

RESEARCH ACHIEVEMENTS PF PUNJAB AGRICULTURAL UNIVERSITY (July 2019-June 2020)

Improved varieties and enabling technologies related to production-protection, farm machinery, post-harvesting and processing along with interventions related to subsidiary occupations constituted the major research output.

Crop Improvement

Varietal development focused not only on productivity and resistance but also on traits related to longer storage life, premium market segment, nutraceuticals and milling quality. Diversification crops had more than 75 per cent share in the varietal output. During the report period, PAU developed/released 14 varieties of different crops (3 of vegetable crops and 11 of other crops including 4 of oilseeds, 3 of rice, 2 of barley, and one each of maize, mash, groundnut, wheat, bajra and fodder maize). In addition to these state releases, nine varieties (two each of *Bt* cotton and oat, and one each of chickpea, wheat, barley, Napier Bajra, and ryegrass) were identified at national level, out of which three have been notified by the Central Variety Release Committee.

Crop	Variety
Onion	POH 1
Brinjal	Punjab Bharpoor
Sponge gourd	Punjab Nikhar
Maize	JC 12 and J 1007 (Fodder maize)
Mash	Mash 1137
Chickpea	GL 13001**
Groundnut	J 87
Pearl millet	PCB 165 and PBN 351*
Oat	OL 1861** and OL 1869-1**
Ryegrass	PBRG 2**
Wheat	PBW 752 and PBW 771*
Cotton	PAU <i>Bt</i> 2** and PAU <i>Bt</i> 3**,
Barley	PL 891* and DWRB 123
Rice	PR 128, PR 129 and HKR 47

* Notified at national level by Central Variety Release Committee

** Identified at national level

GERMPLASM ACQUISITION AND UTILIZATION

In order to expand genetic resource base and tap desirable traits, 7,418 accessions of various vegetable crops (pea, sweet potato, muskmelon, brinjal, cucumber, chilli, Chinese cabbage, tomato, potato, onion, amaranth, bittergourd, cauliflower, fenugreek, turmeric, pumpkin, garlic, spinach, coriander, okra, cowpea and fennel), fruits (citrus, *ber*, mulberry and guava), flower crops (chrysanthemum, gladiolus, narcissus and Phalaenopsis), oilseeds (sesame, sunflower and soybean), pulses (urbean, chickpea, Fababean and pigeonpea), forages (sorghum and oat), millets (pearl millet, finger millet and Little millet) and other cereal crops (maize, wheat and rice) were sourced and evaluated for potential traits.

BIOTECHNOLOGY

Crop	Research activities
Pigeonpea	<ul style="list-style-type: none"> • Transgenic pigeonpea with <i>cry1Ab</i> gene for resistance against <i>Maruca vitrata</i> was developed.
Wheat	<ul style="list-style-type: none"> • PBW 771 variety (notified at national level) was developed by introgressing <i>Lr57-Yr40</i> gene in DBW 17 background by marker assisted selection (MAS). • High grain weight gene was pyramided with two stripe rust and one leaf rust resistance genes (<i>Lr57-Yr40+Yr15</i>) in PBW 550 background.
Rice	<ul style="list-style-type: none"> • Development of new varieties PR 128 and PR 129, white grained versions of PAU 201, was facilitated by MAS for bacterial blight resistance and grain pigmentation. • Introgression lines of <i>Oryza nivara</i> and <i>O.rufipogon</i> with brown plant hopper resistance were developed in cultivated rice background.

SEED AND NURSERY PRODUCTION

- During 2019-20, PAU produced 424q of vegetable crops, 63,279q seed of other field crops besides providing 5,403q propagation material of turmeric and potato.
- About 6 lakh fruit nursery seedlings (worth Rs 1.37 crore) were made available to the farmers.
- In case of agroforestry, 93,539 seedlings were provided to the farmers and one lakh poplar cuttings were supplied to the Department of Forests and Wildlife Preservation, Punjab.

CROP PRODUCTION TECHNOLOGIES

Horticultural crops

Microirrigation

- Drip irrigation and fertigation schedules were recommended for guava and bittergourd.
- Mixed use (with fresh water) of poor quality irrigation water was recommended in coarse-textured soils of canal command areas through drip irrigation in potato planted in paired rows on raised beds.

Paddy residue mulching

- Paddy residue mulching (@ 5.5 tons/acre) was recommended in pear, peach and plum for better yields.

