

RESEARCH ACHIEVEMENTS DURING RABI-2017-18 AND RESEARCH PROGRAMMES FOCUSING RABI 2018-19

Rainfall Pattern

After the withdrawal of Monsoon in the state on 30th September, 2017, the Rabi season 2017-18 commenced from October, 2017 with scanty rains (0.3 mm). During, November, 2017, 6.9 mm rainfall was received. With wide spread rain (average 48 mm) in the state during December, all the districts (except Kinnaur, L&S and Sirmaur) received either normal (-19 to +19%) or excess ($\geq 20\%$) rainfall which largely compensated the negative effect of less rains of previous months and created good moisture build up in soil.

During January, 2018 all the districts received scanty (-60 to -99%) rain with an average of 9.2 mm only. Rain during February and March was also below normal (45.9 mm by 50% and 37.5 mm by 67%), respectively. Fluctuation in temperature due to rains also delayed the sowing and planting of summer vegetables especially cucurbits.

Intermittent rain of 58.5 mm during April proved useful for wheat in the mid hills but caused damage to vegetables viz., peas, onion, spinach and garlic etc. Flowering in mango, litchi, plum, apricot, peach, pear and citrus crops was also affected in some districts.

During May, 2018, 47.3 mm rainfall was received against the normal of 65.3 mm which was below normal by 28%. High rainfall in low hills and snow in mid hills created cold wave conditions. Flattening and lodging of wheat, mustard and gram was also observed in some regions due to rain and hailing. Higher convective activity coupled with rainfall and hail caused damage to vegetables viz., peas, tomato, potato, cauliflower and cabbage in certain areas of Kangra, Mandi, Una and Sirmaur districts during March to May. Flowering and fruit setting was also affected in apricot, almond, cherry, plum and peach due to aberrant weather conditions.

Since October 1, 2017 to May 31, 2018, a total of 253.6 mm (below normal by 52 %) rainfall was received in the state against the normal of 532.6 mm, corresponding value of 2016-17 was 418.5 mm (below normal by 21 %). A cursory look shows higher negative departures of rainfall from normal in October, January, March and May during 2017-18 as compared to 2016-17 (Table 1 and Fig. 1 & 2). As a whole, the crops performance was, though affected in some pockets, but was generally good during the season.

Lecture delivered by Dr. D.K. Vatsa, Director of Research, CSKHP Krishi Vishvavidyalaya, Palampur in the Agricultural Officers' Workshop on Rabi Crops held at CSKHPKV, Palampur on October 30, 2018.

Table 1: Monthly rainfall during Rabi 2017-18 as compared to Rabi 2016-17 in Himachal Pradesh

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Seasonal total
Actual (mm)									
2017-18	0.3	6.9	48.0	9.2	45.9	37.5	58.5	47.3	253.6
2016-17	5.3	0.0	2.2	157.6	46.3	57.3	87.8	62.0	418.5
Normal (mm)	40.6	19.2	42.9	92.5	92.5	114.2	65.4	65.3	532.6
Departure (%)									
2017-18	-99	-64	12	-90	-50	-67	-11	-28	-52
2016-17	-87	-100	-95	70	-50	-50	34	-5	-21

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Fig 1. Rainfall (mm) during *rabi* season 2016-17 and 2017-18

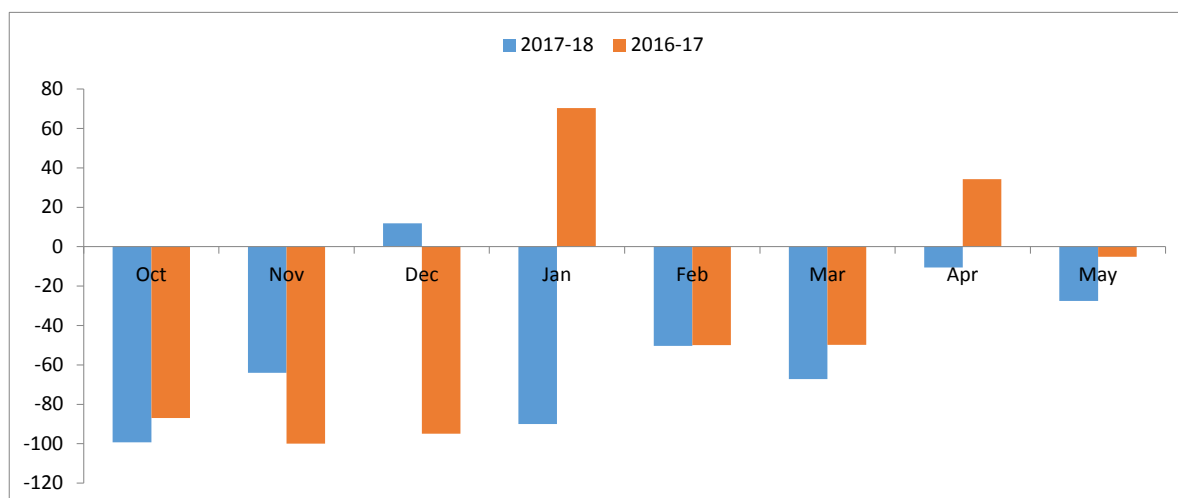


Fig 2. Rainfall departure (%) during *rabi* season 2016-17 and 2017-18

RESEARCH HIGHLIGHTS: RABI 2017-18

Significant research accomplishments for different ongoing programmes of the University during *rabi* 2017-18 are given as under:

CROP IMPROVEMENT

CEREALS

Wheat:

- Him Palam Gehun 3 (HPW 373), a promising wheat variety having high grain yield potential (27.5 q/ha) under late sown rainfed conditions with high degree of resistance to yellow rust and brown rust was identified in REC and Agricultural Officers' Workshop during October, 2017 for release by the State Variety Release Committee.

