and low humidity during flowering may damage the foliage, dessicate the pollen and interfere with proper pollination, resulting in poor grain setting. Fifty to seventy-five cm well-distributed rain is conducive for good growth. Proper drainage of excess water during rains is essential to get good yield.

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

Rotations

Irrigated Maize

Improved Varieties

Long Duration Varieties/Hybrids

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 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 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 Its’ average 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 yield is 21.0 quintals per acre.

Parbhat (1987): This composite has medium thick stem which resists lodging. Plant and ear height is medium tall. Husk covers are well developed. Ears are medium long and thick. The grains are medium bold, yellow-orange and semi-flint to flint. It matures in about 95 days. It yields about 17.5 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.

Kesri (1992): It is a medium maturing, high yielding composite with attractive orange-flint grains. Plant height and ear placement are medium. The ears are thick at the base, taper towards the tip and have good tip filling and husk cover. It matures in about 85 days and Its’ average yield is 16.0 quintals per acre.

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 Its’ average yield is 18.0 quintals per acre.

Special Purpose Varieties

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.
Unrecommended Varieties

**DKC 9125:** It is a late maturing hybrid having tall plants and moderate resistance to post flowering stalk rot.

**P 3396:** It is a late maturing hybrid moderately resistant to post flowering stalk rot.

**TX 369:** It is a late maturing hybrid moderately resistance to post flowering stalk rot.

**PAC 751:** It is a late maturing hybrid with medium plant height.

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 *torial* 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. Inoculation with bio-fertilizer should be done after treating the seed with fungicide. 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.

**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.

**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.

- 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.
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 intercropping of cowpea, use 16 kg per acre for variety cowpea 88 and 8 kg per acre for variety 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 buried and allowed to decompose for about 10 days before sowing of maize. In case, summer moong crop is grown the straw should be buried 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 @ 180 kg per acre 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:

<table>
<thead>
<tr>
<th>Varieties</th>
<th>*Nutrients</th>
<th>Fertilizers (kg per acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(kg per acre)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>P₂O₅</td>
</tr>
<tr>
<td>PMH 1, 11 &amp;13, ADV 9293, JC 12, Parbhat and Punjab Sweet Corn 1</td>
<td>50</td>
<td>24</td>
</tr>
<tr>
<td>PMH 2, JC 4, Kesri and Pearl Popcorn</td>
<td>35</td>
<td>12</td>
</tr>
</tbody>
</table>

* 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:P₂O₅:K₂O:S)
  if other phosphorus or sulphur containing fertilizers are not available.

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 (Appendix-IV) 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 (Appendix IV). 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 liters/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/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 days and rest of the plant can be used for feeding cattle.

Parkash (Hybrid) and Kesri (Composite) are most appropriate varieties for taking baby corn crop, which give on an average 7.0 and 5.7 quintals per acre yield of dehusked ears, respectively. Hybrid Parkash is most suitable as it gives higher yield of uniform and good quality ears. 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. 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. 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.

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.
Rainfed Maize

Improved Varieties

**PMH 2 (2005):** It is a short duration drought tolerant hybrid. It has medium plant height with medium ear placement. It’s 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. It’s 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.

**Megha (1990):** This composite combines early maturity with drought tolerance and is specifically suited for the rainfed area of the state. It matures in 82 days. It has medium tall plants with medium ear placement. The grains are attractive, medium sized, yellow-orange flint. It yields about 12 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.

<table>
<thead>
<tr>
<th>Soil type</th>
<th><em>Nutrients (kg per acre)</em></th>
<th>Fertilizers (kg per acre)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P$_2$O$_5$</td>
<td>K$_2$O</td>
</tr>
<tr>
<td>Sandy loam to clay loam soils with adequate moisture stored</td>
<td>32</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>Loamy sand to sandy soils with low moisture stored</td>
<td>16</td>
<td>8</td>
<td>4</td>
</tr>
</tbody>
</table>
These nutrients can also be supplied from other fertilizers available in the market (Appendix IV)
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 Stations, Abohar, Gurdaspur and Bathinda.
- 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.

**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 control, 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 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) 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 + 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) in 100 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 Chapter Management of 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:

<table>
<thead>
<tr>
<th>Hybrid</th>
<th>Parental Lines</th>
<th>Ratio of Female to Male line with Seed rate per acre</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMH 1</td>
<td>LM 13, LM 14</td>
<td>3 (12 kg): 1 (3 kg) Sowing of male and female lines at same time</td>
<td></td>
</tr>
<tr>
<td>PMH 2</td>
<td>LM 15, LM 16</td>
<td>3 (7 kg): 1 (3 kg) Sowing of male and female lines at same time</td>
<td></td>
</tr>
<tr>
<td>Parkash</td>
<td>CM 139, CM 140</td>
<td>3 (7 kg): 1 (3 kg) Sowing of male and female lines at same time</td>
<td></td>
</tr>
<tr>
<td>PMH 7</td>
<td>CM 140, LM 20</td>
<td>3 (7 kg): 1 (3 kg) Female line should be planted one week later than male line</td>
<td></td>
</tr>
<tr>
<td>PMH 8</td>
<td>LM 5, LM 20</td>
<td>3 (12 kg): 1 (3 kg) Female line should be planted 10 days prior to male line</td>
<td></td>
</tr>
<tr>
<td>PMH 10</td>
<td>LM 23, LM 24</td>
<td>3 (9 kg): 1 (3 kg) Female line should be planted 5 days prior to male line</td>
<td></td>
</tr>
<tr>
<td>PMH 11</td>
<td>LM 25, LM 11</td>
<td>3 (12 kg): 1 (3 kg) Female line should be planted 5 days prior to male line</td>
<td></td>
</tr>
<tr>
<td>PMH 13</td>
<td>LM 27, LM 17</td>
<td>3 (12 kg): 1 (3 kg) Female line should be planted 4-6 days later than male line</td>
<td></td>
</tr>
</tbody>
</table>
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 at least 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, Kesri, Pearl Popcorn, Punjab Sweet Corn 1, Parbhat, Megha, 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.
American cotton was grown on 2.45 lakh hectares in Punjab during 2019-20. The total production was 11.93 lakh bales with an average yield of 8.29 quintals lint per hectare (3.35 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.
- Grow non-Bt cotton as refuge on the periphery of Bt cotton.
- 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 after September 15 to minimize resurgence of whitefly. Use recommended insecticides.
- Avoid tank mixing and use of ready made insecticidal mixtures.

**Climatic Requirements**

A daily minimum temperature of 16°C is required for germination and 21°C to 27°C for proper crop growth. During the fruiting phase, the day temperature ranging from 27°C to 32°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**


**Improved Varieties**

**Bt cotton variety**

**PAU Bt 1 (Adhoc release):** It is the first Bt cotton variety developed by public sector with inbuilt resistance against American, spotted and pink bollworms in the country. It has bigger boll size of 4.3g and ginning out turn is 41.4%. It possesses superior fibre properties with 28.2 mm fiber length, 28.6 g/tex bundle strength and 4.5 µg/inch micronaire value. Its’ average seed cotton yield is 11.2 quintals per acre. It is moderately resistant to cotton leaf curl disease.
Bt cotton hybrids

Grow Bt cotton hybrids recommended by Punjab Agricultural University. Every year, 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

LHH 144 (1998): This is an intra-hirsutum cotton hybrid with semi-okra leaves. It is tolerant to jassid and bacterial blight. It matures in about 180 days. It produces an average seed cotton yield of 7.6 quintals per acre.

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.

F 2383 (2015): This is suitable for sowing under high density plantation system. The variety has medium sized super-okra leaves. It matures in about 160 days and gives an average seed cotton yield of 7.9 quintals per acre.

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

LH 2076 (2008): It matures in 165-175 days with an average seed cotton yield of 7.8 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:

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Seed rate (kg per acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bt variety</td>
<td>PAU Bt 1</td>
</tr>
<tr>
<td>Bt hybrids</td>
<td>Recommended hybrids</td>
</tr>
<tr>
<td>Non-Bt hybrid</td>
<td>LH 144</td>
</tr>
<tr>
<td>Non-Bt varieties</td>
<td>F 2228, LH 2108 and LH 2076</td>
</tr>
<tr>
<td></td>
<td>F 2383</td>
</tr>
</tbody>
</table>

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

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.

**Seed Treatment and Seed Soaking:** 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. After this treatment, the seed should be smereared with 5 g Gaucho 70 WS (imidacloprid) or 7 g Cruiser 30FS (thiomethoxam) per kg seed for preventing damage by cotton jassid. In case non-delinted seed is used, rub it with fine earth, cow-dung or ash to remove its fuzz and ensure uniform sowing.

**Sowing and Spacing:** Sow in lines 67.5 cm apart with a cotton sowing drill or cotton planter. The plants of varieties within rows be kept 60 cm apart during thinning, whereas for PAU Bt 1, plants within rows be kept 45 cm apart. However, for hybrids (both Bt and non-Bt) the plant-to-plant distance should be kept at 75 cm. Plant-to-plant spacing of 15.0 cm should be kept for variety F 2383. It 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, LH 2108 and LH 2076 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:

<table>
<thead>
<tr>
<th></th>
<th><em>Nutrients (kg per acre)</em></th>
<th>Fertilizers (kg per acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P₂O₅</td>
</tr>
<tr>
<td>Non-Bt varieties</td>
<td>30</td>
<td>12</td>
</tr>
<tr>
<td>Bt variety (PAU Bt 1)</td>
<td>37</td>
<td>12</td>
</tr>
<tr>
<td>Bt and non- Bt hybrids</td>
<td>42</td>
<td>12</td>
</tr>
</tbody>
</table>

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

**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 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:

<table>
<thead>
<tr>
<th>Leaf Colour as per PAU LCC</th>
<th>More than LCC shade 4.5</th>
<th>LCC shade 4.5</th>
<th>LCC shade 4.0</th>
<th>LCC shade 3.5 or below</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea dose (Kg per acre)</td>
<td>0</td>
<td>20</td>
<td>35</td>
<td>50</td>
</tr>
</tbody>
</table>

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.

**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.

**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.
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.

<table>
<thead>
<tr>
<th>Month</th>
<th>Time of irrigation (min)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>May/June</td>
<td>50</td>
</tr>
<tr>
<td>July</td>
<td>45</td>
</tr>
<tr>
<td>August</td>
<td>40</td>
</tr>
<tr>
<td>September</td>
<td>35</td>
</tr>
</tbody>
</table>

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

\[
\text{Adjusted time (min)} = \frac{(2.2 \times \text{Time of irrigation (min)*})}{\text{Discharge of dripper (litre/hour)}}
\]

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.
• 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 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 or plant debris and un-opened bolls.
• Do not stalk the cotton sticks under shade or in the field. Beet the sticks on ground to dislodge the pink bollworm larvae surviving the unopened bolls. Stalk the cotton stick vertically.
• Prevent the movement of the cotton stalk from the infested areas to the new areas.

ii. Chemical Control
a. Insect Pests (Bt cotton)
   Bt cotton provides effective protection against all cotton bollworms. However, 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. 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. 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. 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 insecticides hould 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

<table>
<thead>
<tr>
<th>Brand (Insecticides)</th>
<th>Dose/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Whitefly</strong></td>
<td></td>
</tr>
<tr>
<td>Sefina 50 DC (afidopyropen)</td>
<td>400 ml</td>
</tr>
<tr>
<td>Osheen 20 SG (dinotefuran)</td>
<td>60 g</td>
</tr>
<tr>
<td>Polo/Craze/ Ruby/ Ludo/Shoku 50 WP (diafenthiuron)</td>
<td>200 g</td>
</tr>
<tr>
<td># Lano/Daita10 EC (pyriproxyfen)</td>
<td>500 ml</td>
</tr>
<tr>
<td># Oberon/ Voltage 22.9 SC (spiromesifen)</td>
<td>200 ml</td>
</tr>
<tr>
<td>Ulala 50 WG (flonicamid)</td>
<td>80 g</td>
</tr>
<tr>
<td>Applaud 25 SC (buprofezin)</td>
<td>400 ml</td>
</tr>
<tr>
<td>Dantotsu 50 WG (clothianidine)</td>
<td>20 g</td>
</tr>
<tr>
<td>Fosmite/E-mite/Volthion/ Gold Mit 50 EC (ethion)</td>
<td>800 ml</td>
</tr>
<tr>
<td>Nimbecidine or Achook (Neem based biopesticide)</td>
<td>1.0 litre</td>
</tr>
<tr>
<td>*PAU Homemade neem extract</td>
<td>1200 ml</td>
</tr>
</tbody>
</table>

- 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, fenvalrate, deltamethrin), acephate and acetamiprid to minimize resurgence of whitefly
**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
- **Applaud/Tribune 25 SC** (buprofezin) 500 ml

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

## This pesticide is safe for natural enemies.

* **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.

