RESEARCH ACHIEVEMENTS OF PUNJAB AGRICULTURAL UNIVERSITY (July 2017 – June 2018)

Research is a core mandate of Punjab Agricultural University. Main focus of PAU research is on crop improvement, climate adaptive technologies, conservation of natural resources, crop residue management, integrated pest management, high input use efficiency and farm mechanization. Efforts are also being made towards value addition through post harvest handling and processing technologies, subsidiary occupations, strengthening and exploring value chains, and market analysis. The salient achievements during the period under report are as under:

Crop Improvement

Twenty five varieties of different crops (13 of field, 4 of fruit, 6 of vegetable, and 2 of ornamental crops) developed/approved by the University were recommended for cultivation in Punjab. During the period under report, five varieties were released at the national level.

	Crops	**Varieties**
Field Crops	Rice	PR 127
	Basmati Rice	Pusa Basmati 1637
	Wheat	Unnat PBW 550
	Maize	**PMH 12***
	Desi Cotton	LD 1019
	Sugarcane	**CoPb 92***, CoPb 93 & CoPb 94
	Pigeonpea	AL 882
	Raya	Giriraj
	Groundnut	TG37A
	Oats	OL 11(**OL 1760***), OL 12 (**OL 1802-1***) & **OL 1769***
	Berseem	BL 43
Fruits	Guava	Punjab Safeda & Punjab Kiran
	Sweet Orange	Early Gold
	New rootstock for Kinnow mandarin	Carrizo
Vegetables	Pumpkin	PAU Magaz Kadoo-1
	Cucumber	Punjab Kheera-1
	Tinda	Punjab Tinda-1
	Tomato	Punjab Swarna
	Potato	Kufri Ganga
	Brinjal	Punjab Raunak
Flowers	Chrysanthemum	Punjab Shingar & Punjab Mohini

***Released/identified at national level**

- To strengthen the genetic resource base, a total of 10,663 germplasm accessions were sourced. As a special initiative, a total of 5,017 accessions of minor millets with the aim of exploring their potential as summer crop; 770 of cotton for resistance to whitefly, cotton leaf curl virus (CLCV) and to jassid; and 2,669 entries of sesame for phyllody resistance and earliness were acquired from National Bureau of Plant Genetic Resources (NBPGR), New Delhi. Twenty five neem genotypes were used for nursery raising and evaluation of azadirachtin content. In-house germplasm development initiatives helped identify new plant type of American cotton that enabled high density plantation and mechanical harvesting.
- Biotechnological advances in wheat included development of SSR(simple sequence repeat)/SNP (single nucleotide polymorphism) markers, appropriate for MAS, for leaf rust and stripe rust resistance genes introgressed from certain wild species; use of Karnal bunt resistant alien introgression lines in breeding strategies; pyramiding of high grain weight and high grain protein traits with stripe rust resistance genes in elite varietal backgrounds; and genome editing approaches for developing high resistant starch and low acrylamide wheat genotypes.
- In rice, biotechnological initiatives focussed on identification and subsequent transfer of genes for brown plant hopper resistance (Bph34), root knot nematode resistance, neck blast resistance, and mapping of putative QTL (quantitative trait locus) for sheath blight resistance.
- Biotechnological research in pulses involved development of SSR and SNP markers from *Vigna mungo* and *V. radiata*; use of MAS for mobilizing *Cry1Ac* gene to elite chickpea backgrounds and validation of *in silico* polymorphic markers in 48 *Vigna* genotypes; and transfer of *Ascochyta* blight resistance to chickpea background.
- In *Brassica* oilseeds, MAS was employed for enhancing oil quality and white rust resistance. Aphid resistance gene was transferred from *B. fruiticulosa*.
- In fruit crops, biotechnological work involved development of SSR and SNP markers for mapping traits important for processing and nutritional quality in guava; and identification of *Phytophthora* resistant F1 hybrids developed from crosses of rough lemon with resistant root stocks.
- In vegetables, biotechnological research output pertained to employment of SSR markers employed for mapping male sterility and *Fusarium* wilt resistance genes in muskmelon; transfer of yellow vein mosaic virus to cultivated okra genotypes; and initiation of CRISPR/Cas9 approach for knocking out pectate lyase gene, implicated in enhanced shelf life, in tomato.

Crop Production Technologies

Crop production technologies generated during the report period aimed at aligning technologies with new varieties besides production of biofertilizers and management of crop residue, nutrients and irrigation water.