- A high yielding yellow rust resistant genotypes HPW 441 having high grain yield potential of 32.0 q/ha and 43.7 q/ha, under timely sown rainfed and irrigated conditions, respectively of NHZ was promoted to AVT-I in All India coordinated trials.
- A high yielding yellow rust resistant genotype HPW 442 having high grain yield potential of 31.8 q/ha and 39.5 q/ha, under timely sown rainfed and irrigated conditions, respectively of NHZ was promoted to AVT-I in the All India coordinated trials.
- Entry HPW 459 included in the AICRP late sown trial have been identified with high quality traits i.e. high protein (12.9%), high iron (49.7 ppm) and high zinc (48.2 ppm).
- Wheat varieties HS 562 (42.55q/ha), MACS 6222 (39.95 q/ha) and HD 3086 (38.49 q/ha) were found most suitable for sowing under irrigated conditions in Himachal Pradesh.
- At Dhaulakuan, two station trials on wheat were conducted i.e. timely sown rainfed and late sown rainfed. In timely sown, 24 entries alongwith two checks and in late sown 18 entries alongwith two checks were tested. In timely sown, out of 24 entries, only three entries i.e. PW1703, PW1704 and PW1712 were found to be significantly superior over checks whereas in late sown out of 18 entries only five entries viz; PW1703, PW1704, PW1710, DW244 and DW248 were found promising and significantly superior over checks.
- Among wheat varieties, HS 490 gave the highest grain yield followed by HPW 349 and VL Gehun 907 in Lahaul valley at Kukumseri.
- Wheat variety HPW 360 was included in the National Genetic Stock Nursery (NGSN) for two consecutive years 2016-17 and 2017- 18 as it is the most utilized entry for hybridization programme by different cooperating centres.

Barley

- Genotypes HB 843, HB 846, HB 851, HB 853, HB 858 and HB 863 were found to be completely resistant (0 score) to yellow rust in the Initial Barley Disease Screening Nursery (IBDSN).
- Amongst the barley varieties tested significantly highest grain yield was recorded in BHS 400 followed by VLB 118, HBL 113 and BHS 352. Significantly highest grain yield was recorded with seed rate of 125 kg / ha though it remained at par with 100 kg / ha.

PULSES:

- At Berthin, entry LSS-17-4 of lentil resulted in significantly highest seed yield (2317.71 kg/ha). However, it remained statistically at par with LSS-17-6 (2274.31 kg/ha), LSS-17-3 (2022.57 kg/ha), LSS-17-2 (2204.86 kg/ha) and LSS-17-8 (2005.21 kg/ha) and lowest being from LSS-17-1 (1500.0 kg/ha). Number of pods per plant were height in LSS-17-3 (96.3 No.) which was at par with LSS-17-4 (88.5 No.). Less number of days to maturity (138 days) were taken by LSS-17-1.
- The Entry LSS-17-110 of Lentil resulted in significantly highest seed yield (2391.98 kg/ha). However, it remained statistically at par with LLS-17-109

(2145.06 kg/ha), LLS-17-101 (2052.47 kg/ha) and LLS-17-95 (2061.60 kg/ha), lowest being from LLS-17-102 (277.78 kg/ha). Number of pods per plant were maximum in LLS-17-90 (95.7 No.), Less number of days to maturity (136 days) were taken by LLS-17-104.

- The Entry KU17-12 (1631.94 kg/ha) remaining at par with KU17-20 (1475.69 kg/ha) recorded highest urdbean seed yield. The lowest seed yield was observed in KU17-21 (399.31 kg/ha), however, it remained significantly at par with KU17-19 (416.67 kg/ha), KU17-34 (468.75 kg/ha) and KU17-29 (590.28 kg/ha).
- The entry KU17-1 of Urdbean recorded highest seed yield (1419.17 kg/ha), however, it remained at par with KU17-4 (1367.19 kg/ha), KU17-2 (1178.39 kg/ha) and KU17-3 (1139.32 kg/ha).
- The entry KM17-1 of mungbean out yield (1015.63 kg/ha) as compared to all others entries. The lowest seed yield (486.11 kg/ha) was obtained in KM17-4.