Intercropping

- Short duration groundnut TG37A can be grown as an intercrop in *ber* orchards after pruning in May for additional income.

Floriculture

- Prolonged (4 year-long) natural development process of gladiolus cormels into flowering grade corms can be shortened (to 2 years) by treating cormels with GA₃ (gibberellic acid) @ 200 ppm.

Field crops

Cultivation methods

- New DSR (direct seeded rice) technique – *Tar wattar* DSR – was proposed.
- AL 882, a short duration and early maturing variety of *arhar*, can be densely planted from June 15 -25 for higher yields.

Intercrops, relay crops and new cropping sequences

- Two rows of okra can be intercropped in spring sugarcane planted at 90 cmX30 cm or 120 cm X 30 cm.
- A new diversification oriented cropping system, groundnut-pea-sunflower, was recommended.
- Under certain soil situations (such as waterlogging/sodicity) which prohibit timely harvesting of *parmal/basmati* rice and use of farm machinery, wheat can be relay cropped by broadcasting wheat seed in standing rice crop just before or immediately after last irrigation to rice during October 10-25.
- Celery can be intercropped in short duration varieties of pea for higher returns. Alternatively, pea can be planted in fields under celery during the previous year; naturally germinated seedlings of celery crop can be retained.

Nutrient management

- Urea @ 45 kg/acre in timely sown wheat and @ 35 kg/acre in late sown wheat should be applied each with first and second irrigation for better nitrogen use efficiency.
- Use of Leaf Colour Chart (LCC) was extended to *basmati* rice. Critical green shade levels vary from 3.5 to 4, depending on the variety.

Biofertilizers

- Liquid microbial inoculant comprising *Burkholderia seminalis* and *Bradyrhizobium* species was recommended for better yield and quality of forage pea.
- The University prepared and provided biofertilizers for 16 crops, which were enough for inoculating more than 63 thousand acres.

Productivity enhancement through growth regulators

- To address low germination in sugarcane, seed cane setts can be soaked overnight in Etherel (2-chloroethyle phosphonic acid) solution @ 100 ppm.
- Foliar application of urea @ 2% in chickpea at flowering and pod formation stages was recommended.
- Foliar application of potassium nitrate @ 1.5% in case of paddy crop at boot stage was recommended for enhancing grain yield.

Abiotic stress management

- Irrigation induced salinity stress in cotton-wheat system can be managed by adding rice residue biochar (@ 4t/ha) in cotton.

Residue management

- Field trials for *in situ* paddy straw degradation, conducted at five locations with four different microbial preparations developed by PAU and four commercial products suggested that *Delftia* treatment showed higher decrease in total fibre content and C:N ratio at most of the locations.

CROP PROTECTION

Fruits

- To evade fruit fly infestation, mature green and hard guava fruits of rainy season before colour break stage can be covered with white non-woven bags during end of June to middle of July.
- The common brown snail, *Macrochlamys indica*, an important pest of citrus nursery in Punjab can be managed by following integrated measures involving application of metaldehyde (2.5% dust) based bait, cleaning up debris in/around nursery and by spreading papaya leaves or gunny bags to lure and eventually destroy snails.

Vegetable crops

- Use of aqueous neem fruit extract was recommended for eco-friendly management of mites in capsicum under protected cultivation.
- A minimum waiting period of one week, 20 days and 30 days was recommended to be observed in case the rapeseed-mustard crop meant for use as *saag*, is sprayed with thiomethoxam 25WG, dimethoate 30 EC/chlorpyrifos 20 EC and quinalphos 25EC, respectively.
- Purple blotch of onion can be managed by foliar application of Caviet 25WG (tebuconazole 25% w/w).
- Black scurf of potato can be managed by dipping tubers in Emesto Prime (penflufen 22.43% FS) for 10 minutes.
- Whitefly was accorded the status of pest on brinjal. Difenthiuron 50 WP @ 200g/acre can be sprayed to manage this pest.
- Average life of *Bemisia tabaci* (whitefly) was observed to be shorter during June-July as compared to April-May in brinjal.
- Mites infesting capsicum under protected cultivation can be managed by foliar spray of Omite (propargite) 57EC @ 200ml/acre or Oberon (spiromesifen) 22.9SC @ 100 ml/acre. The latter can also be used (@ 150 ml/acre) to control mites in okra.