**Note:** In the beginning of crop season on appearance of whitefly, first spray of Nimbecidine or Achook @ 1.0 litre 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 ready made 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. 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 sexphoromone 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/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/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/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/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.
Table 2. Insecticides for the control of bollworms in cotton

<table>
<thead>
<tr>
<th>Brands (Insecticides)</th>
<th>Dose/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pink and spotted bollworms</strong></td>
<td></td>
</tr>
<tr>
<td><strong>A. Synthetic Pyrethroids</strong></td>
<td></td>
</tr>
<tr>
<td>Fastac/Alphagaurd/Merit Alpha 10 EC (Alphamethrin)</td>
<td>100 ml</td>
</tr>
<tr>
<td>Bulldock 0.25 SC (β-cyfluthrin)</td>
<td>300 ml</td>
</tr>
<tr>
<td>Ripcord/Bilcyp/Bullet/Ustad/Cypergaurd 10 EC (Cypermethrin)</td>
<td>200 ml</td>
</tr>
<tr>
<td>Cymbush/Cyperkill/Hillcyper/Colt/Basathrin/Agrocyper/Cypergaurd 25 EC (Cypermethrin)</td>
<td>80 ml</td>
</tr>
<tr>
<td>Decis/Rukrain/Decicare 2.8 EC (Deltamethrin)</td>
<td>160 ml</td>
</tr>
<tr>
<td>Sumicidin/Fenval/Agrofen/Fenlik/Triumph card/SB Fenvalerate/Milfen/Markfenval 20 EC (Fenvalerate)</td>
<td>100 ml</td>
</tr>
<tr>
<td>Meothrin 10 EC (Fenpropathrin)</td>
<td>300 ml</td>
</tr>
<tr>
<td><strong>Pink, spotted and younger larvae of American bollworm</strong></td>
<td></td>
</tr>
<tr>
<td><strong>A. Carbamates</strong></td>
<td></td>
</tr>
<tr>
<td>Larvin 75 WP (Thiodicarb)</td>
<td>250 g</td>
</tr>
<tr>
<td><strong>B. Organophosphatic</strong></td>
<td></td>
</tr>
<tr>
<td>Curacron/Carina/Profex/Celcron 50 EC (Profenophos)</td>
<td>500 ml</td>
</tr>
<tr>
<td>Fosmite/E-mite/Volthion 50 EC (Ethion)</td>
<td>800 ml</td>
</tr>
<tr>
<td><strong>C. Miscellaneous group</strong></td>
<td></td>
</tr>
<tr>
<td>Fame 480 SC (Flubendiamide*)</td>
<td>40 ml</td>
</tr>
<tr>
<td><strong>Grown up larvae of American bollworm</strong></td>
<td></td>
</tr>
<tr>
<td><strong>A. Naturalyte</strong></td>
<td></td>
</tr>
<tr>
<td>Tracer 48 SC (Spinosad)</td>
<td>60 ml</td>
</tr>
<tr>
<td><strong>B. Oxadiazine</strong></td>
<td></td>
</tr>
<tr>
<td>Avaunt 15 SC/ Avaunt 15 EC (Indoxacarb)</td>
<td>200 ml</td>
</tr>
<tr>
<td><strong>C. Miscellaneous group</strong></td>
<td></td>
</tr>
<tr>
<td>Sumipleo 10 EC (Pyridalyl)</td>
<td>300 ml</td>
</tr>
<tr>
<td>Coragen 18.5 SC* (Chlorantraniliprole)</td>
<td>60 ml</td>
</tr>
<tr>
<td><strong>D. Organophosphates</strong></td>
<td></td>
</tr>
<tr>
<td>Coroban/Dursban/Durmet/Chorgaurd/Radar/Lethal/Force/Markpyriphos 20 EC (Chlorpyriphos)</td>
<td>2 litres</td>
</tr>
<tr>
<td>Orthene/Asataf/Starthene/Markphate 75 SP (Acephate)</td>
<td>800 g</td>
</tr>
<tr>
<td><strong>Tobacco caterpillar</strong></td>
<td></td>
</tr>
<tr>
<td><strong>A. Insect Growth Regulator</strong></td>
<td></td>
</tr>
<tr>
<td>Rimon 10 EC* (Novaluron)</td>
<td>150 ml</td>
</tr>
<tr>
<td><strong>B. Miscellaneous group</strong></td>
<td></td>
</tr>
<tr>
<td>Coragen 18.5 SC* (Chlorantraniliprole)</td>
<td>60 ml</td>
</tr>
</tbody>
</table>
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 after mid September.
• Repeat the spray immediately if it rains within 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 lancolated 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 liters spray material per acre by using backpack type air-assisted electrostatic sprayer or 300-400 liters spray material per acre by using Auto rotate gun type sprayer or 250-400 liters 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 hollow 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 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. 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. 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 intermittent 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°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/litre of water should be applied in last week of October. It leads to 85-90% defoliation after seven 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 along with 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/hr and at a depth of 12 to 15 cm with 45hp 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/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 the 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 3.4 thousand hectares during 2019-20. The total production was 13.3 thousand bales with an average lint yield of 6.64 quintals per hectare (2.69 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/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 lose 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.
SUGARCANE

Sugarcane occupied 91 thousand hectares in Punjab during 2019-20. The average cane yield was 802 quintals per hectare (325 quintals per acre). The average sugar recovery was 9.59 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 tons 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


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 broad 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.

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.

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.

* 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 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 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.
**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 reduces 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.

**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 at all 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 sets or 15 thousand four-budded sets or 12 thousand five-budded sets 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/h. The capacity of machine varies from 2-3 acres/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:

<table>
<thead>
<tr>
<th>Practice</th>
<th>Summer moong</th>
<th>Summer mash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed rate per acre</td>
<td>4 kg</td>
<td>5 kg</td>
</tr>
<tr>
<td>Time of sowing</td>
<td>March 20 to April 10</td>
<td>March 15 to April 7</td>
</tr>
</tbody>
</table>

**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 P₂O₅ (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.

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:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nutrients (kg per acre)</th>
<th>Fertilizers (kg per acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P₂O₅</td>
</tr>
<tr>
<td>Plant crop</td>
<td>60</td>
<td>#</td>
</tr>
<tr>
<td>Ratoon crop</td>
<td>90</td>
<td>#</td>
</tr>
</tbody>
</table>

# If the soil is low in available phosphorus, apply 12 kg P₂O₅ (75 kg single super phosphate) per acre at sowing.

• Sugarcane does not respond to potash in Punjab.
• 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.

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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) 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. 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 broad leaf 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:

<table>
<thead>
<tr>
<th>Month</th>
<th>Time of irrigation (Minutes)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>April-June</td>
<td>120</td>
</tr>
<tr>
<td>July-Aug</td>
<td>100</td>
</tr>
<tr>
<td>Sept-Oct</td>
<td>80</td>
</tr>
<tr>
<td>Nov-Dec</td>
<td>60</td>
</tr>
</tbody>
</table>

If discharge rate is different, then time of irrigation may be adjusted proportionally by the formula:-
Adjusted time (min) = \((2.2 \times \text{Time of irrigation (min)} \times \text{Discharge of dripper (litre/hour)})\)

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 (Raya/Potato/Wheat/Winter Maize/Gobhi Sarson/cabbage) 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.
## Table 1: Intercrops in autumn sugarcane

<table>
<thead>
<tr>
<th>Name of Intercrop</th>
<th>Variety</th>
<th>Sowing/planting time</th>
<th>Seed rate (kg per acre)</th>
<th>No. of intercrop rows</th>
<th>Spacing between the rows of intercrop</th>
<th>Fertilizers recommended per acre</th>
<th>Harvesting time</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>Recommended varieties</td>
<td>Last week of October to 15th Nov.</td>
<td>16</td>
<td>2</td>
<td>20 cm</td>
<td>25 kg N (54 kg urea) 12 kg P₂O₅ (75 kg single superphosphate, SSP) 12 kg K₂O (20 kg muriate of Potash, MOP)</td>
<td>Mid-April</td>
<td>---</td>
</tr>
<tr>
<td>Raya (Brassica juncea)</td>
<td>Recommended varieties</td>
<td>Whole of October</td>
<td>1</td>
<td>2</td>
<td>30 cm</td>
<td>20 kg N (44 kg urea) 8 kg P₂O₅ (50 kg SSP)</td>
<td>Mid-March</td>
<td>Sow raya either with Sugarcane in Oct. or after giving first irrigation.</td>
</tr>
<tr>
<td>Gobhi Sarson (B. napus)</td>
<td>GSL-1 or GSL-2</td>
<td>October 10 to 31</td>
<td>1</td>
<td>1</td>
<td>–</td>
<td>10 kg N (22 kg urea) 6 kg of P₂O₅ (37.5 kg SSP)</td>
<td>First fortnight of April</td>
<td>---</td>
</tr>
<tr>
<td>Toria (B. campestris) var. Toria</td>
<td>Recommended varieties</td>
<td>20th Sept. to end Sept.</td>
<td>1</td>
<td>2</td>
<td>30 cm</td>
<td>15 kg N (33 kg urea) 5 kg P₂O₅ (32 kg single super phosphate)</td>
<td>End Dec.</td>
<td>Wheat can also be sown after harvesting toria.</td>
</tr>
<tr>
<td>Gram</td>
<td>Recommended varieties for different zones</td>
<td>25th Oct. to 10th Nov.</td>
<td>12</td>
<td>2</td>
<td>30 cm</td>
<td>6 kg N (13 kg urea) + 8 kg P₂O₅ (50 kg SSP)</td>
<td>April</td>
<td>---</td>
</tr>
<tr>
<td>Potato</td>
<td>Chander-mukhi or any other short duration variety</td>
<td>20 Sept. to 15th Oct.</td>
<td>800</td>
<td>1</td>
<td>–</td>
<td>35 kg N (78 kg urea) 16 kg P₂O₅ (100 kg SSP) 35 kg K₂O (60 kg MOP)</td>
<td>End of Dec.</td>
<td>Wheat can also be taken after harvesting potato crop in end-December.</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>----</td>
<td>----------------------------------------</td>
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<td>---------</td>
<td>----------</td>
<td>----------------------------------------</td>
<td>----------------------------------------</td>
<td>----------------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td><strong>Cabbage</strong></td>
<td><strong>Recommended variety</strong></td>
<td>Last week of October to November</td>
<td>--</td>
<td>1</td>
<td>--</td>
<td>25 kg N (54 kg urea) 12.5 kg P(_2)O(_5) (78 kg SSP) 12.5 kg K(_2)O (20 kg MOP)</td>
<td>January &amp; February</td>
</tr>
<tr>
<td>2</td>
<td><strong>Radish</strong></td>
<td><strong>Recommended varieties</strong></td>
<td>October</td>
<td>4-5</td>
<td>2</td>
<td>30 cm</td>
<td>25 kg N (54 kg urea) 12 Kg P(_2)O(_5) (78 kg SSP)</td>
<td>January</td>
</tr>
<tr>
<td>3</td>
<td><strong>Peas</strong></td>
<td><strong>Recommended Varieties</strong></td>
<td>October</td>
<td>22</td>
<td>2</td>
<td>30 cm</td>
<td>14 kg N (31 kg urea) 16 kg P(_2)O(_5) (100 kg SSP)</td>
<td>--</td>
</tr>
<tr>
<td>4</td>
<td><strong>Tomato</strong></td>
<td><strong>Recommended Varieties</strong></td>
<td>Nursery: Oct - Nov  Transplanting: Nov-Dec</td>
<td>0.05 (nursery)</td>
<td>1 (Sugar-cane in paired row trenches at 120:30cm)</td>
<td>At centre between two cane rows</td>
<td>30 kg N (65 kg urea) 12.5 kg P(_2)O(_5) (77.5 kg SSP), 12.5 kg K(_2)O (21 Kg MOP)</td>
<td>End March to mid May</td>
</tr>
<tr>
<td>5</td>
<td><strong>Garlic</strong></td>
<td><strong>PG-17 PG-18</strong></td>
<td>4th week of Sept. to first week of Oct.</td>
<td>112 to 125 kg</td>
<td>3</td>
<td>15 cm</td>
<td>10 ton FYM, 25 kg N (54 kg urea), 12 kg P(_2)O(_5) (75 kg SSP)</td>
<td>April</td>
</tr>
<tr>
<td>6</td>
<td><strong>Onion</strong></td>
<td><strong>Recommended Varieties</strong></td>
<td>Nursery: Mid Oct- mid Nov Transplanting: First fortnight of January</td>
<td>2.0 to 2.5 (nursery)</td>
<td>5 (Sugar-cane in paired row trenches at 120:30cm)</td>
<td>15 cm</td>
<td>20 kg N (45 kg urea) 10 kg P(_2)O(_5) (62.5 kg SSP), 10 kg K(_2)O (17 Kg MOP)</td>
<td>Mid May</td>
</tr>
</tbody>
</table>
**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:

<table>
<thead>
<tr>
<th>Nutrients (kg per acre)</th>
<th>Fertilizers (kg per acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Urea</td>
</tr>
<tr>
<td>90</td>
<td>195</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>#</td>
</tr>
</tbody>
</table>

# If the soil test is low in phosphorus, apply 12 kg P₂O₅ (75 kg single super phosphate) per acre at sowing. Sugarcane does not respond to potash in Punjab.