OILSEEDS:

- One entry of gobhi sarson AKGS 8141 (2076 kg/ha) performed significantly better by giving 19.8 % higher seed yield over the national check GSL 1 (1733 kg/ha) and has been promoted from IVT to AVT for further testing during *Rabi 2018-19*.
- Two strains of gobhi sarson AKGS 8146 (1838 kg/ha) and AKGS 8217 (1668 kg/ha), one strain of Mustard AKMS 1002 (1416 kg/ha), which have been performing consistently better than respective checks for last two years 2016-17 and 2017-18, have been inducted in respective Initial Varietal Trials under AICRP of RM for the year *Rabi 2018-19*.

FODDER CROPS:

- Two entries namely, Palam rye grass-2 and Palam rye grass-1 recorded 14.36% and 13.25% superiority for green fodder yield and 13.51% and 10.61% for dry matter yield, respectively, over the check (PBRG-1) and were promoted to AVT-II in All India Coordinated trials. Over locations, entry Palam Rye Grass -2 gave highest green fodder yield i.e. 308.1q/ha, dry matter yield of 58.1 q/ha and crude protein yield of 10.7 q/ha.

SEED PRODUCTION AND SEED TECHNOLOGY

NUCLEUS AND BREEDER SEED PRODUCTION

Nucleus seed production

- During Rabi 2017-18, a total of 1000 kg Nucleus seed of different varieties of wheat crop was produced by the University.

Breeder seed production

- The University produced 66849 kg breeder seed of cereals, pulses, oilseeds, fodder and vegetable crops during *rabi 2017-18* (Table 2).

Table 2: Breeder Seed (kg) of cereals, pulses, oilseeds, fodder and vegetable crops produced during Rabi 2017-18.

Crop	Variety/Hybrid	Total Breeder Seed
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		produced (kg)
Cereals		
Wheat	HPW 155, HPW 236, HPW 249, VL 829, HPW 349, HPW 360, HPW 368, HPW 373, HS 507, HS 542, HS 562, WH 1080, DBW 88, Him Pratham	58059
Barley	HBL 713, HBL 113, VLB 118, BHS 380, HBL 316, HBL 276, HBL 391, BHS 400	1490
Total		59549
Oilseeds		
Brown Sarson	KBS 3	106
Gobhi Sarson	ONK 1, Neelam,	1654
Toria	GCS-7, Bhawani	211
Karan Rai	Jayanti	25
Raya	RCC 4	415
Linseed	Nagarkot, Surbhi (KL 1), Himani, Him Alsi 1, Him Alsi 2	290
Total		2701
Pulses		
Gram	HC 1, HC 2, GPF 2, DKG-986 and HPG 17, GNG 1581	1214
Lentil	Vipasha, Markandey	430
Total		1644
Fodder		
Oat	Palampur 1	1567
Total		1567
Vegetables		
Chinese cabbage	Palampur green	63
Palak	Pusa Harit	314
Broccoli	P. Samridhi	12
Radish	Japanese White	90
Turnip	Purple Top White Globe	26
Pea	P. Triloki, Palam Priya, PB 89	111
Onion	Palam Lohit	1
Garlic	GHC 1	750
Fenugreek	P. Soumya, Kasturi	21
Total		1388
Grand total		66849

- A total of 10006 kg foundation seed of cereals, pulses, oilseeds , vegetables and fodder crops was also produced during *Rabi* 2017-18 (Table 3).

Table 3: Foundation Seed (kg) of cereals, pulses, oilseeds, vegetables and fodder Crops

produced during Rabi 2017-18.

Crop	Variety/Hybrid	Total Foundation Seed produced (kg)
Cereals		
Wheat	HS 507, HS 542, HPW 349, HPW 368, VL 907 and DBW 88	4747
Barley	HBL 713	147
Total		4894
Oilseeds		
G.obhi Sarson	Sheetal, Neelam, GSC 7, GHC 7	712
Brown Sarson	ONK 1	95
Toria	RCC 4, Bhawani	293
Mustard	KBS 3	5
Total		1105
Pulses		
Gram	GPF 2, HC 1, HC2, HPG 17, Aman 515, DKC 986	1920
Lentil	Vipasha, Markandey	600
Total		2520
Vegetables		
Pea	Pb 89	59
Palak	Pusa Harit	115
Garlic	GHC 1	810
Total		984
Fodder		
Oat	Palampur 1, Kent	503
Grand Total		10006

Seed Technology Research

- An experiment conducted during 2017-18 on revalidation of wheat seeds revealed that seed lot HPW 349 (2015-16) having germination percentage (89.67%) above minimum seed certification standard (85%) did not show increase with respect to different vigour parameters viz. seedling length (cm), seedling dry weight (g), vigour index-I (final count x seedling length), vigour index-II (final count x seedling dry wt.), electrical conductivity (m mhos/cm/g), speed of germination and field emergence in comparison to fresh seed lots HPW 249 (2016-17) and HPW 349 (2016-17). Thus revalidated seed lot HPW 349 (2015-16) can not be used for raising the wheat crop.

