

RESEARCH ACHIEVEMENTS OF PUNJAB AGRICULTURAL UNIVERSITY (July 2018 – June 2019)

Research, teaching and extension activities in agriculture and related fields constitute mandate of Punjab Agricultural University. These activities helped State touch record productivity levels of major crops and address challenges of residue management, pesticide use, soil health and groundwater management.

RESEARCH

Main thrusts of research activities of PAU included varieties, production-protection technologies, farm machinery and processing. Varietal development focussed not only productivity traits but also other traits enabling natural resource conservation, limiting chemical use, and capturing premium and processing markets. During the report period, PAU developed/released 19 varieties (7 of field crops, 3 of fruit crops, 8 of vegetables and 1 of ornamental crops). Out of these, two varieties of wheat, PBW 752 and PBW 757 were released at National level. Besides, three varieties of vegetables (CH 27 of chilli, Matar Ageta 7 of pea, and Punjab Raunak of brinjal) released earlier at state level were identified at the national level. Lentil variety, LL 1373, was also identified at national level.

Crop	Variety
Wheat	PBW 752*, PBW 757*
<i>Basmati</i> rice	Pusa <i>Basmati</i> 1718
Maize	PMH 11, P 1844
Summer Mungbean	SML 1827
Lentil	LL 1373*
Napier Bajra	PBN 342
Guava	Punjab Apple Guava
Fig	Black Fig I
Tangerine	Daisy Tangerine on Rough Lemon Rootstock
Tomato	PTH 2
Capsicum	PSM 1
Onion	PRO 7, PWO 35, PYO 102

Carrot	PC 161
Bitter gourd	Punjab Karela 15
Pumpkin	Punjab Nawab
Chilli	CH 27*
Pea	Matar Ageta 7*
Brinjal	Punjab Raunak*
Gladiolus	Punjab Glad 3

* Released/Identified at National level

GERMPLASM ACQUISITION AND UTILIZATION

In order to strengthen genetic pool and harness useful traits, 4921 accessions of different cereal crops (wheat, rice, maize and pearl millet), cotton, pulses (pigeonpea, mungbean, and chickpea), oilseeds (soybean and sunflower), vegetable crops (okra, potato, brinjal, pea, chilli, muskmelon, snapmelon and wild melon), fruits (dragon fruit, papaya and guava), flowers (chrysanthemum, gladiolus, orchid and rose) and agroforestry materials, namely, willow, poplar, neem and eucalyptus were sourced from various national and international research institutes and diversity rich regions.

BIOTECHNOLOGY

Crop/Domain	Research activities
Field crops	<ul style="list-style-type: none"> • Wheat <ul style="list-style-type: none"> - MAS was used for transferring <i>Yr10</i> and <i>Yr15</i> genes, respectively, in PBW 752 and PBW 757 varieties. - Four populations derived from two synthetic hexaploid wheats and two cultivated wheat genotypes were evaluated for nitrogen use efficiency. - Mapping populations are being developed through speed breeding for mapping Karnal bunt resistance transferred from three wild species. - Aphid resistance is being transferred from two <i>Ae. tauschii</i> accessions to bread wheat background. • Rice <ul style="list-style-type: none"> - Advanced breeding lines carrying brown plant

	<p>hopper (BPH) resistance conferred by BPH 34 gene (previously transferred from <i>Oryza nivara</i>) were developed.</p> <ul style="list-style-type: none"> - To locate genomic regions responsible for nematode resistance, introgression profiling of interspecific lines derived from the cross of PR121 x <i>O. glaberrima</i> has been generated. • Maize <ul style="list-style-type: none"> - The genetic mapping for heat stress tolerance has suggested location of QTL on chromosome 3 and 5. • Chickpea <ul style="list-style-type: none"> - The Bt-<i>Cry1Ac</i> gene has been introgressed, through backcross breeding, into elite lines which were subsequently evaluated against <i>Helicoverpa armigera</i>.
Horticultural crops	<ul style="list-style-type: none"> • Genome editing approach is being used in Tomato variety Punjab Ratta for enhancing shelf life. • New molecular markers have been developed in guava by comparative transcriptomics. • High-throughput genome sequencing of guava cv. Allahabad Safeda has been carried out for creating chromosomal level genome assembly.

SEED AND NURSERY PRODUCTION

- During the year 2018-19, PAU produced 57,224q seed of various field crops and 612.1q of various vegetable crops in addition to 3064q propagation material of potato and turmeric.
- About 5.70 lakh nursery fruit plants and 63,500 agroforestry seedlings were produced and provided to farmers.