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/ Marksufo 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.

**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.

- **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 96, 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)**

<table>
<thead>
<tr>
<th>Varieties*</th>
<th>Crop</th>
<th>Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>CoPb 92, CoPb 96, Co 15023, Co 238, Co 118, CoPb 95, CoJ 85 and CoJ 64</td>
<td>Ratoon (A &amp; S)</td>
<td>November and December</td>
</tr>
<tr>
<td>CoPb 93, CoPb 98, Co 238, CoPb 91, CoJ 88 and CoPb 94</td>
<td>Ratoon (S)</td>
<td>December and January</td>
</tr>
<tr>
<td>CoPb 92, CoPb 96, Co 15023, Co 238, Co 118, CoPb 95, CoJ 85 and CoJ 64</td>
<td>Plant (A)</td>
<td>December and January</td>
</tr>
<tr>
<td>CoPb 92, CoPb 96, Co 15023, Co 238, Co 118, CoPb 95, CoJ 85 and CoJ 64</td>
<td>Plant (S)</td>
<td>January and February</td>
</tr>
<tr>
<td>CoPb 98, CoPb 93, CoPb 91, CoPb 94 and CoJ 88</td>
<td>Plant (S)</td>
<td>February, March and April</td>
</tr>
</tbody>
</table>

* 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 18.5 SC (chlorantraniliprole*) or 2 litres of Durmet/Classic/Dursban/Markpyrifos 20 EC (chlorpyriphos) in 400 litres of water/acre along the rows at post-germination stage (about 45 days after planting).
- Earth up slightly followed by light irrigation. OR
- 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.

**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.

**Pyrrilla:** Pyrrilla 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

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- 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.
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 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 up to 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 Stations, Abohar, Gurdaspur and Bathinda.
- 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 leaf tip, 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 therogued-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 lose 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 not only the affected stalks; instead, uproot entire clump.
- 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 put under 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°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 54°C 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 settb-orne, 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.
SORGHUM (FODDER)

Sorghum (jowar) is a very important kharif fodder cultivated on 2.71 lakh hectares (2019-20). It remains green and palatable over a longer period than maize and bajra foders.

**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**
SL44 (1974): It is a sweet, juicy and thin-stemmed variety suitable for cultivation in summer and kharif in the irrigated areas of Punjab. Its green and sweet fodder is relished by cattle. It has a high content of digestible dry matter. It gives about 240 quintals green fodder per acre.

**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. 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 P₂O₅ (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.

- 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/Marksunflo/Total/Markpower herbicide has been used in wheat.
**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 P₂O₅ (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.

**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’
BAJRA (FODDER)

*Bajra* (pearl millet), cultivated on 1.52 lakh hectares (2019-20) 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 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.

**PHBF 1 (2009):** It is a hybrid meant for green fodder. It flowers in 50 days. Its' plants attain a height of 198 cm. It has succulent stem and multicut nature. It is better in tillering and has long and broad leaves. It is tolerant to major diseases and pests. The fodder quality of this hybrid is better than FBC-16 in terms of dry matter intake, digestible crude protein and total digestible nutrients. The average green fodder yield of this hybrid is 256 quintals per acre.

**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 (45-55 days after sowing). 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 parental lines of the hybrid PHBF 1 are given below:

**Female Parent 408 A:** The male sterile line has an average plant height of 140 cm. It takes about 55 days to 50% flowering and matures in 86 days. It has small ears with ear length less than 30 cm.

**Male Parent PIB 213:** The average plant height is 150 cm. It takes about 58 days to 50% flowering and matures in 90 days. It has long ears with ear length of 31-35 cm.

The procedure of the seed production of the hybrid and 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’.
MAIZE (FODDER)

Maize is an important kharif fodder and is cultivated on approximately 0.77 lakh hectare in Punjab state (2019-20). 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 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 15 kg seed of Cowpea 88 or 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 (50-60 days after sowing). 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 Stations, Abohar, Gurdaspur and Bathinda.

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.
2. OTHER CROPS

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 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.

**PHB 2168 (2006):** This hybrid is about 210 cm tall, bears 2-3 productive tillers and matures in 83 days. It has medium long ears having an average length of 26 cm and girth 9 cm. Its’ grains are medium bold and slate in colour. It is tolerant to downy mildew. Its’ average grain yield is 16.4 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:

<table>
<thead>
<tr>
<th>*Nutrients (kg per acre)</th>
<th>Fertilizer (kg per acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>N</strong></td>
<td><strong>P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;</strong></td>
</tr>
<tr>
<td>Hybrid/composite</td>
<td>40</td>
</tr>
</tbody>
</table>

**Irrigated Conditions**

| Hybrid/composite | 25 | 12 | 55 | 27 | 75 |

**Rainfed Conditions**

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

**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:

<table>
<thead>
<tr>
<th>Hybrid</th>
<th>Parental Lines</th>
<th>Ratio of female to male line with seed rate/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHB 2884</td>
<td>ICMA 02777, PIB 686</td>
<td>4 (1kg): 2 (0.5 kg)</td>
</tr>
<tr>
<td>PHB 2168</td>
<td>ICMA 92333, PIB 686</td>
<td>4 (1kg): 2 (0.5 kg)</td>
</tr>
</tbody>
</table>

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:** The green-ear disease or downy-mildew 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 hybrids such as PHB 2884, PHB 2168 and composite varieties such as 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 which get disseminated and 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 next year in a field in which the crop had suffered heavily from ergot.

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

*Moong* occupied 2.6 thousand hectares and the total production was 2.3 thousand tonnes during 2019-20 in Punjab. Its' average yield was 8.70 quintals per hectare (3.52 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*

**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.

**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

- **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.**
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/kerja. 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 P₂O₅ (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-III).

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. It excretes honey dew, 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. Jassid nymphs and adults suck sap from the leaves resulting in yellowing and drying of leaves.

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.

**Blisters beetle:** Blisters 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 V.

### 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 2.0 thousand hectares and the total production was 1.2 thousand tonnes in the Punjab state during the year 2019-20. The average grain yield was 5.78 quintals per hectare (2.34 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 114 (2008):** This variety is recommended for the whole Punjab state. Its’ 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 Punjab 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 intercropped 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 V.

**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* 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. Adopt the following measures to check the disease. Grow disease resistant varieties, *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* varieties, *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 2.0 thousand hectares and the total production was 2.2 thousand tonnes during 2019-20. It gave an average yield of 10.99 quintals per hectare (4.45 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.

**AL 201 (1993):** It is an early maturing variety with indeterminate growth habit. It matures in about 140 days and vacates the field by the end of October permitting timely sowing of the succeeding wheat crop. The plants are erect and about 2.5 metre tall. The main stem is much longer than the side branches and its flower is yellow with prominent red streaks on the standard petal. Pod formation is profuse and each pod contains 3-5 yellowish brown and medium sized seeds. The average grain yield is about 5 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:** 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.

**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.

<table>
<thead>
<tr>
<th><em>Nutrient (kg per acre)</em></th>
<th>Fertilizer (kg per acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>6</td>
<td>16</td>
</tr>
</tbody>
</table>

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

**Note:**
- 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.

**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. For control of spotted pod borer, spray the crop at flower initiation stage using 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*): 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, shreveded and malformed seeds are observed. The damage results in shreveded or deformed seeds. 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, spray the crop at seed filling stage of the crop upon pest appearance using 1250 ml per acre homemade neem extract using 100-125 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 filtrate for spraying at the recommended dose.

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.

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.

• 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.
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 along with 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 (13 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 P₂O₅ (200 kg of single superphosphate). However, apply only 24 kg of P₂O₅ (150 kg of single superphosphate) per acre to soybean when it follows wheat which had received recommended dose of phosphorus. For obtaining higher yields, 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:P₂O₅:K₂O: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. To ameliorate iron deficiency, spray the crop with 0.5% ferrous sulphate (1 kg of ferrous sulphate in 200 litres of water) at 30 and 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.
GROUNDNUT

Groundnut was grown on 1.4 thousand hectares during 2019-20 in Punjab. Its’ production was 2.8 thousand tonnes with an average yield of 19.75 quintals per hectare (7.99 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/Gobhi sarson+Toria/Potato/Peas/Torial/Rabi crops, 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 and 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%. 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, with100 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.

SG 84 (1986): It is recommended for sowing in spring as well as kharif seasons. It is a bunch type variety with profused primary and secondary branches. During spring season, it matures in 130 days with pod yield of 10 quintals per acre while in kharif season, it matures in 120 days with pod yield of 8 quintals per acre. The pods are medium in size with
one or two kernels. Kernels have slight beak and medium constriction. The kernels are light brown. It has a shelling outturn of 64 per cent with a 100 kernel weight of 49 g and oil content of 50 per cent. The nutritive value of the straw has been adjudged comparable to that of berseem and cowpea hay.

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 cultivation (Appendix IV). 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 (tetrathiomethyl thiurium disulphide) or 3.0 g Indofil M-45 (mancozeb) per kg of kernels. Seed treatment with Neonix also controls white 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 wheat.

Sow the rainfed crop with the advent of monsoon in the last week of June or in the 1st 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 (Appendix IV). The following seed rates and spacings are recommended for different varieties:

<table>
<thead>
<tr>
<th>Variety</th>
<th>Seed rate (kg kernels/acre)</th>
<th>Spacing (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>J 87</td>
<td>48</td>
<td>30 x 22.5</td>
</tr>
<tr>
<td>TG 37A</td>
<td>32</td>
<td>30 x 15</td>
</tr>
<tr>
<td>SG 99</td>
<td>40</td>
<td>30 x 15</td>
</tr>
<tr>
<td>M 522</td>
<td>38</td>
<td>30 x 22.5</td>
</tr>
<tr>
<td>SG 84</td>
<td>38</td>
<td>30 x 15</td>
</tr>
</tbody>
</table>
**Fertilizer Application:** For medium fertility conditions:

<table>
<thead>
<tr>
<th>Season</th>
<th>Nutrients (kg per acre)</th>
<th>Fertilizers (kg per acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P₂O₅</td>
</tr>
<tr>
<td>Spring</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Kharif</td>
<td>6</td>
<td>8</td>
</tr>
</tbody>
</table>

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

**Method of fertilizer application:** In spring season groundnut, 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 groundnut, 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 preceding period 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 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 (Appendix IV). 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. It would help in exposing 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. It will also control termite.

**Hairy Caterpillar:** Hairy caterpillar, if appearing in epidemic form cause 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.

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 with 2 ml Neonix 20 FS (imidacloprid 18.5%+hexaconazole1.5%) or 5 g Seedex 2 DS (tebuconazole) or 5 g of Thiram (tetramethyl thiurum disulphide) or 3 g of Indofil M-45 (mancozeb) per kg of kernels. Seed treatment with Neonix 20FS takes care of collar rot and white grub with single seed treatment and it also controls termites.
- 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 Bavistan*/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 10 “Management of Rodents and Birds”.
SESAME

Sesame (Til) was grown on 2.6 thousand hectares with a production of 1.0 thousand tonnes during 2019-20 in the Punjab. The average yield was 3.82 quintals per hectare (1.55 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 profused branching and dense pod bearing. Pods arranged opposite to each other are long and non-hairy. Its' seeds are white, bold and have 49% 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 profused branching, long non-hairy capsules arranged alternately. It has white, bold seeds which contain 49% oil. It is moderately resistant to *Antigastra* capsule borer. It matures in 87 days.

**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.

- 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 bury 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.
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 pods. 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 pods. The diseased plants give blighted appearance followed by defoliation. Avoid excessive use of nitrogenous fertilizers and field should be free from weeds and debris.
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 *kerja* 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<sub>2</sub>O<sub>5</sub> (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. It occupies about 15000 hectares in the State. 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 cm 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-Maize (August), Mentha-DSR-Potato, Mentha-DSBR-Potato

Improved Varieties

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, borne 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.

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.

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.