CROP PRODUCTION

- The study conducted on wheat phenology revealed that with delay in sowing time all varieties took significantly more number of days for germination (5.66 to 11.5), crown root initiation (27.58 to 41.75), maximum tillering (39.16 to 53.58) where as opposite trend was observed under days to heading (99.66 to 79.5), days to grain filling (125.33 to 102.9), days to physical maturity (160.1 to 119.6). Highest grain yield was recorded under VL 907(50.61q/ha) and was at par with HPW 349 (47.03q/ha) but superior to HS-542 (46.29q/ha) and HS 490 (41.23 q/ha).
- Significantly higher grain yield of wheat was recorded at 5th Nov. sowing followed by 25th Nov. and 15th Dec. and 5th Jan in a decreasing order of yield. As far the performance of various varieties, it was observed that significantly higher grain yield of wheat was found by sowing HS 562
- Grain yield of barley was recorded significantly higher in conventional tillage treatment, however it remained at par with zero tillage + residue @ 6t/ha treatment. Amongst different varieties significantly highest grain yield was obtained from the variety BHS 400.
- **Development and validation of On-station Integrated farming System Model:** One-hectare farming system model being developed at Bhadhiarkhar farm revealed that a gross revenue of Rs. 2, 34,557/- and net returns of Rs. 1, 16,652/- were obtained during 2017-18. The highest net returns of Rs. 47,967/- was received from cropping system unit followed by Livestock unit with net returns of Rs. 41,834/- followed by Horticulture-cum-vegetable unit with net returns of Rs. 11,821/-. The net returns from forage unit were Rs. 10,006/- whereas from Mushroom unit, net returns of Rs. 5025/- were obtained.
- Three years pooled data of two locations Bajaura and Malan showed that inoculation of barley seed with Azotobacter + PSB can increase the barley grain yield upto 15.62 % as compared to no inoculation. The application also saves 25 % nitrogen of the recommended dose. The residual effect of PSB has been observed in **succeeding blackgram crop at Bajaura centre. It increased the grain yield up to 18.76 %.**
- Annual **ryegrass genotype** (Makhan grass) produced higher herbage yield than Punjab rye grass-1 and Kashumir collection. Compounding of ryegrass with berseem had no advantage in terms of green and dry fodder yields over sole Makahn grass but significantly better than sole berseem. Makhan grass sown with berseem in 50:50 seed ratio resulted in higher crude protein yield. Five forage cuts in rabi season from this crop mixture can be obtained if crops are sown in second fortnight of October. Genotype Makhan grass realized higher net returns and was followed by Makhan grass + berseem sown using seed rate ratio of 75:25.

Soil Water and Nutrient Management

- Two years pooled results of two locations viz. Bajaura and Malan showed that the application of 150% higher doses of fertilizer to the recommended doses + 15 t/ha FYM can increase the wheat grain yield up to 28.54 % (52.97 q/ha) over the recommended dose of fertilizer (41.21 q/ha). However, 150% higher dose of fertilizer without FYM can increase the grain yield up to 18.75 %.
- Application of zinc in soil @ 37.5 kg/ha along with foliar application @ 0.5% at heading and early milk stage gave significantly higher grain yield of wheat.

- Significantly highest grain yield of wheat was recorded with the application of 150% of recommended NPK. However, this treatment was followed by recommended NPK dose and application of fertilizer dose recommended by Nutrient Expert – Wheat.
- In long term experiment on balanced nutrition, liming was found to be an effective proposition. The yield of wheat (24 q ha⁻¹) recorded at 100 % NPK + lime was comparable to the yield under 100% NPK + FYM.
- In long term experiment on balanced nutrition, the results revealed that there was a marked reduction in yield of wheat (58 %) without the use of sulphur. Therefore, application of sulphur containing P fertilizer i.e. single super phosphate is necessary to enhance the productivity of maize-wheat system.
- Under protected conditions, straw berry crop should be irrigated 60 per cent of pan evaporation and fertigated with 75 per cent of recommended NK,
- The zero-tillage (39.35 q/ha) with mulch application recorded statistically similar grain yield to convention tillage (41.31q/ha) in barley in the second year of experimentation.
- Grain yield of barley increased with increasing nitrogen levels up to 100% but the differences were not significant statistically. Amongst the biofertilizer treatments, significantly highest grain yield was recorded with the seed inoculation of Azotobacter + PSB.
- In a long term targeted yield experiment, IPNS based nutrient doses for targeted yield of 25, 35 and 30 and 40 q ha⁻¹ recorded higher productivity of wheat over non-IPNS treatment for same yield targets, respectively.
- In validation trials at farmers' field, higher B:C ratio of 2.30 and 2.20 in potato was recorded with the STCR approach with and without FYM as compared to the farmers' practice (1.44) and general recommended dose (1.71).
- Application of Sulphur @ 37.5 kg /ha along with recommended NPK (125-75-50) through Gypsum increased productivity of garlic to the tune of 18 to 24 %.
- Optimum dose of boron to enhance cauliflower yields for acid soil (Palampur conditions) was worked out to be 2.72 kg ha⁻¹.
- The highest potato tuber yield, gross return, net return and B:C ratio can be obtained by applying drip irrigation @ 60 per cent of cumulative pan evaporation (0.6 PE) and 75 per cent recommended dose of NPK

CROP PROTECTION

Disease Management

- New fungicides BAS 751 04 F EC, BAS 750 02 F and Azoxystrobin 7.5% + Propiconazole 12.5% SE were tested for their bio-efficacy against stripe rust of wheat and found effective for its management.
- Among the growth regulators significantly higher wheat yield was recorded with the application of two sprays of tebuconazole (Folicur 430 SC) @ 0.1% at first Node and flag leaf stage.