Oilseeds and Pulses

- Commercial Bt formulation, Mahastra 0.5% WP @ 800g/acre was found effective in reducing pod damage due to *Helicoverpa armigera* in gram.
- Pod sucking bug, *Clavigralla gibbosa* Spinola, was identified as a pest of pigeonpea in Punjab. Foliar application of home-made neem extract (@ 1250 ml/acre in 100-125 litres of water) was recommended for managing this pest.

- White rust in rapeseed and mustard can be managed by foliar application of metalaxyl M4%+mancozeb 64% WP (Ridomil Gold) @ 250g/100 litres of water per acre.

Maize

- Biocontrol of maize stem borer using *Trichogramma chilonis*, carried out at farmers' fields, resulted in 53.2 per cent reduction in dead hearts incidence as compared to 82.9 per cent in chemical control.
- Fall armyworm can be managed by foliar application of chlorantraniliprole 18.5SC, emamectin benzoate 5WG or spinetoram 11.7SC in grain maize. In fodder maize, it can be managed by chlorantraniliprole 18.5SC.

Sugarcane

- Biocontrol of sugarcane borers using egg parasitoids, *Trichogramma* spp. reduced their incidence by 53.4-57.9 percent.
- Early shoot borer, *Chilo infuscatellus* Snellen, can be managed with Takumi 20WG (flubendiamide).
- Sugarcane termite, *Odontotermes obesus* Rhamb, can be managed with Coragen 18.5 SC (chlorantraniliprole).

Cotton

- Thrips can be managed with Celcron 50 EC (profenofos).
- Jassids can be managed with Keefun 15EC (tolfenpyrad).
- Daita 10 EC (pyriproxyfen) and Sefina 50 DC (afidopyropen) were recommended for managing whitefly.
- Amistar 325SC (azoxystrobin 18.2%+difenoconazole 11.45SC) was found effective in managing fungal leaf spot and sooty mould.

Wheat

- Foliar application of Opera 18.3SE (pyraclostrobin and epoxyconazole) or Caviet 25WG (tebuconazole 25% WG) was recommended to control yellow rust.
- Neonix (imidacloprid 18.5% and hexaconazole 1.5% FS) was recommended to manage termites and smuts. Seed treatment with Cruiser (thiomethoxam 70WS) was recommended to manage termites.

Rice

- Rice root nematode, *Meloidogyne graminicola*, in nursery beds can be managed in an eco-friendly way by applying mustard cake (@ 40g/m²) before sowing of nursery.
- Augmentative releases of *T. chilonis* and *T. japonicum* in organic basmati rice resulted in 55.2 percent and 49.9 percent reduction in stem borers and leaf folders, respectively.
- Sheath blight can be managed by two foliar applications of Pikapika 25 EC (propiconazole).
- Treating seed with Sprint 75WS (carbendazim 25%+mancozeb 50%) was found effective in controlling seedborne and early soilborne infections of sheath blight, brown spot and blast.

Weed control

- New pre-emergence herbicides AWKIRA 85WG (pyroxasulfone) and Platform 385 SE (pendimethalin 35%+metribuzin 3.5%) were recommended to manage *Phalaris minor*.
- Existing recommended dose of pre-emergence herbicide pendimethalin 30EC was revised upward to 1.5 litres/acre to manage likely risk of resistance development against pendimethalin by *P. minor*.
- A selective post-emergence herbicide Hitweed Maxx 10MEC (pyrithiobac sodium 6%+quizalofop ethyl 4%) was recommended for broad spectrum weed control in cotton.

RESIDUE ANALYSIS

- Out of 592 vegetable samples collected from market (149) and farmgate (443), 2.22 per cent of market samples and 1.34 per cent of farmgate samples contained pesticides above maximum residue limit (MRL).
- In case of 319 samples of *basmati* rice, six samples had pesticide residue above MRLs.