- Use two quintals of disease free sucker for planting an acre.
- Sow the crop during mid January to end January, however Kosi and CIM Kranti 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.
- For higher returns, grow mentha as an intercrop in sunflower / sugarcane or onion as an intercrop in 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 and CIM Kranti should be planted from end of January to mid of February. The crop can also be raised by transplanting in April.

**Inter cropping:** 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 P₂O₅ (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 P₂O₅ (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 P₂O₅ (44 kg SSP) and 7 kg K₂O (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:

<table>
<thead>
<tr>
<th>Nutrients (kg per acre)</th>
<th>Fertilizers (kg per acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N₂O₅</td>
<td>Urea</td>
</tr>
<tr>
<td>60</td>
<td>16</td>
</tr>
</tbody>
</table>

* 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:

<table>
<thead>
<tr>
<th>Month</th>
<th>Time of irrigation (Minutes)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>40</td>
</tr>
<tr>
<td>April</td>
<td>65</td>
</tr>
<tr>
<td>May</td>
<td>70</td>
</tr>
<tr>
<td>June</td>
<td>75</td>
</tr>
</tbody>
</table>

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

\[
\text{Adjusted time (min)} = \frac{(2.2 \times \text{Time of irrigation (min)*})}{\text{Discharge of dripper (litre/hour)}}
\]

For first cut, apply 24 kg N and 12.8 kg P\text{$_{2}$O$_{5}$} per acre in 10 equal splits with drip irrigation. Fertigate with first 1/10th of N and P\text{$_{2}$O$_{5}$} with first irrigation just after planting and thereafter, remaining 9 doses of N and P\text{$_{2}$O$_{5}$} 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\text{$_{2}$O$_{5}$} 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.

**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** (*Odentotermes 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 buried 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$_2$O$_5$ (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$_2$O$_5$ (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.
3. OTHER FODDER CROPS

Fodder production in the Punjab state has to be substantially increased if the present population of 81.2 lakh cattle and buffaloes (62.4 lakh adult animals) is to be provided with sufficient fodder of good quality. The area under fodder crops in the state (2019-20) is approximately 9.0 lakh hectares (5.39 lakh hectare in kharif) and the annual production is about 716 lakh tonnes of green fodder. Each animal gets fodder supply of about 31.4 kg per day. This quantity is inadequate. On the basis of 40 kg green fodder per adult animal per day, approximately 911 lakh tonnes of fodder will be 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.

Important Hints

- The supply of protein to animals from legumes is cheaper than from concentrates. The non-legume forages are rich in energy. It is, therefore, essential that 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.
- Use specific weedicide/herbicide as per recommendation in case of mixture of forage crops grown. Avoid use of un-recommended agro-chemicals on fodder crops as this may be harmful to dairy animals
- Plants attacked by any insect pest 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 green fodder as silage and Hay.
Nutritive value (on dry matter basis) of Kharif fodders

<table>
<thead>
<tr>
<th>Fodders</th>
<th>Crude protein (%)</th>
<th>Total digestible nutrients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>11.4</td>
<td>66.2</td>
</tr>
<tr>
<td>Sorghum</td>
<td>9.0</td>
<td>55.6</td>
</tr>
<tr>
<td>Bajra</td>
<td>8.8</td>
<td>58.2</td>
</tr>
<tr>
<td>Napier-bajra hybrid</td>
<td>8.7</td>
<td>59.3</td>
</tr>
<tr>
<td>Guinea grass</td>
<td>10.8</td>
<td>62.4</td>
</tr>
<tr>
<td>Guara</td>
<td>18.1</td>
<td>60.0</td>
</tr>
<tr>
<td>Cowpea</td>
<td>22.5</td>
<td>61.2</td>
</tr>
</tbody>
</table>

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 up to onset of winter. Its' winter dormancy period is about 15 days less than PBN 83. It yields 1100 quintals of green fodder per acre.

PBN 83 (1984): It is a non-hairy, smooth-leaved fast growing and late-flowering hybrid. It maintains its active growth longer in winter and sprouts earlier in spring. It yields 960 quintals 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 P₂O₅ (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.

PGG 101 (1991): Plants of this variety have profuse tillering and leafy growth. Loss of nutrients in this variety is less on unavoidable delay in harvesting. It has bold seeds which help in better germination. It produces 675 quintals green fodder per acre in 5-6 cuttings from May to November. Harvesting should be done before flowering to get nutritious fodder.

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.

Cowpea 88 (1990): This is a dual purpose variety recommended for cultivation throughout the State for fodder and as a pulse crop. It is tolerant to yellow mosaic virus and anthracnose disease. It has large pods and bold seeds. The seed colour which is chocolate-brown is most attractive for culinary purpose. It matures uniformly during second fortnight of October and later on wheat and other rabi crops can be sown timely. Its’ average grain yield is 4.3 quintals per acre. It yields 100 quintals of green fodder per acre.

Agronomic Practices

Land Preparation: Two ploughings followed by plankings are sufficient.

Seed Rate and Sowing Time: For fodder, sow 20-25 kg seed of cowpea 88 and 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 or 15 kg of Cowpea 88 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 of cowpea CL 367 in first week of August and 16 kg seed of Cowpea 88 from last week of July to 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 Appendix 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 an 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:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Stage of harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum and Maize</td>
<td>Flowering to milk</td>
</tr>
<tr>
<td>Bajra</td>
<td>Boot stage</td>
</tr>
<tr>
<td>Napier-bajra hybrid and Guinea grass</td>
<td>1 metre tall</td>
</tr>
</tbody>
</table>

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.
4. 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:

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 (cowpea 88) 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:

- Leaf folder: 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 ponded in the crop.
**Stem borers and Leaf folder:** 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 Stations at Abohar, Gurdaspur and Bathinda.

Spray neem based 80 ml of Ecotin (azadirachtin 5%) or 1000 ml of Neem Kavach/Achook (azadirachtin 0.15%) in 100 litre of water per acre at pest initiation stage.

**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.

**Nutrition:** 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/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 t/acre FYM (1% N), 1.1 t/acre vermicompost (1.5% N) and 0.7 t/acre castor cake (2.5% N).

**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. 44 under Cotton chapter

**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.
**Nutrition:** Incorporate the residues of previous wheat crop in the field. Apply well rotten farm yard manure on dry weight basis @ 8 t 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/acre in the third week of April or immediately 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/triphal/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 uniformly 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 thoroughly one packet of Bradyrhizobium sp. (LSBR 3) with it and let it dry in shade. Sow the seed immediately.

**Nutrition:** 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 q per acre rice straw mulch at the time of sowing and if needed, give one hand weeding to remove the emerged weeds. 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**

**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.

**Nutrition:** Incorporate the residues of previous maize or soybean crop in the field. Apply well rotten farm yard manure on dry weight basis @ 8 t/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 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.44 under cotton chapter

**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.

**Nutrition:** The nutritional requirement of 50 kg nitrogen per acre to maize can be supplied through 1.7 tonne FYM (1% N) + 1.1 tonne vermicompost (1.5% N) + 0.7 tonne 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.

**Nutrition:** The nutritional requirement of 75 kg nitrogen per acre to potato can be supplied through 2.5 tonne FYM (1% N) + 1.7 tonne vermicompost (1.5% N) + 1.0 tonne 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.

**Nutrition:** The nutritional requirement of 40 kg nitrogen per acre to onion can be supplied through 1.3 tonnes FYM (1% N) + 0.9 tonne vermicompost (1.5% N) + 0.5 tonne 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.

Maize-Potato-Summer Moong

Maize

Seed Inoculation: Inoculate the seed as given under maize/soybean-wheat system in this chapter.

Nutrition: The nutritional requirement of 50 kg nitrogen per acre of maize can be met through 5.0 t dry FYM (1% N) or 3.3 t dry FYM and 1.1 t 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.

Nutrition: The nutritional requirement of 75 kg nitrogen per acre of potato can be met through 7.5 t dry FYM (1% N) or 5.0 t dry FYM and 1.7 t 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. LSRM-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.

Nutrition: The nutritional requirement of 5 kg nitrogen per acre of summer moong can be met through 0.5 t dry FYM (1% N) or 0.3 t dry FYM and 0.1 t vermicompost (1.5% N).

Weed Control: Give need based manual weedings.

Maize-Durum Wheat-Cowpea (fodder)

Maize

Seed Inoculation: Inoculate the seed as given under maize/soybean-wheat system in this chapter.

Nutrition: 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 t/acre FYM (1% N) + 1.1 t/acre vermicompost (1.5% N) + 0.7 t/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.

**Nutrition:** 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 t/acre FYM (1% N) + 1.1 t/acre vermicompost (1.5% N) + 0.7 t/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**

**Nutrition:** 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.

**Turmeric-Onion**

**Turmeric**

**Biofertilizers:** Apply consortium biofertilizer @ 4 kg per acre as soil application at the time of planting.

**Nutrition:** 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 tonne of fully dried farmyard manure) supplemented with 1.3 tonne 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. If straw mulch is not applied then give three hand weedicings 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.

**Nutrition:** 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 tonne 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.

**Gobhi Sarson**

**Sowing method:** Use 1.5 seed per acre. Sow the crop in rows 67.5 cm apart with plant to plant spacing of 10 cm.

**Nutrition:** Apply 4 tonne 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.

Insect-pest control: The natural predators (Coccinella septumpunctata) become active on appearance of aphid. If needed, neem based biopesticide may be used to control insect-pests.

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 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 2.0 tonne 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 tonne 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 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 Stations at Abohar, Gurdaspur and Bathinda.

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.

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

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.
5. 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/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/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/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 bury 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/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 (Variety PBW 590) could be sown. Such a groundnut 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 substantial 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 moong bean in the first fortnight of April. The summer moong bean 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 moong bean in the 2-3 week of April. This system also improves the soil fertility, soil micro flora and fauna over rice-wheat system.

16. Groundnut-Toria + Gobhi sarson: This cropping system produces more yield and economic returns than the maize-wheat and rice-wheat cropping systems. Therefore, the groundnut (SG 99) should be sown in the first fortnight of May. Sow toria and gobhi sarson in Mid September in alternate rows 22.5 cm apart or sowing toria by broadcast and gobhi sarson in lines 45 cm apart, using one kg seed rate per acre for each crop. In this system, the toria will be harvested around mid December, while gobhi sarson will continue in the field till end March. Apply 25 kg nitrogen/acre (55 kg Urea) and 12 kg P₂O₅/acre (75 Kg Single super phosphate) to toria+gobhi sarson at sowing and apply 30 kg N/acre (65 kg urea) after the harvesting of toria with second irrigation.

17. 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.

18. 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 fortnight 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.

19. 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.

20. 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.

21. 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.

22. 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.

**Fodder cropping system**

23. 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.

24. 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.
SUB SURFACE DRIP IRRIGATION AND FERTIGATION

25. 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:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Month</th>
<th>Time of irrigation (Minutes)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>July</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Aug</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Sept</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Oct</td>
<td>30</td>
</tr>
<tr>
<td>Wheat</td>
<td>Dec</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Jan</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>Feb</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>March</td>
<td>50</td>
</tr>
<tr>
<td>Summer Moong</td>
<td>May</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>June</td>
<td>45</td>
</tr>
</tbody>
</table>

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

\[ \text{Time of irrigation (min)} = \frac{2.2 \times \text{Time of irrigation (min)*}}{\text{Discharge of dripper (litre per hour)}} \]

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.

26. Zero till direct seeded rice-Wheat: Place drip line 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:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Month</th>
<th>Time of irrigation (Minutes)*</th>
<th>Interval (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>June</td>
<td>65</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>July</td>
<td>65</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>August</td>
<td>65</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>September</td>
<td>65</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>October</td>
<td>65</td>
<td>2</td>
</tr>
<tr>
<td>Wheat</td>
<td>November</td>
<td>45</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>December</td>
<td>45</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>January</td>
<td>45</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>45</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>March</td>
<td>45</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>45</td>
<td>5</td>
</tr>
</tbody>
</table>

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

\[ \text{Adjusted time of irrigation (min)} = (2.0 \times \text{time of irrigation (min)} + \text{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.

27. 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:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Month</th>
<th>Time of irrigation (Minutes)*</th>
<th>Interval (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>June</td>
<td>45</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>July</td>
<td>45</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>August</td>
<td>45</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>September</td>
<td>45</td>
<td>7</td>
</tr>
</tbody>
</table>
If the discharge rate is different, then time of irrigation may be adjusted proportionally by the formula

\[
= (1.6 \times \text{time of irrigation (min)}) / \text{Discharge of dripper (litre per hour)}
\]

This system improves system productivity about 9% with saving of 53% applied irrigation water and 20% nitrogen over conventional maize-wheat system.