CROP PRODUCTION TECHNOLOGIES

Focus area	Technologies recommended
Micro irrigation	<ul style="list-style-type: none"> • Drip irrigation has been recommended in Summer <i>Moong</i>-maize-wheat, direct seeded rice – wheat, sugarcane, <i>Raya</i>, <i>Gobhi Sarson</i>, densely planted Kinnow, pumpkin and

	<p>marigold.</p> <ul style="list-style-type: none"> • Micro-irrigated soil-less rooftop/terrace vegetable nutrition garden model, and Microirrigated soil-less (cocopeat slabs) cultivation of seedless (parthenocarpic) cucumber under naturally ventilated polyhouse have been recommended.
Cropping systems integrating micro-irrigation and conservation agriculture	<ul style="list-style-type: none"> • A solar energy operated tubewell and drip irrigation system has been recommended in two sub-surface drip irrigation systems: direct seeded zero-till rice - wheat system and maize-wheat permanent bed system.
Direct seeded rice and legume based systems	<ul style="list-style-type: none"> • Direct seeded rice (DSR)-potato-onion, DSR-potato-mentha, and direct seeded <i>Basmati</i> rice (DSBR)-potato-mentha cropping system have been recommended.
Fine tuning method and time of planting	<ul style="list-style-type: none"> • Bed planting and ridge planting methods have been recommended in maize. • For obtaining better yields from transplanted <i>Gobhi Sarson</i> and <i>African Sarson</i>, seedling age of 30 days is optimum for current set of varieties. • Sowing time of <i>Toria</i> has been extended from first half of September to whole of September.
Minor crop agronomy	<ul style="list-style-type: none"> • Package of standardized production technologies for sugarbeet has been recommended. • Relay planting of pea, on ridges placed 60 cm apart, with celery germinating naturally from shattered seed of previous crop has been recommended.
Nutrient management	<ul style="list-style-type: none"> • The GreenSeeker optical sensor technology has been recommended for nitrogen fertilizer management in wheat crop. • A smart phone application, PAU Urea Guide App, has been developed for crops like wheat,

	<p>rice, <i>Basmati</i>, maize and cotton.</p> <ul style="list-style-type: none"> • Use of neem-coated urea @ 120 kg N/ha has been recommended in wheat to derive higher yields. • In case of short duration varieties PR 126 and PR 124, the previously recommended schedule for nitrogen fertilizer (urea) application in rice has been modified to three equal splits – 7, 18 and 36 days after transplanting. • Foliar application of potassium nitrate and/or salicylic acid has been recommended in wheat for yield enhancement. • Two foliar sprays of potassium nitrate @ 1.5 % help increase the <i>Ber</i> fruit weight and yield. <p style="text-align: center;">Biofertilizers</p> <ul style="list-style-type: none"> • Dipping rice seedlings in <i>Azospirillum</i> biofertilizer solution has been recommended. • Dipping of <i>Rabi</i> onion seedlings in biofertilizer solution, made by mixing <i>Azotobacter</i> sp.+<i>Sphingobacterium</i> sp.+<i>Burkholderia</i> sp. has been recommended for yield improvement. • During 2018-19, the University produced biofertilizers for 69,500 acres of wheat and rice for distribution among farmers.
--	--

CROP PROTECTION TECHNOLOGIES

Crop/Focus	Technologies recommended/Salient findings
Wheat	<ul style="list-style-type: none"> • Forewarning system for the effective management of yellow rust has been recommended. • Loose smut can be controlled by treating seed with Tebuseed 2DS (tebuconazole 2%) • DNA barcoding studies were conducted to characterize wheat armyworm collected from different

	<p>parts of the state.</p> <ul style="list-style-type: none"> • An integrated weed management approach combining Happy Seeder use for wheat sowing, herbicide application and hand pulling of escaped weed plants was developed to tackle multiple herbicide-resistance of <i>Phalaris minor</i> to post-emergence herbicides. • Post-emergence spray of ACM-9 (metribuzin 20% + clodinafop propargyl 9%) provides effective control of herbicide resistant <i>Phalaris minor</i> and other grass and broadleaf weeds. • New pre-emergence weedicides pyroxasulfone 85 WG and flumioxazin (Maxx 50% SC) have been recommended. • The dosage of pre-emergence spray of pendimethalin 30 EC has been enhanced to 3.75 litres/ha to provide effective control of <i>P. minor</i>.
Rice	<ul style="list-style-type: none"> • <i>Tetragnatha javana</i> was predominant species of spiders (which act as natural enemies), followed by <i>Tetragnatha maxillosa</i> (30.2%), <i>Neoscona theisi</i> (18.2%) and <i>Oxyopes kusumae</i> (6.0%) in southwestern districts. • To manage seed-borne diseases, seed treatment with Sprint 75WS has been recommended.
<i>Basmati</i> rice	<ul style="list-style-type: none"> • Application of neem based formulation, Achook (azadirachtin 1500 ppm) has been recommended for managing rice stem borers and leaf folders under organic and normal cultivation conditions. • The augmentative releases of <i>Trichogramma chilonis</i> and <i>T. japonicum</i> each resulted in 51.2 and 57.1 per cent reduction in stem borers and leaf folders, respectively. • Planting of border rows of certain flowering plants raised the abundance of natural enemies. • The bio-intensive pest management (BIPM) practices in organic <i>Basmati</i> rice resulted in 31.7 per cent