FOOD SCIENCE AND TECHNOLOGY

Non-cereal pudding mix	<ul style="list-style-type: none">• Potato tubers of table purpose variety Kufri Pukhraj were used for making ready-to-cook non-cereal puddings. Due to its non-cereal, gluten free composition, it can cater to special clientele e.g. celiac patients, non-cereal fast keepers, etc.
<i>Kinnow</i> fruit bar	<ul style="list-style-type: none">• <i>Kinnow</i> fruit bars, having shelf life of six months, were prepared from <i>Kinnow</i> juice. The bar was microbiologically safe during the entire shelf life period of six months. This value adding technology considerably improves shelf life of otherwise perishable <i>Kinnow</i> juice.
Onion products	<ul style="list-style-type: none">• Low cost technologies were developed for the production of diverse onion products (onion puree, paste and flakes) which can be available for consumption throughout the year.
Lactic acid starter culture	<ul style="list-style-type: none">• Consortium of ten lactic acid bacterial strains was developed as a starter culture for preparing metabiotic lacto-fermented beverages and pickles from powder and rhizomes of turmeric and <i>amla</i>.
New microbes	<ul style="list-style-type: none">• Two fungus strains <i>Aspergillus nomius</i> and <i>A. flavus</i> were isolated, respectively, from pineapple peel and citrus pulp for their potential use in Kojic acid production.• Four strains of <i>Pediococcus acidilactici</i> were isolated from infant faeces for

	potential application in lactic acid fermented beverage production.
Incubational facilities	<ul style="list-style-type: none"> • Food Industry Business Incubation Centre provided incubation facilities to six entrepreneurs.

FOOD AND NUTRITION

Novel health foods from traditional sources

- Wheatgrass powder prepared from 7-10 days old wheatgrass (shade-or freeze-dried) was found to be suitable for enrichment of frequently consumed foods.
- Six products, namely, jam, *chutney*, crush, syrup, leather and dried mulberry, prepared from three types of otherwise perishable mulberry fruits, exhibited moderate loss in antioxidant activity after four months.
- Eight products, namely, powder, *chutney*, *murabba*, two types of pickles, candy, jam and syrup were prepared from ripe and green *karonda* (*Carissa* spp.).
- Pumpkin seed flour (from raw or roasted seeds) can be used to supplement (upto 30%) various food products like *panjeeri*, *matthi* and cookies at commercial scale.

Community health

- The nutritional bars developed with the quality protein maize (QPM) and different ratios of other ingredients like cauliflower leaves, carrots, green chickpea and jaggery were highly acceptable in terms of sensory scores and could be safely stored for about four months.
- Supplementation of carom (*ajwain*) and fennel (*saunf*) seeds significantly improved lipid profile and antioxidant status of adult women.

POST-HARVEST TECHNOLOGY

Solar curing system for <i>Kharif</i> onion	<ul style="list-style-type: none"> • The developed and recommended solar curing system allows curing by maintaining room temperature at 30°C and relative humidity at 45±10% for nine days to ensure three-month storage.
Refrigeration system	<ul style="list-style-type: none"> • A prototype of mobile thermoelectric refrigeration system (100L capacity) was designed and developed for retail sale and storage of summer fruits and vegetables.
Tuberose tinting	<ul style="list-style-type: none"> • Tuberose spikes at tight-bud stage can be variably tinted by dipping basal portion (5-7 cm) in the dye solution comprising 1% food dye of desired colour, 2% sucrose solution and 300 mg/L citric acid for two hours.
Handholding for agro-processing	<ul style="list-style-type: none"> • Seven new agro processing complexes and 10 jaggery processing plants were established by farmers with technical guidance from University.

AGRO-FORESTRY

Eucalyptus clone and planting technology for waterlogged areas	<ul style="list-style-type: none"> • Clone PE 11 was found suitable for planting in salt-affected and waterlogged regions of the state. • In such areas, eucalyptus should be planted on polythene-covered ridges for better survival and growth.
Intercropping	<ul style="list-style-type: none"> • The onion variety PWO-35 recorded significantly higher bulb yield (19.8 t/ha) as compared to Punjab Naroya, PRO-6 and PRSC-10 under three-year old poplar plantation.
Nutrient management of nursery	<ul style="list-style-type: none"> • In case of <i>Casuarina junghuhniana</i> under nursery conditions, dual inoculation (phosphorus solubilizing bacteria (PSB) + <i>Frankia</i>) resulted in more plant height, collar diameter and root length as compared to uninoculated control and single inoculation of either PSB or <i>Frankia</i>.

BEEKEEPING

- During spring, 10-frame hives performed better than 7- and 8-frame hives in terms of brood rearing and bee population build-up.
- Studies on muskmelon (var. Punjab Sunheri) grown under polynet house revealed that fruit set did not take place in polyhouse without bees.