28. 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). Fertilize 100 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:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Month</th>
<th>Time of irrigation (Minutes)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>May</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>June</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>July</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>August</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>September</td>
<td>25</td>
</tr>
<tr>
<td>Wheat</td>
<td>December</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>January</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>March</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>50</td>
</tr>
</tbody>
</table>

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

\[
= (2.2 \times \text{time of irrigation (min)}) / \text{Discharge of dripper (litre per hour)}
\]
6. 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:

<table>
<thead>
<tr>
<th>Component</th>
<th>Area (kanal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field crops</td>
<td>7.0</td>
</tr>
<tr>
<td>Fodder</td>
<td>4.0</td>
</tr>
<tr>
<td>Oilseeds/pulses</td>
<td>1.0</td>
</tr>
<tr>
<td>Fruit trees with intercropping of seasonal vegetables</td>
<td>4.0</td>
</tr>
<tr>
<td>Agro-forestry</td>
<td>1.0</td>
</tr>
<tr>
<td>Dairy(2 cows/buffaloes) shed with composting/vermicomposting unit</td>
<td>0.5</td>
</tr>
<tr>
<td>Fishery (with high density boundary planting of fruit trees and Napier bajra)</td>
<td>2.0</td>
</tr>
<tr>
<td>Kitchen gardening</td>
<td>0.5</td>
</tr>
<tr>
<td>Planting of turmeric on bunds around field crops</td>
<td>-</td>
</tr>
<tr>
<td>Boundary plantation of karonda and galgal (optional)</td>
<td>-</td>
</tr>
</tbody>
</table>

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.
7. 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/acre are rated as low, those with 5-9 kg phosphorus/acre as medium, with 9-20 kg phosphorus/acre as high and with more than 20 kg phosphorus/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 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

<table>
<thead>
<tr>
<th>Crops</th>
<th>Soil test category</th>
<th>Nitrogen</th>
<th>Phosphorus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Urea</td>
<td>SSP</td>
</tr>
<tr>
<td>Rice</td>
<td></td>
<td>110</td>
<td>90</td>
</tr>
<tr>
<td>Maize</td>
<td></td>
<td>130</td>
<td>110</td>
</tr>
<tr>
<td>Cotton (Bt and non-Bt hybrids)</td>
<td></td>
<td>110</td>
<td>90</td>
</tr>
<tr>
<td>Cotton (varieties)</td>
<td></td>
<td>80</td>
<td>65</td>
</tr>
<tr>
<td>Sugarcane (plant crop)</td>
<td></td>
<td>165</td>
<td>130</td>
</tr>
</tbody>
</table>

* 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

<table>
<thead>
<tr>
<th>Soil organic carbon (%)</th>
<th>Available Phosphorus (kg per acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low (below 5)</td>
</tr>
<tr>
<td>Below 0.4</td>
<td>25% more than Recommended</td>
</tr>
<tr>
<td>0.4-0.6</td>
<td>25% more than Recommended</td>
</tr>
<tr>
<td>Above 0.6</td>
<td>25% more than Recommended</td>
</tr>
</tbody>
</table>

* Fertilizer dose for medium soils as given in table 1.

Potassium: Based on the available potassium status, soils are grouped into two categories viz. deficient (less than 55 kg K₂O/acre) and sufficient (more than 55 kg K₂O/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 confined to the soils in the districts 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, Dept. 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.
8. 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.

6. Use organic amendments: In calcareous soils with more than 2% calcium carbonate, use organic manures viz. farmyard manure @ 8 tonnes/acre or green manure or wheat straw @ 2.5 tonnes/acre/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: 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 and sodium in undesirable amounts. Therefore, this water should be got tested from the Soil and Water Testing Laboratory and may be used for irrigation as per recommendation.
9. 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 – III). 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 across 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.
10. 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
   In fields, place 16 traps/acre covering runways, damage and activity sites of rodents. In houses, godowns, poultry farms etc., set traps (1 trap per 4-8 m² 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.

- **Paddy**: 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.

- **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 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).

**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 bury 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 original 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 Prices of Different Crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Crop Year</th>
<th>2015-16</th>
<th>2016-17</th>
<th>2017-18</th>
<th>2018-19</th>
<th>2019-20</th>
<th>2020-21</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy (Common)</td>
<td>1410</td>
<td>1470</td>
<td>1550</td>
<td>1750</td>
<td>1815</td>
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<td>Paddy (Grade 'A')</td>
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<td>1590</td>
<td>1770</td>
<td>1835</td>
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<tr>
<td>Jowar (Hybrid)</td>
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<td>1700</td>
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<td>Bajra</td>
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<td>1425</td>
<td>1950</td>
<td>2000</td>
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<td>Maize</td>
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<td>1365</td>
<td>1425</td>
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<tr>
<td>Tur (Arhar)</td>
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<td>5050@@</td>
<td>5450$</td>
<td>5675</td>
<td>5800</td>
<td>6000</td>
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<td>Moong</td>
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<td>5225@@</td>
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<td>7196</td>
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<td>Mash (Urad)</td>
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<td>5400$</td>
<td>5600</td>
<td>5700</td>
<td>6000</td>
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<td>Groundnut</td>
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<td>4220^^</td>
<td>4450$</td>
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<td>4100^^</td>
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<td>6249</td>
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<td>4020</td>
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<td>4160</td>
<td>4320</td>
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<td>1735</td>
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<td>1925</td>
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<td>Gram</td>
<td>3425@</td>
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<td>4400^</td>
<td>4620</td>
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<td>Lentil (Masur)</td>
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<tr>
<td>Rapseed/ Mustard</td>
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<td>3700^^</td>
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<td>300</td>
<td>310</td>
<td>310</td>
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@ Additional bonus of Rs 75 per quintal
$ Includes bonus of Rs 200 per quintal
^ Includes bonus of Rs 150 per quintal
^ ^ Includes bonus of Rs 100 per quintal
# State Advisory Price
## ANNEXURE - II

District-wise Area, Yield and Production of Various *Kharif* Crops in Punjab during 2019-20

<table>
<thead>
<tr>
<th>District</th>
<th>Paddy</th>
<th>Maize</th>
<th>Bajra</th>
<th>Total <em>Kharif</em> Cereals</th>
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<tr>
<td></td>
<td>A</td>
<td>Y</td>
<td>P</td>
<td>A</td>
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<tr>
<td>Amritsar</td>
<td>181</td>
<td>4933</td>
<td>893</td>
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<tr>
<td>Barnala</td>
<td>114</td>
<td>6870</td>
<td>783</td>
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<td>Bathinda</td>
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<td>6369</td>
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<td>Faridkot</td>
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<td>5606</td>
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<td>F.G. Sahib</td>
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<td>951</td>
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<td>5978</td>
<td>466</td>
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A= Area in thousand hectares         Y= Average yield in Kg/ha         P= Production in thousand tons

Source: Department of Agriculture and Farmers' Welfare, Punjab
### District-wise Area, Yield and Production of Various *Kharif* Crops in Punjab during 2019-20

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A = Area in thousand hectares   Y = Average yield in kg/ha   P = Production in thousand tons

Source: Department of Agriculture and Farmers’ Welfare, Punjab
## District-wise Area, Yield and Production of Various Kharif Crops in Punjab during 2019-20

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A=Area in thousand hectares  Y=Average yield in kg/ha  
P=Production in thousand bales (One bales of 170 kg lint)  
*in terms of lint  
Source: Department of Agriculture and Farmers' Welfare, Punjab
## District-wise Area, Yield and Production of Various *Kharif* Crops in Punjab during 2019-20

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(b)- Production less than 50 tons

**A=Area in thousand hectares  Y=Average yield in kg/ha  P=Production in thousand tons**

Source: Department of Agriculture and Farmers’ Welfare, Punjab

146
## District-wise Area, Yield and Production of Various *Kharif* Crops in Punjab during 2019-20

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<tr>
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<td>0.5</td>
<td>80853</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td><strong>State</strong></td>
<td><strong>91.0</strong></td>
<td><strong>80246</strong></td>
<td><strong>7302</strong></td>
<td><strong>16.3</strong></td>
</tr>
</tbody>
</table>

A = Area in thousand hectares  
Y = Average yield in kg/ha  
P = Production in thousand tons

Source: Department of Agriculture and Farmers' Welfare, Punjab
### ANNEXURE - III

#### Seed Standards for Foundation and Certified Seed

<table>
<thead>
<tr>
<th>Crops</th>
<th>Pure seed (Minimum) (%) (Per Kg)</th>
<th>Inert matter (Maximum) (%)</th>
<th>Other crop Seed (Max.) (Per Kg)</th>
<th>Weed seeds (Maximum) (Per Kg)</th>
<th>Objectionable Weed Seeds (Maximum) (%)</th>
<th>Germination (Minimum) (%)</th>
<th>Moisture (Ordinary) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>C</td>
<td>F</td>
<td>C</td>
<td>F</td>
<td>C</td>
<td>F</td>
</tr>
<tr>
<td>Rice</td>
<td>98.0</td>
<td>98.0</td>
<td>2.0</td>
<td>2.0</td>
<td>10</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Maize</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Hybrids</td>
<td>–</td>
<td>98.0</td>
<td>–</td>
<td>2.0</td>
<td>–</td>
<td>10</td>
<td>–</td>
</tr>
<tr>
<td>(ii) Composite and open pollinated varieties</td>
<td>98.0</td>
<td>98.0</td>
<td>2.0</td>
<td>2.0</td>
<td>5</td>
<td>10</td>
<td>None</td>
</tr>
<tr>
<td>Bajra (Hybs. &amp; Vtys.)</td>
<td>98.0</td>
<td>98.0</td>
<td>2.0</td>
<td>2.0</td>
<td>10</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Mash</td>
<td>98.0</td>
<td>98.0</td>
<td>2.0</td>
<td>2.0</td>
<td>5</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Moong</td>
<td>98.0</td>
<td>98.0</td>
<td>2.0</td>
<td>2.0</td>
<td>5</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Arhar</td>
<td>98.0</td>
<td>98.0</td>
<td>2.0</td>
<td>2.0</td>
<td>5</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Soybean</td>
<td>98.0</td>
<td>98.0</td>
<td>2.0</td>
<td>2.0</td>
<td>None</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Cotton (Hybs. &amp; Vtys.)</td>
<td>98.0</td>
<td>98.0</td>
<td>2.0</td>
<td>2.0</td>
<td>5</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Groundnut</td>
<td>796.0</td>
<td>96.0</td>
<td>4.0</td>
<td>4.0</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Sesamum</td>
<td>97.0</td>
<td>97.0</td>
<td>3.0</td>
<td>3.0</td>
<td>10</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Sunflower (Hybs. &amp; Vtys.)</td>
<td>98.0</td>
<td>98.0</td>
<td>2.0</td>
<td>2.0</td>
<td>None</td>
<td>None</td>
<td>5</td>
</tr>
</tbody>
</table>

Standards in percentage unless indicated otherwise.
F: Foundation            C: Certified.
## ANNEXURE - IIIA