- In Powdery Mildew Screening Nursery (PMSN) entry CZ-RI-302 was found highly resistant to powdery mildew in wheat while entries NHTSZ-1705, NWTS-110, NWRI-308, NE-IR-111, NE-IR-112, NE-IR-115, NE-IR-303, CZ-TS-109, DIC-106 were also resistant to powdery mildew
- An experiment was conducted to see the efficacy of Sedaxane 2.5% w/v + Fludioxonil 2.5 % w/v (50FS) as seed treatment against important soil and seed borne diseases of wheat. It was observed that seed treatment with Sedaxane 2.5% w/v + Fludioxonil 2.5 % w/v (50FS) @ 3gm / kg gave significantly higher yield (39.47 q/ha) and maximum control of Karnal bunt as compared to control. No/negligible incidence of loose smut was observed in the treatments.
- Two sprays of fungicide-cum-growth retardant (GR) TEBUCONAZOLE yielded significantly higher grain yield (43.17q/ha). It also reduced the plant height up to 4.5 cm and resulted in 4.10 % increase in grain yield over no spray of growth retardants.
- Fungicides tebuconazole, hexaconazole, propiconazole and nativo were effective in reducing severity of wheat powdery mildew and increasing the yield.
- Genotypes HB 843, HB 846, HB 851, HB 853, HB 858 and HB 863 were found to be completely resistant (0 score) to yellow rust in the Initial Barley Disease Screening Nursery (IBDSN).
- The results on the management of leaf miner in pea indicated that malathion (0.05%) was the most effective in controlling the leaf miner with least leaf infestation (5.69%) and gave higher green pod yield (120.45 q/ha) followed by oxydemeton methyl (Metasystox 25 EC) with leaf infestation of 6.19 per cent and green pod yield of 111.65 q/ha.
- Chickpea genotype ICWA 1640, 1642, 1644 and ICWA 05529 were resistant whereas, ICWA 133, 1643 and 1648 were moderately resistant to *Ascochyta* blight.
- Karnal bunt incidence in the state varied between 0.1 to 2.8 per cent (30.43% samples) with a maximum incidence of 2.8% in Bhalana area of district Hamirpur. However, ~71 percent of the samples showed infection above certification level, though much less over previous years. The hybrid rice grown in Bheora area of Mandi showed very high incidence (62.5%) of neck blast.
- Two brassica germplasm lines RH-1573 and RAUDT-10-33 were found resistant to white rust.
- In uniform disease nursery trial, six rapeseed-mustard genotypes namely YSB-9, PDZ-2, PDZ-3, PDZ-5, PDZ-7, DRMR-1-5 were resistant to white rust disease.
- In uniform disease nursery trial on linseed, two entries coded RLC-164 and RLC-92 were found resistant to wilt.

Insect –Pest-Management

- Population buildup of wheat aphid complex (*Rhopalosiphum padi* and *Sitobion avenae*) studied at Palampur revealed the peak of population (30.4 aphids/shoot) to occur during 3rd week of March.

- Seven coccinellid beetles species were recorded associated with the aphid, amongst them *Coccinella septempunctata*, *Hippodamia variegata* and *Coccinella transversalis* were more abundant. Population of coccinellids was higher in the plots treated with *darekastra* and azadirachtin as compared to synthetic insecticidal treatments.
- In Himachal Pradesh, ten insect species were recorded associated with *rabi* onion. Amongst them, onion thrips, *Thrips tabaci* was the most abundant and recorded from all the onion growing localities surveyed in low and mid hill regions of the state.
- Nine insect species namely, *Altica* sp., *Chromatomyia horticola*, *Euconocephalus* sp., *Gryllus* sp., *Helicoverpa armigera*, *Melolontha furcicauda*, *Nezara viridula*, *Spodoptera litura* and *Trichoplusia orichalcea* were recorded for the first time to infest onion from Himachal Pradesh.
- White grub species namely, *Brahmina coriacea*, *B. crinicollis*, *B. flavoserica*, *Holotrichia longipennis*, *Lepidiota stigma*, *Phyllognathus dionysius*, *Anomala dimidiata*, *A. lineatopennis*, *A. varicolor*, *Melolontha furcicauda* *M. indica* and *Maladera insanabilis* have been identified as major species causing economic losses in potato, pea, cabbage, ginger, maize, rajmash, apple, apricot, walnut, peach and pear.
- Twelve different insecticides were tested against grubs of *B. coriacea* and *H. longipennis*. Chlorpyrifos 20 EC, acephate 50% + imidacloprid 1.8% SP and clothanidin 50 WDG at recommended doses resulted in 100 per cent mortality among 2nd instar grubs of *B. coriacea*.
- Among the insecticides evaluated against tomato pin worm under protected and open conditions flubendamide 480 SC @ 0.012% and indoxacarb 14.5 SC (0.015%) resulted in 45-52 and 38-44 per cent reduction in fruit infestation, respectively.
- Installing pheromone traps @ 5/ha for monitoring alongwith foliar application of flubendamide 480 SC @ 0.012% at flowering or azadirachtin (@ 0.00045%) at 15 days interval not only reduced incidence of pin worm but also increased the yield and profitability in OFTs under protected and open conditions.
- In parthenocarpic cucumber under protected environment, three organic products namely, *darekastra*, *tamarlassi* and vermiwash (@ 10%) applied as foliar spray initiated 10 days after transplanting at 10 days interval were found to be at par with chemical acaricides (spiromesifen 0.02% and fenazaquin 0.01%) with respect to bio-efficacy and crop yield. Based on two year evaluation, these products were found suitable for incorporation in mite management programme under protected environment.
- Among the insecticides tested against aphids in sarson crop, oxydemeton methyl and dimethoate recorded the lowest index of aphid (0.88 and 0.92/plant), respectively followed by quinalphos. Among the plant extracts, 5% ARE (aqueous root extract of sweet flag) registered the lowest index of aphid i.e. 1.74 aphid index per plant whereas the treatment containing biopesticide neemban recorded pooled aphid index of 1.32/plant.