	reduction in plant hoppers' population.
Cotton	<ul style="list-style-type: none"> • Home-made neem extract has been recommended for managing cotton whitefly. • Study on temporal distribution of whitefly, a polyphagous pest, showed that its population remained low during winter and spring season whereas the highest population was recorded during second half of April. • Applaud 25SC (buprofezin) and Dantotsu 50WDG (clothianidin) can be used to control whitefly. • Delegate 11.7 SC (spinetoram) has been recommended for managing thrips.
Maize	<ul style="list-style-type: none"> • Banded leaf and sheath blight has been identified as an emerging disease and Amistar Top 352 SC has been recommended for its management.
Sugarcane	<ul style="list-style-type: none"> • Egg parasitoids of <i>Trichogramma</i> spp. reduced incidence of early shoot borer, top borer and stalk borer by 54.2 to 59.4 per cent. • Sugarcane leaf hopper can be managed with Dursban 20 EC (chlorpyrifos).
Fodder crops	<ul style="list-style-type: none"> • Stem borer in fodder maize can be managed by using <i>Trichogramma</i> based T- cards. • Sorghum shoot fly, <i>Atherigona soccata</i>, in forage sorghum can be managed by seed treatment with Slayer 30FS (thiamethoxam).
Pulses	<ul style="list-style-type: none"> • Pod borer complex in pigeonpea can be managed by using green triangle (slightly toxic) insecticides Coragen 18.5 SC (chlorantraniliprole) or Fame 480 SC (flubendiamide). • Gram pod borer, <i>Helicoverpa armigera</i> in gram can be managed by spraying green triangle Coragen 18.5 SC (chlorantraniliprole) or Proclaim 5 SG (emamectin benzoate) or Rimon 10 EC (novaluron). • Integration of microbial (Bt formulation Mahastra) and insecticide (Coragen 18.5 SC) spray schedule for the management of gram caterpillar was statistically as

	<p>good as control involving two sprays of Coragen 18.5 SC.</p> <ul style="list-style-type: none"> • Integration of microbial and insecticide spray schedule for the management of pod borer complex in mungbean had effect at par with two sprays of Spinosad 45SC.
Oilseeds	<ul style="list-style-type: none"> • Sclerotinia rot disease in rapeseed-mustard can be partly managed by avoiding irrigation during the period 25 December to 15 January. • Collar rot or seed rot of groundnut can be managed by seed treatment with Tebuconazole 2 DS. • Integrated use of paddy straw mulch and one hand weeding at 6 weeks after sowing provides effective weed control in organic soybean.
Vegetables	<ul style="list-style-type: none"> • Eco-friendly management of fruit fly, <i>Bactrocera cucurbitae</i>, using cue-lure based bottle trap in cucurbits (bitter gourd and sponge gourd) has been recommended. • The BIPM (involving seed treatment with <i>Trichoderma harzianum</i>, marigold as trap crop, pheromone traps, <i>Trichogramma pretiosum</i> and azadirachtin) in tomato resulted in 31.6 per cent reduction in fruit damage due to tomato fruit borer. • Three releases of <i>Chrysoperla zastrowi sillemi</i> resulted in 88.2 percent reduction in aphid population over untreated control on capsicum grown under net house. • Spiromesifen 22.9SC, which is safe to natural enemies and does not cause any phytotoxicity to crop, can be used for managing mites in okra.
Fruits	<ul style="list-style-type: none"> • To control weeds and derive higher yields in <i>Ber</i> orchards, application of paddy straw mulch has been recommended.