### Field Standards for the Production of Foundation and Certified Seeds

<table>
<thead>
<tr>
<th>Crop</th>
<th>Isolation (in metre)</th>
<th>Pollen shedders</th>
<th>Off type Plants/Earheads</th>
<th>Objectional weed</th>
<th>Plants/Earheads affected by seed borne diseases</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F        C</td>
<td>F        C</td>
<td>F        C</td>
<td>F       C</td>
<td>F       C</td>
<td>F       C</td>
</tr>
<tr>
<td>Rice</td>
<td>3        3</td>
<td>-        -</td>
<td>0.05     0.2</td>
<td>0.01    0.02</td>
<td>-        -</td>
<td>Wild rice or red rice</td>
</tr>
<tr>
<td>Maize Varieties hybrids</td>
<td>400      200</td>
<td>1.0       1.0</td>
<td>0.1      -</td>
<td>-       -</td>
<td>-       -</td>
<td>With same colour and texture</td>
</tr>
<tr>
<td></td>
<td>-        300</td>
<td>0.5       1.0</td>
<td>-        -</td>
<td>-       -</td>
<td>-       -</td>
<td>With different kernel colour</td>
</tr>
<tr>
<td></td>
<td>-        200</td>
<td>-        -</td>
<td>-        -</td>
<td>-       -</td>
<td>-       -</td>
<td>With same kernel colour</td>
</tr>
<tr>
<td>Bajra (hybrid)</td>
<td>1000     200</td>
<td>0.05      0.1</td>
<td>0.01     0.05</td>
<td>-        -</td>
<td>0.05     0.1</td>
<td>Grain ear and grain smut</td>
</tr>
<tr>
<td>Bajra (Composite)</td>
<td>400      200</td>
<td>-        -</td>
<td>0.05     0.1</td>
<td>-        -</td>
<td>0.05     0.1</td>
<td></td>
</tr>
<tr>
<td>Mash</td>
<td>10       5</td>
<td>-        -</td>
<td>0.1      0.2</td>
<td>-        -</td>
<td>-        -</td>
<td>At final inspection</td>
</tr>
<tr>
<td>Moong</td>
<td>10       5</td>
<td>-        -</td>
<td>0.1      0.2</td>
<td>-        -</td>
<td>0.1      0.2</td>
<td>For disease</td>
</tr>
<tr>
<td>Arhar</td>
<td>200      100</td>
<td>-        -</td>
<td>0.1      0.2</td>
<td>-        -</td>
<td>-        -</td>
<td>Permitted at final inspection</td>
</tr>
<tr>
<td>Soybean</td>
<td>3        3</td>
<td>-        -</td>
<td>0.1      0.2</td>
<td>-        -</td>
<td>-        -</td>
<td>At final inspection</td>
</tr>
<tr>
<td>Cotton</td>
<td>50       30</td>
<td>-        -</td>
<td>0.1      0.2</td>
<td>-        -</td>
<td>-        -</td>
<td>Same species, permitted at flowering</td>
</tr>
<tr>
<td></td>
<td>5        5</td>
<td>-        -</td>
<td>-        -</td>
<td>-        -</td>
<td>-        -</td>
<td>Different species, permitted at flowering</td>
</tr>
<tr>
<td>Groundnut</td>
<td>3        3</td>
<td>-        -</td>
<td>0.1      0.2</td>
<td>-        -</td>
<td>-        -</td>
<td></td>
</tr>
<tr>
<td>Sesamum</td>
<td>100      50</td>
<td>-        -</td>
<td>0.1      0.2</td>
<td>-        -</td>
<td>0.5*     1.0*</td>
<td></td>
</tr>
<tr>
<td>Sunflower (hybrid)</td>
<td>600      400</td>
<td>0.05     1.0</td>
<td>0.2      0.5</td>
<td>-        -</td>
<td>-        -</td>
<td></td>
</tr>
</tbody>
</table>

Standards are in percentage unless indicated otherwise
F: Foundation          C: Certified
* Cercospora leaf spot disease
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:

\[
\text{Number of revolutions} = \frac{\text{Area of an acre (4000 sq. m.)}}{\text{Size of drill (m) \times Circumference of wheel (m)}}
\]
• 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)

<table>
<thead>
<tr>
<th>Distance between rows</th>
<th>Size of Wheel 45 cm/18&quot;</th>
<th>60 cm/24&quot;</th>
<th>75 cm/30&quot;</th>
<th>90 cm/36&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 cm/8&quot;</td>
<td>15-18 grams</td>
<td>20-22 grams</td>
<td>25-28 grams</td>
<td>32-34 grams</td>
</tr>
<tr>
<td>22 cm/9&quot;</td>
<td>18-20 grams</td>
<td>24-26 grams</td>
<td>30-33 grams</td>
<td>37-39 grams</td>
</tr>
</tbody>
</table>

**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 concave shaft 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

<table>
<thead>
<tr>
<th>Operation</th>
<th>Name of the implement/machine</th>
<th>Size</th>
<th>Power required</th>
<th>Capacity (acre/day)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw Management</td>
<td>Stubble Shaver</td>
<td>1.35 m</td>
<td>Tractor (35 hp)</td>
<td>12-14</td>
<td>For cutting standing stubbles</td>
</tr>
<tr>
<td></td>
<td>Paddy straw cutter sum spreader</td>
<td>1.2 m</td>
<td>Tractor (35 hp)</td>
<td>9-10</td>
<td>It improves the efficiency (20%) of PAU Happy Seeder by chopping and spreading of straw after combine harvesting of paddy.</td>
</tr>
<tr>
<td></td>
<td>Straw baler</td>
<td>1.4 m</td>
<td>Tractor (50 hp)</td>
<td>8.0</td>
<td>It collects the straw and compress in the form of bales.</td>
</tr>
<tr>
<td></td>
<td>Paddy straw chopper cum spreader</td>
<td>2.0 m</td>
<td>Tractor (50 hp)</td>
<td>6.0-7.0</td>
<td>The paddy straw chopper cum spreader chop the straw into small pieces and spread it on the surface.</td>
</tr>
</tbody>
</table>
| | Combine harvester with SMS attachment | 4-5 m | Tractor mounted (50-60 hp) | 8-10 | 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. |
<p>| | | | Self-propelled (80-120 hp) | 15-20 | |
| | 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. |</p>
<table>
<thead>
<tr>
<th>Tillage</th>
<th>Implement Type</th>
<th>Size (cm)</th>
<th>Tractor HP</th>
<th>Capacity (hrs)</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mould board</td>
<td>Tractor 30 hp &amp; above</td>
<td>30 cm (2 bottom)</td>
<td></td>
<td>3.75-5.0</td>
<td>Field capacity will depend upon size of implement and soil conditions.</td>
</tr>
<tr>
<td>Sub-soiler</td>
<td>Tractor 45 hp &amp; above</td>
<td>single tine</td>
<td></td>
<td>6-8</td>
<td></td>
</tr>
<tr>
<td>Disc harrow</td>
<td>(a) Trailing type</td>
<td>1.35 m</td>
<td>Tractor 30 hp &amp; above</td>
<td>8-10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.85 m</td>
<td>Tractor above 40 hp</td>
<td>12-16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b) Mounted type</td>
<td>0.9 m</td>
<td>Tractor 20-30 hp</td>
<td>5-7</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.35 m</td>
<td>Tractor 30-35 hp</td>
<td>10-12</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.85 m</td>
<td>Tractor above 40 hp</td>
<td>12-16</td>
<td></td>
</tr>
<tr>
<td>Levelling</td>
<td>Leveller</td>
<td>2.3 m</td>
<td>Tractor 35 hp &amp; above</td>
<td>17.5</td>
<td>The field capacity will depend upon the soil type and the extent of undulation in the field.</td>
</tr>
<tr>
<td></td>
<td>Super leveller</td>
<td>3.0 m</td>
<td>-ditto-</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Laser land leveller</td>
<td>2.0 m</td>
<td>Tractor 50 hp and above</td>
<td>4-6</td>
<td></td>
</tr>
<tr>
<td>Puddling</td>
<td>Straight-</td>
<td>2.5 m</td>
<td>Tractor 35 hp and above</td>
<td>12.5</td>
<td>For puddling of fields before paddy transplanting</td>
</tr>
<tr>
<td></td>
<td>angular blade</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>puddler</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paddy-disc-harrow</td>
<td>1.8 m</td>
<td>Tractor 30 hp and above</td>
<td>10-12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cultivator with</td>
<td>2.7 m</td>
<td>Tractor above 35 hp</td>
<td>15-20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>pulverizing roller</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trans-planting</td>
<td>Paddy transplanter</td>
<td>1.2 m</td>
<td>Manually Operated</td>
<td>0.6-0.8</td>
<td>Machine uses only mat type nursery. Three persons are required for machine operation including nursery uprooting and transportation.</td>
</tr>
<tr>
<td></td>
<td>-ditto-</td>
<td>1.2 m (set the machine at spacing of 30x12 cm)</td>
<td>Engine operated machine (walk behind type)</td>
<td>2.5</td>
<td>Four persons are required for machine operation including nursery uprooting and transportation.</td>
</tr>
<tr>
<td>Sowing</td>
<td>Seed-cum-fertilizer</td>
<td>Four rows</td>
<td>Tractor 35 hp &amp; above</td>
<td>6.0</td>
<td>For Maize, groundnut, cotton, soybean, gram and peas.</td>
</tr>
<tr>
<td></td>
<td>planter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lucky seed drill</td>
<td>9-11 rows</td>
<td>Tractor 35 hp &amp; above</td>
<td>6.0-8.0</td>
<td>For simultaneous spray of herbicide and sowing</td>
</tr>
<tr>
<td></td>
<td>Seed-cum-fertilizer</td>
<td>9-11 rows</td>
<td>Tractor 35 hp &amp; above</td>
<td>9-11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>drill</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zero till drill</td>
<td>9 rows</td>
<td>Tractor 35 hp &amp; above</td>
<td>7-8</td>
<td>For sowing maize</td>
</tr>
<tr>
<td></td>
<td>Ridger</td>
<td>Two rows</td>
<td>Tractor 35 hp &amp; above</td>
<td>6-7</td>
<td>For making ridges</td>
</tr>
<tr>
<td></td>
<td>Ridger planter</td>
<td>-ditto-</td>
<td>-ditto-</td>
<td>5-6</td>
<td>For sowing cotton, maize on ridges.</td>
</tr>
<tr>
<td>Equipment Type</td>
<td>Details</td>
<td>Power Requirement</td>
<td>Speed</td>
<td>Notes</td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-------------------------------------------</td>
<td>-------------------</td>
<td>-------------</td>
<td>----------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Sugarcane planter</td>
<td>2 rows</td>
<td>Tractor 30-45 hp</td>
<td>4.0</td>
<td>Use sets of 20” length.</td>
<td></td>
</tr>
<tr>
<td>Sugarcane cutter planter</td>
<td>Two rows, (row spacing 60-90cm adjustable)</td>
<td>35 hp and above</td>
<td>2.5-3.0</td>
<td>The machine cuts sugarcane sets, applies fungicide insecticides automatically</td>
<td></td>
</tr>
<tr>
<td>Sugarcane trench digger</td>
<td>Paired two row spacing (30cm)</td>
<td>-ditto-</td>
<td>6-8</td>
<td>Machine makes trenches and a bed for paired row sugarcane planting</td>
<td></td>
</tr>
<tr>
<td>Inter-culture Speed</td>
<td>Wheel hand hoe</td>
<td>9-30 cm</td>
<td>0.75-1.25</td>
<td>For soyabean, Maize etc crops</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paddy weeder (cono weeder)</td>
<td>10-15 cm</td>
<td>0.3</td>
<td>For paddy crop only</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Self propelled power weeder</td>
<td>Single row</td>
<td>1.5-2.0</td>
<td>For wide row crops like sugarcane, maize, cotton etc.</td>
<td></td>
</tr>
<tr>
<td>Spraying and dusting Speed</td>
<td>Tractor operated rotary weeder</td>
<td>2/ 3 row</td>
<td>8-10</td>
<td>-do-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Knapsack sprayer</td>
<td>500 ml/min.</td>
<td>1.5-1.75</td>
<td>For spraying on different crops</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Foot sprayer</td>
<td>1200 ml/min.</td>
<td>2.5</td>
<td>-do-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shoulder mounted power-sprayer-cum-duster</td>
<td>8 l/min.</td>
<td>4.5</td>
<td>For maize and cotton</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Self propelled boom sprayer</td>
<td>6.0 m</td>
<td>15-20</td>
<td>For spraying weedicides and insecticides</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tractor-mounted boom sprayer</td>
<td>12 m</td>
<td>30-40</td>
<td>Multipurpose</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Self-propelled high clearance sprayer</td>
<td>13.5 m</td>
<td>30-40</td>
<td>It can be used for even sprays without any damage to crop</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Backpack type air-assisted electrostatic</td>
<td>0.67-0.90</td>
<td>3.0</td>
<td>For efficient control of sucking pests, bollworms and tobacco caterpillar of cotton crop by increasing the deposition of spray on the top side and underside of leaves.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Auto Rotate gun type sprayer</td>
<td>15.0 - 20.0</td>
<td>24-30</td>
<td>For effective spraying on crops especially for the control of whitefly at the initial stage of cotton crop.</td>
<td></td>
</tr>
<tr>
<td>PAU multi-purpose high clearance sprayer</td>
<td>10.0 (without gun)</td>
<td>High clearance tractor ≥ 35 hp</td>
<td>20</td>
<td>For better protection of whitefly pest in cotton crop by increasing deposition of spray especially at top, middle and bottom of the canopy.</td>
<td></td>
</tr>
<tr>
<td>20.0 (with gun)</td>
<td></td>
<td></td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 WD- Paddy transplanter with boom sprayer mounting</td>
<td>7.0 m</td>
<td>17 hp engine</td>
<td>18-26</td>
<td>More annual use of paddy transplanter and judicious spraying in row crops such as wheat and paddy etc.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harvesting</td>
<td>Groundnut-digger shaker</td>
<td>1.22 m</td>
<td>35 hp Tractor-operated</td>
<td>6-8</td>
<td>For digging, shaking and winnowing of groundnut.</td>
</tr>
<tr>
<td>Vertical conveyor reaper</td>
<td>1.9 m</td>
<td>35 hp Tractor-operated</td>
<td>5-8</td>
<td>For harvesting paddy 7 or 8 persons required for machine operation including the crop collection and transportation.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Threshing, Grading etc.</td>
<td>Japanese type pedal Thresher</td>
<td>---</td>
<td>Manually operated</td>
<td>2.5-3.0 q/day</td>
<td>For small farmers and hilly regions.</td>
</tr>
<tr>
<td>Power-operated thresher</td>
<td>---</td>
<td>20-30 hp (bajra)</td>
<td></td>
<td>In bajra, the threshing of heads is done only.</td>
<td></td>
</tr>
<tr>
<td>Paddy-huller</td>
<td>---</td>
<td>2 men</td>
<td>2.0 q/day</td>
<td>For hulling rice.</td>
<td></td>
</tr>
<tr>
<td>Groundnut thresher</td>
<td>---</td>
<td>25 hp Tractor</td>
<td>2.0 q/h</td>
<td>For threshing groundnut crop.</td>
<td></td>
</tr>
<tr>
<td>Groundnut-decoricator</td>
<td>---</td>
<td>Manually operated</td>
<td>2.0 q/day</td>
<td>For shelling groundnut pods.</td>
<td></td>
</tr>
</tbody>
</table>
| Groundnut-decoricator | --- | 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 equivalent diesel engine/tractor | 15-20 q/h | Maize along with husk can be threshed |
| 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.