Weed Management

- A new herbicide combination product having Halauxifen methyl + Florasulam+ carfentrazone+ surfactant was found to be highly effective for managing complex weed flora in wheat.

- A new herbicide combination product having Halauxifen methyl + Florasulam+ carfentrazone+ surfactant was found to be highly effective for managing complex weed flora in wheat.
- In the conservation agriculture system, **zero tillage with integrated weed management** in both maize and wheat crops resulted in significantly higher wheat grain equivalent yield with an increase of about 13% over conventional tillage followed by recommended herbicide in both the crops.
- For control of broadleaved weeds in barley, best results were obtained with the application of new herbicide i.e. Halauxifen methyl + Florasulam+ Carfentrazone +Surfactant.
- In order of preference **early post emergence imazethapyr @ 80 g/ha, imazethapyr @ 70 g/ha, pre-emergence** pendimethalin + imazethapyr @ 900 and 800 g/ha and pre-emergence imazethapyr @ 70 and 60 g/ha may be recommended for effective weed management in peas.
- No residual effect of **Tembotrione @ 130 g/ha** applied to maize was observed on the growth and yield of succeeding wheat and sarson crops and weeds associated.
- Application of either pendimethalin @ 1.0 kg/ha (pre-emergence) fb. metsulfuron methyl @ 4 g/ha (post-emergence) or isoproturon @ 1.0 kg/ha with metsulfuron methyl @ 4 g/ha as post emergence are the best options to control weeds and realizing better seed yield of linseed with higher economic returns under irrigated condition.
- The pooled analysis of two locations viz. Bajaura and Malan for two years show that there is a significant effect of micro-herbicides application on the broad leaved weeds in wheat grain yield. The highest grain yield (46.05q/ha) can be obtained with the application of Halauxifen + Florasulam (10.21g/ha) + Carfentrazone (20g/ha) + surfactant followed by Halauxifen + Florasulam (12.76 g/ha) and Metsulfuron (4g/ha) + Carfentrazone (20g/ha). The herbicide application at 2-3 leaf stage of weeds can increase the grain yield up to 34.02 % as compared to weedy check.

AGRICULTURAL BIOTECHNOLOGY

- **Development of a diagnostic technique for fast, economic and accurate detection of pea wilt pathogen *Fusarium oxysporum* f. sp. *pisi* using DNA-based markers**

A polymerase chain reaction - restriction fragment length polymorphism (PCR-RFLP) based method was developed to detect *F. oxysporum* f. sp. *pisi*, the pea wilt pathogen from Himachal Pradesh, India. Innovation involves three methods, one each for detection of i. isolated *F. oxysporum* f. sp. *pisi*, ii. *F. oxysporum* f. sp. *pisi* in planta i.e. from infected plant tissues and iii. *F. oxysporum* f. sp. *pisi* from soil. This is the first report on molecular diagnostics for this pathogen.

- **Detection of isolated *F. oxysporum* f. sp. *pisi***

A PCR-RFLP marker, HPACAPS1₃₈₀, generated after restriction of 28S rDNA region with enzyme *MvaI*, diagnosed accurately the *Fop* among several other fungi with detection sensitivity of 5 fg of *Fop* genomic DNA. In a mixture of *Fop* and pea DNA, the sensitivity was 500 pg of *Fop* DNA in 50 ng of pea DNA.