Focus area	Technology recommended/Salient finding

Biofertilizers	- *Rhizobium* (LUR6 strain) biofertilizer for summer and *Kharif* urdbean - *Azospirillum* culture for paddy - Integrated application of biofertilizers and chemical fertilizers in poplar and eucalyptus nursery
Crop residue management	- Paddy straw compost as a farmyard manure (FYM) substitute in maize and guava - Incorporation/retention of paddy straw over 3-year period improved wheat yield and soil health parameters.
Nutrient management	- Due to higher efficiency of neem coated urea, soil-test based urea dose in rice reduced (from 110 kg to 90 kg/acre) - Use of PAU Leaf colour chart (LCC) in direct seeded rice and Bt cotton - Change in timings (4, 6, and 9 weeks after sowing) of soil test based fertilizer N application in direct seeded rice
Irrigation water management	- Use of canal water in cyclic mode with sodic water for irrigating cotton, and along with mulch for irrigating potato and okra - Occasional pre-sowing irrigation with sodic water in cotton to avoid delay in sowing
Other technologies	- Foliar application of salicylic acid (7.5%) or potassium nitrate (2%) for better seed-setting in Berseem; and of potassium nitrate (1.5%) for better fruit size and yield in semi-soft pear - Identification of earlier released short duration rice variety PR 126 for direct seeding - Optimum seedling age of 25-30 days prescribed for transplanting PR 124 and PR 126 and 30-35 days for PR 121 and PR 122 rice varieties - Harvesting of turmeric by end of December rather than early for better fresh rhizome yield and curcumin content - Change in row spacing in potato (65 or 75 cm) and brinjal, capsicum, cabbage, *arvi*, turmeric and sweet potato (67.5 cm) to enable tractor operations

Crop Protection Technologies

The focus was on reducing environmental and resistance implications of chemical use for disease, insect-pest and weed control by devising judicious and targeted application of chemicals and integrated measures.

Crop/Focus	**Technology recommended/Salient finding**

Wheat	- Integrated approach for managing yellow rust through deployment of resistant varieties, avoiding early sowing especially under poplar plantations, and timely monitoring of crop - Aphid management with foliar application of Taiyo (thiamethoxam 25WG) - Control of mixed weed flora with post emergence application of pre-mix (Shagun 21-11) of metribuzin and clodinafop propargyl, and pre-emergence application of Zakiyama (Pendimethalin 30EC) for managing *Phalaris minor* - Management of broadleaf weeds with foliar application of Makoto (metsulfuron methyl) 20WP
Rice	- Rotation with *Brassica* rather wheat can help manage sheath blight - Management of plant hoppers with Chess 50WG (pymetrozine) without any residual effect on crop and soil system - Natural enemies (spiders and green mirid bugs) in IPM-handled organic fields found to be higher than in conventional system - Bio-intensive integrated pest management (BIPM) practices led to 60.7% reduction in incidence of stem borer - Identification of Bacterial foot rot or *Erwinia* rot as an emerging disease in Punjab
Cotton	- Ten species of natural enemies of whitefly, *Chrysoperla* being the predominant, identified in cotton growing regions of Punjab - Molecular (mitochondrial cytochrome oxidase I gene) identification (as AsiaII_1) of whitefly species in different regions of Punjab, Haryana and Rajasthan - BIPM module led to 38.3 % reduction in whitefly population - Thrips as sucking pests, along with the control measures, included in Package of Practices - New systemic insecticide Osheen 20SG (dinotefuran) recommended for controlling jassid and whitefly
Maize	- Biocontrol of stem borer with two releases of *Trichogramma chilonis*
Fruit trees	- Traps made of 24-holed earthen pots filled with threshed maize cobs recommended for managing termites - Citrus fruit rot/gummosis can be managed with application of sodium hypochlorite (5%)

	- Seven new mutant strains of *Trichoderma* helped control foot rot in citrus nursery
Vegetable crops	- Integrated application of mustard cake, neem cake and FYM found effective in containing root knot nematode in cucumber - Fruit borer in tomato can be managed with chlorantaniliprole 18.5SC and shoot and fruit borer in brinjal with emamectin benzoate 5SG and chlorantaniliprole 18.5SC - Control of jassid in okra with imidacloprid 17.8SL and thiamethoxam 25WG and diamondback moth in cole crops with EGAO (emamectin benzoate) 5SG - Fruit rot of chilli especially during challenging (to control with contact fungicides) humid/wet conditions manageable with systemic fungicide Folicur 25EC (Tebuconazole) - Weed control in potato through pre-emergence application of Tanoshi 70 WP (metribuzin)
Rodent and bird management	- Control of rodent pests in wheat fields sown with Happy Seeder through double burrow baiting with 2% zinc phosphide - Use of micro-encapsulated 2.5% methyl anthranilate against rodent attack in stored wheat
Pesticide residue assessment	- Out of 960 samples of different food commodities collected from Malerkotla, Moga and Ludhiana areas, 106 found to be contaminated with pesticide residues and 27 had residues above respective maximum residue levels (MRLs) - Of vegetable samples, 1.7% had ethion, chlorpyriphos and monocrotophos above their respective MRLs