<table>
<thead>
<tr>
<th>Combine</th>
<th>Tractor mounted Combine</th>
<th>Tractor (55-60 hp)</th>
<th>8-10</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-propelled Combine</td>
<td>4.0 m</td>
<td>80-120 hp</td>
<td>15-20</td>
<td>-</td>
</tr>
<tr>
<td>Self-propelled Combine (with Maize header)</td>
<td>3.6 m</td>
<td>-do-</td>
<td>5.0-8.0</td>
<td>1. Adjustment needed 2. Six persons are required for machine operation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Removal of sticks</th>
<th>Cotton stalk uprooter</th>
<th>45 hp &amp; above</th>
<th>10-12</th>
<th>For uprooting of cotton sticks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-surface drip laying machine</td>
<td>Two row (135 cm)</td>
<td>-do-</td>
<td>1.6-2.24</td>
<td>For laying drip pipes under surface at 15-30 cm depth</td>
</tr>
</tbody>
</table>

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 initial 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 compared 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, adaptability 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 centrifugal 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 reflex 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, accumulation 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 jute 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 360° 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 h/acre if the mean cut and fill is within 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 q/h of turmeric rhizomes. The same machine can be used to polish 1 q/h 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.
Appendix - V
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
   

   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 - VI
Fertilizer Sources for the supply of Plant Nutrients

(A) Nutrient contents of different fertilizers (Percent)

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>N</th>
<th>P_2O_5</th>
<th>K_2O</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium Sulphate</td>
<td>20.5</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Ammonium Chloride</td>
<td>25.0</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Calcium Ammonium Nitrate</td>
<td>25.0</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Urea</td>
<td>46.0</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Superphosphate (single)</td>
<td>..</td>
<td>16.0</td>
<td>..</td>
<td>12 (S)</td>
</tr>
<tr>
<td>Diammonium Phosphate</td>
<td>18.0</td>
<td>46.0</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Urea-ammonium Phosphate</td>
<td>28.0</td>
<td>28.0</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Nitrophosphate</td>
<td>20.0</td>
<td>20.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulphated phosphate</td>
<td>13</td>
<td>33</td>
<td>..</td>
<td>15 (S)</td>
</tr>
<tr>
<td>Sulphate of Potash</td>
<td>..</td>
<td>..</td>
<td>48.0</td>
<td></td>
</tr>
<tr>
<td>Muriate of Potash</td>
<td>..</td>
<td>..</td>
<td>60.0</td>
<td></td>
</tr>
<tr>
<td>Potassium Nitrate</td>
<td>13</td>
<td>..</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Manganese Sulphate</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>30 (Mn)</td>
</tr>
<tr>
<td>Zinc Sulphate (Heptahydrate)</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>21 (Zn)</td>
</tr>
<tr>
<td>Zinc Sulphate (Monohydrate)</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>33 (Zn)</td>
</tr>
<tr>
<td>Ferrous Sulphate</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>19 (Fe)</td>
</tr>
<tr>
<td>Copper Sulphate</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>24 (Cu)</td>
</tr>
<tr>
<td>Gypsum</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>16 (S)</td>
</tr>
<tr>
<td>FYM/Vermicompost</td>
<td>0.5-1.5</td>
<td>1.2-1.8</td>
<td>1.2-2.0</td>
<td>Sufficient</td>
</tr>
</tbody>
</table>
(B) Quantity of the fertilizer to give 1 kg of nutrient

<table>
<thead>
<tr>
<th></th>
<th>For 1 kg of N</th>
<th>For 1 kg of P₂O₅</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium ammonium nitrate</td>
<td>4 kg</td>
<td>Superphosphate</td>
</tr>
<tr>
<td>Ammonium chloride</td>
<td>4 kg</td>
<td>Diammonium phosphate</td>
</tr>
<tr>
<td>Ammonium sulphate</td>
<td>5 kg</td>
<td>Urea-ammonium-phosphate</td>
</tr>
<tr>
<td>Urea</td>
<td>2.2 kg</td>
<td>Nitrophosphate</td>
</tr>
</tbody>
</table>

For 1 kg of K₂O

<table>
<thead>
<tr>
<th></th>
<th>1.7 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muriate of Potash</td>
<td></td>
</tr>
</tbody>
</table>

**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 (P₂O₅) 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.
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 tourniquet (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 anaphylactic 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. Rescuer 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:

<table>
<thead>
<tr>
<th>Type of injury</th>
<th>Rate of monetary aid (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of life</td>
<td>2,00,000/-</td>
</tr>
<tr>
<td>Loss of two limbs i.e. hands, arms, legs, feet etc.</td>
<td>60,000/-</td>
</tr>
<tr>
<td>Loss of one limb i.e. hand, arm, leg, foot etc.</td>
<td>40,000/-</td>
</tr>
<tr>
<td>Loss of four fingers i.e. equivalent to amputation of one body part.</td>
<td>40,000/-</td>
</tr>
<tr>
<td>Loss of finger/finger parts equivalent to amputation of complete finger</td>
<td>10,000/-</td>
</tr>
<tr>
<td>Physical disability (more than 25%)</td>
<td>50,000/- to 1,00,000/-</td>
</tr>
</tbody>
</table>

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.
## Antidotes for Pesticides for Human Beings

### Signs and Symptoms of Toxicity

<table>
<thead>
<tr>
<th>Mode of Exposure</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhalation</td>
<td>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.</td>
</tr>
<tr>
<td>Oral intake</td>
<td>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.</td>
</tr>
</tbody>
</table>

### I. Insecticides

#### Organochlorines
- **Lindane etc.**
  - No specific antidote. For convulsions: Diazepam 10 mg intravenous (I/V). Could be repeated up to 30-40 mg. Phenobarbitone 100-300 mg in drip.

#### Organophosphates
- **Monocrotophos, chlorpyriphos, methyl parathion, acephate, triazophos, malathion, quinophos, 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 up to 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 minutes. If required it may be repeated every hour till the muscle weakness and fasciculation 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 up to 24-48 hours. Avoid 2 PAM.
  - Warning: Do not use oxime or morphine.

#### Pyrethroids
- **Cypmethrin, fenvalerate, deltamethrin etc.**
  - Only symptomatic treatment, antihistamine are of value, if large amounts are ingested to cause nervous infestation, pentobarbitone (0.7g/day)/diazepam 5-10 mg for convulsions be used. For diarrhoea 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 normal 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 symptomatically.

#### 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 up to 24-48 hours.
<table>
<thead>
<tr>
<th>Compound</th>
<th>Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streptocycline</td>
<td>Injection of adrenalin, antihistamine and cortisone in case of acute anaphylactic shock, high or low blood pressure, profuse respiration and urticaria.</td>
</tr>
<tr>
<td>Copper oxychloride Copper sulphate</td>
<td>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 hry before meals for 5 days.</td>
</tr>
<tr>
<td>Edifenphos (Hinosan)</td>
<td>Atropine: 2-4 mg I/V as a test dose. If no effect double dose may be given every 10 minutes till atropinization.</td>
</tr>
<tr>
<td>Iprobenphos (Kitazin)</td>
<td>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 fasciculation persists. To be continued every 6-8 hours for 1-2 days or 5% solution as infusion @ 1/2 g/hr.</td>
</tr>
<tr>
<td>Methoxy ethyl mercuric chloride</td>
<td>Activated charcoal, egg white or 5% sodium bicarbonate solution (gastric lavage). High colonic irritation: 5% sodium formaldehyde sulfonate (fresh 100 - 200 ml) intravenous. For faster 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.</td>
</tr>
<tr>
<td>Mancozeb, Thiram, Zineb</td>
<td>Ascorbic acid (vitamin C) intravenous @ 0.2 g/min.</td>
</tr>
<tr>
<td>Ridomil MZ (8% metalaxyl + 64% mancozeb)</td>
<td>No specific antidote for metalaxyl. Antidote for mancozeb as given above mancozeb metalaxyl+64% may be recommended as this combination contains 64% mancozeb.</td>
</tr>
<tr>
<td>Triadimifon (beylton), Dinocap (karathane)</td>
<td>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.</td>
</tr>
<tr>
<td>Carboxin (Vitavax)</td>
<td>Treat symptomatically</td>
</tr>
<tr>
<td>Captan (Captaf)</td>
<td>If ingested, induce vomiting by administering a spoon-ful of salt in hot water.</td>
</tr>
<tr>
<td>Chlorothalonil (Kavach)</td>
<td>Treat symptomatically</td>
</tr>
<tr>
<td>Propiconazole (Tilt)</td>
<td>Treat symptomatically</td>
</tr>
<tr>
<td>Wettable sulphur (Sulfaf)</td>
<td>If chemical has gotten into the victim’s eyes, flush eyes with plenty of water for atleast 5 minutes</td>
</tr>
</tbody>
</table>

### III. Herbicides

<table>
<thead>
<tr>
<th>Compound</th>
<th>Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anilophos (Arozin, Libra, Anilguard)</td>
<td>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 fasciculation 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.</td>
</tr>
<tr>
<td>2,4-D</td>
<td>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.</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>Ingestion: immediately dilute by swallowing milk (Roundup) or water.</td>
</tr>
<tr>
<td>Isoproturon (Arelon, Delron Milton etc.)</td>
<td>Flush eyes with soap. Wash skin with soap and water.</td>
</tr>
<tr>
<td>Paraquat (Grammoxone)</td>
<td>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.</td>
</tr>
</tbody>
</table>
IV. Rodenticides

<table>
<thead>
<tr>
<th>Rodenticide (Trade Names)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc phosphide (Ratol, Zinc-Tox etc.)</td>
<td>As under aluminium phosphide</td>
</tr>
<tr>
<td>Coumatetralyl (Racumin)</td>
<td>Vitamin ‘K’ under medical supervision</td>
</tr>
<tr>
<td>Bromadiolone</td>
<td>Vitamin ‘K’ under medical supervision</td>
</tr>
</tbody>
</table>

Some common trade names of antidotes

- Diazepam: Calmose, 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.
## Appendix - IX

### Important Telephone Numbers of Punjab Agricultural University, Ludhiana

*(Dial Exchange 0161-2401960 to 2401979 for Extension No.)*

<table>
<thead>
<tr>
<th>Name/Designation</th>
<th>Telephone Number</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Office</strong></td>
<td><strong>Mobile</strong></td>
</tr>
<tr>
<td>Dr. Jaskarn Singh Mahal, Director Extension Education</td>
<td>0161-2401644</td>
</tr>
<tr>
<td>Dr. Gurmeet Singh Buttar, Additional Director</td>
<td>0161-2401074</td>
</tr>
<tr>
<td>Dr. G P S Sodhi, Additional Director Extension</td>
<td>0161-2400429</td>
</tr>
<tr>
<td>Dr. T S Riar, Additional Director Communication</td>
<td>0161-2405731</td>
</tr>
<tr>
<td>Dr. Vishal Bector, Associate Director (Industrial</td>
<td>---</td>
</tr>
<tr>
<td>Linkages)</td>
<td></td>
</tr>
</tbody>
</table>