- **Detection of *Fop* in planta and from soil**

For detection from infected plant tissues, the infected roots of pea were incubated at 25±1°C for 24 h followed by DNA isolation, PCR and PCR-RFLP. The diagnostic marker HPACAPS1₃₈₀, was present in case of infected roots whereas it was absent in case of non-infected roots. The detection sensitivity was further improved when the incubation period was further increased to 48 h. For detection of the presence of *F. oxysporum* f. sp. *pisi* in soil, the soil was cultured on *Fusarium* selective medium and DNA was isolated from microbes that grew on the medium. This DNA was used in diagnostic assay. The soil infested with *F. oxysporum* f. sp. *pisi* had the presence of diagnostic marker, HPACAPS1₃₈₀ whereas the soil infested non-pathogenic *F. oxysporum* did not have the diagnostic marker.

- **Advantages over traditional diagnostic assay**

The current assay can detect *Fop* from culture, plant tissues and soil in a considerably shorter period of time compared to the traditional method. The traditional method requires more than 60 days. Detection of *Fop* using the current technique could be completed within two days after isolation of the pathogen. By using fast digest enzymes (Thermo Fisher Scientific Inc, MA US), the detection time could further be reduced to one day. Similarly, detection of the pathogen in planta can be accomplished in four days (two days for tissue incubation and two days for detection) and did not require pathogen isolation. Detection of pathogen from soil using the current assay needs 20 days, none the less, it saves 40 days compared to traditional method that requires about two months.

- **Flower development stages in chickpea**

In a significant development in reproductive biology of chickpea, flower development in chickpea was elucidated and classified into 11 development stages (7-18) based on landmarks in chickpea flower development. The development of stamens and pistil, inception of stigma receptivity, anther dehiscence are also

reported. The study of flower development stages also led to the elucidation of sequence of events by which chickpea ensures pollination. The pollination in chickpea is governed by a series of events ensuring synchronous elongation of stamens and pistil, and inception of stigma receptivity and dehiscence. Whole of this process takes about 24 h or less to accomplish. This is the first conclusive report on flower development in chickpea.

- **Anther and pollen development stages in chickpea**

In another breakthrough, anther/pollen development stages in chickpea were also discovered. The stages involving microsporogenesis and male gametogenesis were elucidated. Chickpea anther development from microspore mother cell to dehiscence was ascribed into 14 stages (stage 4-14c). The study also describe the meiosis, tetrad formation, young microspore formation, mature pollen grain formation and tapetum degeneration etc. The study can be used to understand gene regulatory networks in chickpea floral organ differentiation and development as well as those governing abiotic stress induced disruptions in male gamete formation and dehiscence. The study also demonstrated that there was a direct correlation between flower length and anther development and this knowledge will provide a convenient tool for predicting anther development stages in chickpea without anther sectioning. This is the first report on identification of anther and pollen developmental stages in chickpea.

VEGETABLE CROPS

- Garden pea variety, Palam Triloki (early season) and Palam Sumool (Mid-season) has been notified by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Horticultural Crops in the 25th meeting held at New Delhi on 18.9.2017 and vide Statutory Order S.O. 261 E dated 16th January 2018 by Ministry of Agriculture and Farmers Welfare, New Delhi.
- Isogenic line of commercial garden pea variety Lincoln namely, line 1-2 has out yielded the commercial check variety, Azad Pea-1 with yield advantage of 24.36 per cent at KVK Bara, 25.66 per cent at KVK Mandi (Sunder Nagar), 28.60 per cent at KVK Una and 32.93 percent at KVK Berthin. Line 1-2 exhibited high shelling percentage, more number of pods per plant, more number of seeds per pod, high average pod weight and showed resistance to powdery mildew disease under field condition in comparison to the commercial variety Azad Pea-1.
- Two lines of garden pea namely, DPP-SP-6 and DPP-SP-22 have been identified as the most promising lines with superior pod yield at Kukumseri (Lahaul & Spiti), Palampur, Berthin and Sundernagar. At Kukumseri during summer 2017, DPP-SP-6 recorded yield advantage of 24 and 7 per cent over the most promising varieties Pb-89 and Azad P-1, respectively while DPP-SP-22 had increase in the yield to the extent of 19 and 3 % over the respective checks. Both the lines were also found to be most promising for pod characteristics namely, pod length, seeds/pod, shelling percentage and lush green pod colour with sweetness (TSS). During winter 2017-18, DPP-SP-6 and DPP-SP-22 with respective increase of 19 and 14 per cent at Palampur, 38 and 51% at Sundernagar, and 17 and 27 % at Berthin over Pb-89.
- Edible pod pea line DPEPP-15-1 produced maximum pod yield at Palampur and Sundernagar while DPEPP-10-1 was the most promising for pod yield and other traits at Berthin during winter 2017-18. These lines significantly surpassed Arka