LAC CULTURE

- The life cycle and productivity-linked parameters of lac insects (*Rangeeni* strain) were studied on plants of *Flemingia semialata*, *Flemingia macrophylla* and *Zizyphus mauritiana*. The *Rangeeni* strain completed all the life stages on these hosts. The duration of Katki crop varied from 105-110 days under Punjab conditions.

MUSHROOM CULTIVATION

- The cultivation technology of king oyster mushroom, *Pleurotus eryngii*, on wheat straw under Punjab conditions was recommended.
- Wheat straw and paddy straw based composts were prepared following the short method. Maximum yield, 18.65 kg/q, of *Agaricus bisporus* was harvested from wheat straw compost in comparison to 13.72 kg/q from paddy straw compost.

FARM MACHINERY

Boom type sprayer on paddy transplanter	<ul style="list-style-type: none"> • A boom type sprayer attachment was developed and mounted on the rear of self-propelled four-wheel drive paddy transplanter, after removing its transplanting unit. The technology
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	improves economics of the machine by minimizing its disuse period.
Sugarcane trench planter	<ul style="list-style-type: none"> Existing two paired rows sugarcane trencher was modified to single paired row trench planter.
Tractor operated vertical cup type vegetable transplanter	<ul style="list-style-type: none"> Tractor operated vertical cup type vegetable transplanter developed for cell type nursery was recommended. It is a two-row semi-automatic tractor mounted vegetable transplanter used for transplanting cell type nursery of different vegetable crops.
Happy Seeder refinement	<ul style="list-style-type: none"> Three flail blade rows, having replaceable sharp edge section of 4 mm thickness mounted on the rotor of Happy Seeder at an angular spacing of 120⁰ with tines having serrated bit (4mm replaceable), improved field capacity and fuel consumption of Happy Seeder by 13.7 and 21.5 per cent, respectively, as compared to existing design.
Sanitizing tunnel	<ul style="list-style-type: none"> Two prototypes of sanitizing tunnel (9'x4'x7.5'), capable of running on electrical and solar energy, were designed and developed.
Quality control	<ul style="list-style-type: none"> The Farm Machinery Testing Centre tested 28 farm machines.

APPARELS AND TEXTILES

Protective gloves for okra pluckers	<ul style="list-style-type: none"> Protective full arm length gloves for plucking okra were prepared from the knitted fabric. Double layer of fabric was provided for palms and fingers.
Mosquito repellent fabric	<ul style="list-style-type: none"> The microencapsulated fabric developed using eucalyptus oil (10%) was found effective in repelling mosquitoes.
Waste management	<ul style="list-style-type: none"> The knitted fabrics were constructed from a blend of soybean and waste wool fiber. The weft knitted fabrics were found to be suitable for both apparel and upholstery applications like sweaters, cardigans, socks, T-shirts, cushion covers and table linens. Paddy straw was used for fibre extraction and blending with cotton to develop yarn for blinds, wall hanging and <i>durrie</i>.
Plant-based fabric finishes	<ul style="list-style-type: none"> Functional finishes were developed using plant extracts. Pomegranate, <i>Mousami</i> and

	<i>Ratanjot</i> can be effectively used for treating fabric against microbial activity.
Community service	<ul style="list-style-type: none"> • During lockdown period, stitching of face masks, face shields and gloves was initiated to fulfill the requirement of farm labour in University. A video on the development of protective masks was prepared to provide mask preparation skills.

RODENT, BIRD AND VERTEBRATE PEST MANAGEMENT

- Survey of rodent damage in wheat crop fields sown with different technologies like conventional tillage, rotavator or drill machine, Happy Seeder with standing stubbles, and Happy Seeder with paddy mulch in different villages of district Fatehgarh Sahib, Tarntaran, Gurdaspur and Hoshiarpur revealed that rodent damage in these fields is not technology specific but location specific.
- Use of reflective ribbon in tomato and mustard crops was found up to 95-97 per cent effective in bird control. Nylon nets installed in mustard crop during the germinating stage gave 100 per cent protection from bird damage.
- Damage by fruit bats was minimized by using eco-friendly method of artificial light using LED (30W) bulbs in *ber* orchard.

TECHNOLOGIES COMMERCIALIZED

During the report period, 13 Memoranda of Agreement (MoA) were signed to commercialize a range of varietal, farm machinery, processing and other technologies.