### Help Line Numbers for the Farmers

<table>
<thead>
<tr>
<th>Kisan Call Centre</th>
<th>1800-180-1551 (Toll Free)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Surinder Kumar Thind, Plant Clinic</td>
<td>417 94630-48181</td>
</tr>
<tr>
<td>Dr. Khushwinder Singh Brar, Plant Breeding &amp; Genetics</td>
<td>435 94175-77458</td>
</tr>
<tr>
<td>Dr. Amarjit Singh, Plant Pathology</td>
<td>505 94637-47280</td>
</tr>
<tr>
<td>Dr. Y S Pandha, Entomology</td>
<td>504 83602-19847</td>
</tr>
<tr>
<td>Dr. S.S. Manhas, Agronomy</td>
<td>401 81463-78885</td>
</tr>
<tr>
<td>Dr. R K Gupta, Soil Science</td>
<td>506 81462-00940</td>
</tr>
<tr>
<td>Dr. Kulbir Singh, Vegetable Science</td>
<td>452 81463-44445</td>
</tr>
<tr>
<td>Dr. Jaswinder Singh Brar, Fruit Science</td>
<td>303 99158-33793</td>
</tr>
<tr>
<td>Dr. Mahesh Kumar Narang, FM&amp;PE</td>
<td>446 94173-83464</td>
</tr>
<tr>
<td>Dr. Arshdeep Singh, Food Science and Technology</td>
<td>305 98762-35555</td>
</tr>
<tr>
<td>Dr. R. Sharda, Soil &amp; Water Engineering</td>
<td>284 98555-45189</td>
</tr>
<tr>
<td>Dr. Raj Kumar, Economics &amp; Sociology</td>
<td>461 81460-96600</td>
</tr>
<tr>
<td>Dr. Tarsem Chand, Processing &amp; Food Engineering</td>
<td>384 97790-00640</td>
</tr>
<tr>
<td>Dr. Ranjit Singh, Landscaping &amp; Floriculture</td>
<td>440 94631-40872</td>
</tr>
<tr>
<td>Dr. Dharmander Singh, Extension Education</td>
<td>321 98726-12124</td>
</tr>
<tr>
<td>Dr. (Mrs.) Neena Singla, Rodent Management</td>
<td>382 93573-25446</td>
</tr>
<tr>
<td>Dr. (Mrs.) Tejdeep Kaur Kaler, Bird</td>
<td>382 99559-65904</td>
</tr>
<tr>
<td>Management</td>
<td>Seed Shop 419 ---</td>
</tr>
<tr>
<td></td>
<td>Biocontrol Lab, Ludhiana 320 ---</td>
</tr>
<tr>
<td></td>
<td>Biocontrol Lab, Abohar 01634-225326 ---</td>
</tr>
<tr>
<td>Biocontrol Lab, Gurdaspur</td>
<td>01874-220825</td>
</tr>
<tr>
<td>--------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Biocontrol Lab, Bathinda</td>
<td>0164-212159</td>
</tr>
</tbody>
</table>

**Phone Number of Heads of Various Departments**

<table>
<thead>
<tr>
<th>Department</th>
<th>Phone Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Breeding &amp; Genetics</td>
<td>224</td>
</tr>
<tr>
<td>Wheat Section</td>
<td>250</td>
</tr>
<tr>
<td>Cotton Section</td>
<td>334</td>
</tr>
<tr>
<td>Maize Section</td>
<td>437</td>
</tr>
<tr>
<td>Oilseed Section</td>
<td>433</td>
</tr>
<tr>
<td>Pulses Section</td>
<td>413</td>
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<tr>
<td>Fodder Section</td>
<td>443</td>
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<tr>
<td>Entomology</td>
<td>320</td>
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<tr>
<td>Plant Pathology</td>
<td>319</td>
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<tr>
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</tr>
<tr>
<td>Soil Science</td>
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<tr>
<td>Vegetable Science</td>
<td>370</td>
</tr>
<tr>
<td>Fruit Science</td>
<td>303</td>
</tr>
<tr>
<td>Landscaping &amp; Floriculture</td>
<td>440</td>
</tr>
<tr>
<td>Extension Education</td>
<td>321</td>
</tr>
<tr>
<td>Farm Machinery &amp; Power Engineering</td>
<td>257</td>
</tr>
<tr>
<td>Economics &amp; Sociology</td>
<td>301/461</td>
</tr>
<tr>
<td>Microbiology</td>
<td>330</td>
</tr>
<tr>
<td>Rats &amp; Birds Control</td>
<td>429</td>
</tr>
</tbody>
</table>

**Associate/Deputy Directors of *Krishi Vigyan Kendras***

<table>
<thead>
<tr>
<th>Name</th>
<th>Contact Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Parvinder Singh Dhillon, Amritsar</td>
<td>---</td>
</tr>
<tr>
<td>Dr. A P S Dhaliwal, Bathinda</td>
<td>0164-2215619</td>
</tr>
<tr>
<td>Dr. Kuldeep Singh, Faridkot</td>
<td>01639-253142</td>
</tr>
<tr>
<td>Dr. Vipin Kumar Rampal, Fatehgarh Sahib</td>
<td>01763-221217</td>
</tr>
<tr>
<td>Dr. Gurjant Singh Aulakh, Ferozepur</td>
<td>01632-279517</td>
</tr>
<tr>
<td>Dr. S.S. Aulakh, Gurdaspur</td>
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</tr>
<tr>
<td>Dr. Maninder Singh Bons, Hoshiarpur</td>
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</tr>
<tr>
<td>Dr. Kuldeep Singh, Jalandhar</td>
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</tr>
<tr>
<td>Dr. Narinderdeep Singh, Ludhiana</td>
<td>01628-261597</td>
</tr>
<tr>
<td>Dr. Paramjit Singh, Kapurthala</td>
<td>01822-233056</td>
</tr>
<tr>
<td>Name</td>
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<tr>
<td>Dr. G.P.S. Sodhi</td>
<td>Mansa</td>
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<tr>
<td>Dr. Amandeep Singh Brar</td>
<td>Moga</td>
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<tr>
<td>Dr. N.S. Dhaliwal</td>
<td>Sri Muktsar Sahib</td>
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<tr>
<td>Dr. Bikramjit Singh</td>
<td>Pathankot</td>
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<tr>
<td>Dr. Jasvinder Singh</td>
<td>Patiala</td>
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<tr>
<td>Dr. Gurpreet Singh Makkar</td>
<td>Ropar</td>
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<tr>
<td>Dr. Gurpreet Singh Makkar</td>
<td>SBS Nagar</td>
</tr>
<tr>
<td>Dr. Mandeep Singh</td>
<td>Sangrur</td>
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</table>

**Senior Most Extension Specialists of Farm Advisory Services**

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Phone 1</th>
<th>Phone 2</th>
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<tbody>
<tr>
<td>Dr. Ajay Kumar Chaudhary</td>
<td>Abohar</td>
<td>01634-225326</td>
<td>94639-74499</td>
</tr>
<tr>
<td>Dr. Narinderpal Singh</td>
<td>Amritsar</td>
<td></td>
<td>84270-07023</td>
</tr>
<tr>
<td>Dr. Navdeep Singh Gill</td>
<td>Barnala</td>
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<td>81461-00796</td>
</tr>
<tr>
<td>Dr. Amarjit Singh Sandhu</td>
<td>Bathinda</td>
<td>0164-2212684</td>
<td>94633-71120</td>
</tr>
<tr>
<td>Dr. Navtej Singh</td>
<td>Chandigarh/Mohali</td>
<td>0172-2775348</td>
<td>98722-18677</td>
</tr>
<tr>
<td>Dr. Harinder Singh</td>
<td>Faridkot</td>
<td>01639-250143</td>
<td>97800-90300</td>
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<tr>
<td>Dr. Jagjot Singh Gill</td>
<td>Ferozepur</td>
<td>01632-242136</td>
<td>82839-32427</td>
</tr>
<tr>
<td>Dr. Sumesh Chopra</td>
<td>Gurdaspur</td>
<td>01874-220828</td>
<td>98148-30820</td>
</tr>
<tr>
<td>Dr. Gurpartap Singh</td>
<td>Hoshiarpur</td>
<td>01882-222392</td>
<td>950-1434300</td>
</tr>
<tr>
<td>Dr. Maninder Singh</td>
<td>Jalandhar</td>
<td>0181-2225768</td>
<td>81460-88488</td>
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<tr>
<td>Dr. Pardeep Kumar</td>
<td>Kapurthala</td>
<td>01822-232543</td>
<td>95010-23334</td>
</tr>
<tr>
<td>Dr. (Mrs) Gurpreet Kaur</td>
<td>Patiala</td>
<td>0175-2200646</td>
<td>94633-69063</td>
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<td>Dr. Raminder Singh Ghuman</td>
<td>Ropar</td>
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<td>Dr. Buta Singh Romana</td>
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<td>01672-234298</td>
<td>94172-81311</td>
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<tr>
<td>Dr. Parminder Kaur</td>
<td>Tarntaran</td>
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<td>94637-74731</td>
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**Directorate Research**

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Phone 1</th>
<th>Phone 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Navtej Singh Bains</td>
<td>Director Research</td>
<td>0161-2401221</td>
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</tr>
<tr>
<td>Dr. Gursahib Singh Manes</td>
<td>Addl. Director Research (FM&amp;BE)</td>
<td>216 (Ext. No.)</td>
<td>98728-76077</td>
</tr>
<tr>
<td>Dr. K.S. Thind</td>
<td>Addl. Director Research (Crop Improvement)</td>
<td></td>
<td>98729-19729</td>
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<tr>
<td>Dr. P.P.S. Pannu</td>
<td>Addl. Director Research (NR&amp;PHM)</td>
<td>263</td>
<td>98727-33111</td>
</tr>
<tr>
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<td></td>
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<tr>
<td>Dr. Ajmer Singh Dhatt</td>
<td>---</td>
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<tr>
<td>Addl. Director Research</td>
<td>99151-35797</td>
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<tr>
<td>(Horticulture &amp; Food Sc.)</td>
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<tr>
<td>Dr. Rajinder Singh</td>
<td>438</td>
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<tr>
<td>Associate Director (Seed)</td>
<td>94649-92257</td>
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<td>Dr. Balkaran Singh Gill</td>
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<tr>
<td>Deputy Director (Farm)</td>
<td>81469-00244</td>
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### Regional Research Station/Seed Farm

<table>
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<th>Location</th>
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<tr>
<td>Abohar</td>
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<td>Bathinda</td>
<td>0164-212159, 0164-215619</td>
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<tr>
<td>Bahadurgarh (Patiala)</td>
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<td>Faridkot</td>
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<td>Gurdaspur</td>
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<td>Gangian (Hoshiarpur)</td>
<td>01883-85075</td>
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<tr>
<td>Ladhowal (Ludhiana)</td>
<td>0161-2801566</td>
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<tr>
<td>Kheri (Sangrur)</td>
<td>01673-285020</td>
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<td>Kapurthala</td>
<td>01822-255094, 01822-255095</td>
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<td>Amloh (Naraingarh)</td>
<td>01765-230126</td>
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<tr>
<td>Ballowal Saunkhri (SBS Nagar)</td>
<td>01885-241601, 241607</td>
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<tr>
<td>Jallowal (Lesriwal) Jalandhar</td>
<td>98141-37547</td>
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<tr>
<td>Usman (Tarntaran)</td>
<td>98146-93189</td>
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<tr>
<td>Dyal Bharang (Amritsar)</td>
<td>98555-56672</td>
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</table>
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 Stem borer
Plate 4: Attack of Leaf folder
Plate 5: Sheath blight
Plate 6: False smut
## IMPORTANT NATURAL RESOURCE CONSERVATION TECHNOLOGIES

<table>
<thead>
<tr>
<th>Crop</th>
<th>Technology (Year)</th>
<th>Other Important Crops</th>
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<tr>
<td><strong>A. Water Conservation</strong></td>
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<tr>
<td>Rice</td>
<td>Discontinuation of ponding of water (1981)</td>
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<tr>
<td><strong>All Crops</strong></td>
<td>Laser Leveller (2005)</td>
<td>-</td>
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<tr>
<td>Rice</td>
<td>Tensiometer (2005)</td>
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<tr>
<td>Rice</td>
<td>Direct Seeding  &lt;li&gt; Normal watter (2010) &lt;li&gt; Tar watter (2020)</td>
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</table>

| **B. Soil Heath Management and Fertiliser Application** | | |
| All crops | Soil test based fertilizer (1962) | - |
| **All crops** | Kallar reclamation (1969) | - |
| Rice | Green Manuring (1983) | - |
| **Wheat** | Happy seeder (2006) | |
पेड़ी दी हदीहाम
माटवाली कहीं मांड़े हाल हुई क्यों?

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हूं अपने रूपमें श्रेय गाउँग रिच मानिश वर्ल्ड।

PAU Kisan App

http://www.pau.edu/fportalnew/

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पैंका तेलीमरी पूरीत पूरी तुलिपाल वृृं भुमिभाड़ रहे

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