Food Science and Technology

Produce/Food	Technologies recommended/Salient findings
--------------	---

Fruits	<ul style="list-style-type: none"> Technology for processing coloured flesh guava varieties (Punjab Kiran and Punjab Pink) into value added products such as guava squash, nectar and leather/bar has been recommended.
Vegetables	<ul style="list-style-type: none"> Blanching and freezing technology for potato fingers and pea grains was developed and recommended. Technology for preparation of Potato parantha/samosa mix from dehydrated tubers of table purpose potato variety 'Kufri Pukhraj' has been developed and recommended.
Cereals and milk products	<ul style="list-style-type: none"> Technology for development of fibre (oat bran) incorporated probiotic <i>Kulfi</i> has been recommended.
Beverages and fermented foods	<ul style="list-style-type: none"> Diverse microbial germplasm accessions including <i>Saccharomyces cerevisiae</i>, <i>Pichia membranifaciens</i>, <i>Cyberlindnera fabianii</i>, <i>Clavispora lusitaniae</i> and <i>Micrococcus luteus</i> isolated mainly from traditional beverages and fermented foods of Himachal Pradesh are being explored for various brewing and dough fermentation traits.

FOOD AND NUTRITION

Focus	Salient Finding
Nutritional profiling of organic produce	<ul style="list-style-type: none"> Protein contents of conventionally grown wheat, rice, chickpea and soybean were significantly higher than organic crops, whereas amino acids composition was better in case of organic crops.
Nutraceutical characterization of vegetable products	<ul style="list-style-type: none"> There was a significant increase in minerals, namely magnesium, iron, zinc, polyphenolic compounds and antioxidant activity as a result of incorporation of black carrots in a range of dairy and traditional delicacies.

	<ul style="list-style-type: none"> Total phenol and ortho-dihydroxy phenol were significantly higher in PG20 (<i>Allium ampeloprasum</i>), a garlic variety grown in Manipur, as compared to PG17 (<i>Allium sativum</i>) cultivated in Punjab. Both showed microbicidal properties comparable with commercially available antibiotics (tetracycline).
Nutrition awareness	<ul style="list-style-type: none"> A positive change in attitude and practices was observed after the delivery of five nutrition awareness 2-hour sessions to 1,516 rural school girls (13-18 years old).

POST-HARVESTING TECHNOLOGIES

Produce	Technologies recommended/Major findings
Fruits	<ul style="list-style-type: none"> Technology for preparation of <i>Jamun</i> (<i>Syzygium cumini</i>) vinegar has been developed. Process for dietary fibre extraction from by-products of Kinnow peel and pomace has been standardized.
Vegetables	<ul style="list-style-type: none"> A batch-type refraction based drying system for potato flakes has been developed.
Cereals	<ul style="list-style-type: none"> Wheat flour prepared from recommended wheat varieties was the best in retaining the properties of wheat flour in terms of protein, fat, carbohydrate and starch content upto 60 days Technology for ethanol production from damaged wheat grains was standardized and patent has been filed.
Flowers	<ul style="list-style-type: none"> Technology of modified atmospheric packaging and storage of gladiolus spike to enhance their postharvest life has been recommended.
Honey	<ul style="list-style-type: none"> - Honey heating-cum-filtration unit (50 litres capacity) has been developed and recommended.

Domain	Technologies recommended/salient research output
Solar energy	<ul style="list-style-type: none"> • A re-circulatory 'Agro-industrial Solar Dryer' has been developed and recommended. • Solar dryer with evacuated tube collector for faster drying of 30-40 kg vegetables like fenugreek and turmeric has been developed and recommended.
Biomass energy	<ul style="list-style-type: none"> • Treatment with various chemicals decreased silica content of straw (2.0-6.7% as compared to untreated silica content 7.7% of untreated straw). • Ash slagging (clinker formation) in boiler from briquette samples of paddy straw, <i>Narha</i>, maize stalks, cotton stalks, and maize cobs can be prevented when burned at temperature of 1100 °C for less than 15 minutes in the furnace. • Paddy straw bale geyser has been installed at 12 locations of KVKs/FASC/farmers' fields for showcasing the technology to farmers and other stakeholders. • A field fermenter has been designed and demonstrated for production of ligno-cellulolytic and proteolytic enzymes from biodigested slurry using fungal cultures.

AGROFORESTRY

Focus	Major findings/recommendations
Phytoremediation	<ul style="list-style-type: none"> • Clone C-413 of eucalyptus recorded maximum height and Clone PE-5 attained the largest diameter when grown in stressed environment of irrigation with effluents of a distillery unit.
Intercropping	<ul style="list-style-type: none"> • Amongst the 16 wheat varieties evaluated for intercropping in 6-year old poplar plantation, highest wheat yield was observed in case of PBW 725.
Weed control	<ul style="list-style-type: none"> • Use of paddy straw mulch for managing weeds in poplar nursery has been recommended.