Seed and Nursery Production

- During 2017-18, the University produced 59,137q seed of field crops and 9,296q seed of vegetable crops.
- About 4.75 lakh high quality nursery plants of fruit trees (citrus, guava, etc.) were produced for the farmers.

A total of 1.22 lakh plants of different tree species, mainly poplar, *eucalyptus*, *dek, shisham, sohanjna* and neem, were provided to farmers.

Food Science and Technology

- Two recommended technologies employed sugarcane juice one for making sugarcane-apple vinegar (1:1 ratio) by packed bed fermentation at 25L scale and the second for *Kheer* using rice, sugarcane juice and water in the ratio 1:4:5.
- Technology for making *Aloo Bhujia, Aloo Chakli*, and *Aloo Wari* from table purpose varieties of potato was standardized.
- The *jamun* vinegar production technology was successfully validated at 25L scale.

- Honey based products, namely multigrain honey cookies, groundnut muffins, groundnut cookies, ginger lemon drink and cereal health bar were developed.

Post-harvest Technologies

- Major post harvest technologies included a mechanically ventilated onion storage structure; drying of freshly harvested onion by pre-treating with NaCl; a solar turmeric dryer of 50 kg capacity; Aloe vera gel extraction machine; alternative economical packaging of potato in leno bags; use of corrugated fibre boxes (CFB) for packaging of litchi and Kinnow fruits; packaging for enhancing shelf life of fresh seedless cucumber, yellow pepper and black carrot by using non-perforated LDPE films; and drying *Gomphrena* flowers, panicles of Goldenrod (*Solidago*) and peduncles of Golden rain tree (*Koelreutria paniculata*).

Beekeeping and Mushroom Production

- Pollination of African *Sarson* (*Brassica carinata*) by *Apis mellifera* is responsible for 80-95 per cent of the seed set as indicated by yield and yield components in isolated net chambers.
- Research on mushrooms involved collection and characterization of seven wild mushrooms; standardization of cultivation of *Pleurotus eryngii,* an aromatic fleshy textured mushroom, under Punjab conditions using locally sourced farm residues; development of Short method of composting for cultivation of *Agaricus bisporus*; and supplementation of compost with neem powder (0.5%), use of *Azotobacter* in casing mixture and spray of Indole-3-acetic acid at the time of first and second flush for higher (by 30%) button mushroom yield.

Farm Machinery

During the period under report, farm engineers developed, modified and tested several machines.

- Newly developed machinery included a hydraulic power side shift offset rotavator for primary tillage and interculture operations in orchards and agro-forestry plantations; tractor operated Rotary Weeder for wider row crops, especially sugarcane; a tractor operated mounted type wheat straw collector; a two-row semi-automatic type vegetable planter, and a manually operated gladiolus planter.

- Modifications were effected in Axial flow paddy thresher for achieving higher feed rate and in PAU Multipurpose High Clearance Sprayer to make it Self-propelled High Clearance Sprayer with four-wheel drive (4-WD) having narrow width tyres.

- PAU Happy Seeder was recommended for sowing fodder oats.

Biomass based Energy and Groundwater Recharge

- Research initiatives in energy conservation included production of protease enzyme, having wide-ranging industrial applications, from bio-digested slurry

derived from poultry droppings; and standardization for no ash slag/clinker formation, for mixed biomass briquettes.

- Use of abandoned wells for recharging groundwater by using canal water rendered surplus during rainy/off season and agricultural runoff was recommended for District Irrigation Plan.

Apparels and Textiles

- Research output in the field of Apparels and Textiles included use of fibre obtained from Himalayan Nettle (*Girardinia diversifolia*) for developing cushion covers, jackets and table runners. Rechargeable thermojackets were designed for managing upper quadrant pain condition.

Technologies Commercialized

- The University offered non-exclusive rights to 136 entrepreneurs for commercialization of a total of 15 technologies encompassing diverse aspects like hybrid seed production (8); farm machinery for crop residue management (120), processing technologies (6); nitrogenous fertilizer management through Leaf Colour Chart (1); and drinking water testing (1).