BEEKEEPING

Focus	Salient Findings
Foraging intensity	<ul style="list-style-type: none"> <i>Apis dorsata</i> had the highest foraging intensity followed by <i>Apis florea</i>. Intensity was higher in American cotton as compared to <i>Desi</i> cotton.
Pesticide toxicity and residue	<ul style="list-style-type: none"> The median lethal value (LD₅₀) of thiamethoxam to <i>Apis mellifera</i> foragers through contact exposure was 7.63 ng bee⁻¹ after 24 h of exposure while LD₅₀ (oral) was 5.490 ng bee⁻¹. The bee-foraged nectar samples collected a day after application contained thiamethoxam residues (0.02±0.01 mg kg⁻¹) which on third day became below limit of quantification (LOQ).
Selective breeding for hygienic behaviour	<ul style="list-style-type: none"> The daughter queen bees were reared from the hygienic colonies. About 84% of colonies so developed were found to be hygienic.

PESTICIDE RESIDUE ANALYSIS

- Pesticide residue analysis of 920 samples of various food products, namely, vegetables (608), *Basmati* rice (216), and red chilli powder, milk and water (36 each) showed that 5.54% samples were contaminated with various pesticide residues and 0.76% had levels above MRL.

MUSHROOM CULTIVATION

Domain	Salient Finding
Characterization and adaptation of germplasm technology	<ul style="list-style-type: none"> Two wild mushrooms identified through 18s rRNA sequencing, have been collected from Punjab environment and are being evaluated for edible purposes.
Composting technology	<ul style="list-style-type: none"> Compost prepared using maize stalks along with paddy straw (1:1, w/w) and wheat straw (2:1, w/w) did not affect button mushroom yield adversely. Pretreatment of wheat and paddy straws with urea and bacteria (<i>Delftia</i> spp.) increases yield of <i>Pleurotus</i> spp. and <i>V.</i>

	<i>vol/vacea</i> , respectively.
--	----------------------------------

FARM MACHINERY

Machinery/Focus	Technologies recommended/Salient Findings
Lucky Seed Drill	<ul style="list-style-type: none"> Lucky Seed Drill developed for simultaneous seeding and spraying of pre-emergence herbicide in direct seeded rice has been recommended.
Sub-surface Drip Laying Machine	<ul style="list-style-type: none"> Tractor operated sub-surface drip laying machine has been developed and recommended.
Other machinery	<ul style="list-style-type: none"> A prototype of tractor operated mat type nursery seeder has been developed. A tractor operated paddy straw bale shredder has been developed for spreading mulch in vegetable crops. A tractor operated two-bottom auger plough has been developed for green manuring and straw incorporation. In order to reduce dust concentration in <i>toori/bhusa</i>, a dust separation system for wheat straw combine has been designed and evaluated.
Testing for quality control	<ul style="list-style-type: none"> Thirty two machines were tested for their conformation to laid out standards.

VERTEBRATE PEST CONTROL

Pest	Salient Finding
Rodents	<ul style="list-style-type: none"> Application of <i>Dharek</i> and neem seed based sprays in grain stores prevented rodent damage to bags for 21-30 days. Rodent infestation in wheat crop sown in fields with retained paddy residue is more location specific rather than being dependent upon the method of

	residue management.
Bats	- For controlling bats in litchi, integrated approach involving lightening with LED bulbs, drum beating and fire crackers gave better results.

AGRICULTURAL ECONOMICS

Field	Salient Finding
Farmer Producer Organisations (FPOs)	- Crucial determinant for the sustainability of FPOs is institutional support.
Supermarkets	- Supermarkets in Punjab have had an adverse impact on the sales and returns of farm produce retailers.

APPARELS AND TEXTILES

Focus	Salient Findings
Dyeing technology	- Cotton and wool may be dyed by using ultrasonic dyeing techniques with <i>Ratanjot</i> and <i>Arjun</i> dye using mordants like <i>amla</i> , <i>babool</i> , alum and tannic acid.
Yarn development from paddy straw	- Cotton waste and paddy fibre could be spun successfully when blended in proportion of 70:30 and the yarn can be satisfactorily dyed using two natural dyes (bark of <i>Terminalia arjuna</i> and rind of <i>Punica granatum</i>). - Low cost woven and non-woven paddy straw mats were developed for use as mulch in papaya crop.

TECHNOLOGIES COMMERCIALISED

Technology Marketing and IPR Cell of the university facilitated commercialization of 18 varietal, farm machinery and processing technologies by signing 48 Memoranda of Agreement (MoA) with various stakeholders. PAU Super SMS technology and Chilli hybrid, CH 27, invited 14 and 9 commercial interests, respectively.