- Apoorva from IIHR. Also, DPEPP-15-1 was the most promising for pod yield with yield advantage of 19% at Kukumseri during summer 2017.
- F₁ cross combinations of cabbage *viz.*, SI I-4-4 × Glory-7, SI I-4-3 × KGAT-1 and SI III-I-I × KGAT-1 under organic conditions and SI I-4-6 × Glory-7, SI III-I-I × KGAT-1 and IIIM CMS × E-1-1&-2 under inorganic conditions were the most promising for head yield and surpassed the standard checks (Varun and KGMR-1). Overall, SI III-I-I × KGAT-1 was the most promising cross combination under both the conditions.
 - The entries of garden pea ‘DPP-2011-SP-22’ and ‘Line 1-2’ were promoted to AVT-I under All India Coordinated Research Project on Vegetable Crops.
 - CMS system introgressed in different inbred lines of cauliflower, cabbage and broccoli were back crossed with respective recurrent parent to isolate isogenic lines with cytoplasmic male sterility.
 - Cauliflower hybrid combinations (F₁) namely, CMS-5 × DPCaY-7 (550.14q/ha), CMS-2 × DPCaY-6 (540.32q/ ha) and CMS-3 × DPCaY-7 (510.03q / ha) produced curd yield at par with the best hybrids of private companies used as checks.
 - Brinjal rootstock VI-047335 was found to be the most compatible rootstock for tomato scion GS-600.
 - Slant cut grafting was observed as the best grafting technique for yield and quality traits, followed by cleft grafting technique in cucumber.
 - The grafted tomato resulted in a cost-benefit ratio of 1:2.35 which was significantly higher than non-grafted tomato (1:1.79) under protected environment.

Organic Agriculture and Natural Farming

- Out of the 12 genotypes of fababean tested under organic conditions HB-19, NDE-10 & HB-32 were found significantly superior to the check HPB-1 (47.41 a/ha) by giving 62.50, 54.91 & 54.63 q/ha of yield.
- Among 13 genotypes of lentil evaluated under organic and zero budget natural farming conditions, HPLO-1 (12.50 q/ha) and HPLO-2 (10.50 q/ha) were superior under organic conditions while under zero budget natural farming conditions HPLO (8.33 q/ha) and DKC 13-12 (7 q/ha) were higher yielder.
- In garlic and onion, four different organic liquid manures *viz.* Himsol, Biosol, Matka khad & Compost tea were evaluated at two intervals *i.e.* 15 & 30 days. Application of vermiwash at 15 days interval (6 sprays) produced significantly highest bulb yield of 88.4 q/ha in garlic and 181.9 q/ha in onion followed by vermiwash spray at 30 days interval (3 sprays) which resulted in 74.8 q/ha yield in garlic.
- In an experiment on testing of organic inputs *viz.* Bio-gold and Phosphate Rich Organic Manure (PROM) in pea and potato, it was observed that both these products were as good as standard organic treatment in recording significantly higher growth, yield attributes and yield in both the crops as compared to the farmer’s practice and inorganic treatment.
- In a weed management experiment in garlic, it was found that one weeding after 30 days of transplanting and mulching of lantana @ 25t/ha thereafter produced significantly highest bulb yield (150.0 q/ha) followed by 118.0 q/ha from five weedings.
- Developed buckwheat line Sangla B-444 through selection which is proposed as IVT entries this year.

Farm Mechanization

- SPRERI Cook stoves were evaluated at farmer's level and it was found that the use of improved fuel-efficient SPRERI stoves can reduce the production of smoke and harmful gases within households, reduce the use of biomass by up to 45-50% percent (wood, crop waste, dung etc), reduce cooking cycle times, and create significant household safety as compared to traditional ones.
- Agricultural accidents survey was carried out in four panchayats of Kangra district of Himachal Pradesh. A low mechanization status was assessed in studied panchayats. Major injury of farmers during agricultural operation was reported due to snakebite (20.83%) followed by 17.71% injury due to fall from tree (for fodder), 9.38% from cattle hit, 8.33 % during use of power tiller and 6.25% from sickle/spade. These accidents/injuries led to poisoning (26.04%), fracture (22.92%), internal injury (17.71%) major cuts (16.67%) and arm/leg damage (15.63%). Most of accidents/injury were due to ignorance (52.08%) followed by carelessness (46.88%), lack of safety devices (37.50%) and lack of protective covers (20.83%).
- Health and nutritional status of sixty farm women of Mandi District was assessed. Anthropometric status of farm women was below national standards. Physical fitness rating showed that 48.33% had high average rating followed by 18.33% having good fitness. Majority of the respondents showed deficiency of vitamins B₁ B₂ and B₃ as well as of vitamin C. Health ailment status revealed that 86.67% suffered from backache followed by joint pain (71.67%), breathlessness (70.00%), body ache and headache (60% each). Drudgery assessment of farm women in agriculture and allied activities was worked out by assessing perceived exertion and overall discomfort in different farm and household activities. Agricultural activities/operations were experienced as moderately heavy to heavy types in exertion by farm women followed by livestock activities and household chores.

Centre for Geo-informatics Research and Training

- Web GIS Portal for Himachal Pradesh Crop Diversification Project (HPCDP) now contains spatial and attribute information of the proposed and actual project sites (completed till now) spread over five districts namely Kangra, Mandi, Bilaspur, Una and Hamirpur of Himachal Pradesh. The web Portal link is <http://14.139.224.135:6090/myapp/cgrtjica>
- Methodology framework for mapping land use, water, soil, habitation, assets etc on high resolution satellite imagery and integrating all data to the lowest unit of land record i.e. khasra at cadastral for Village Information System is being standardized under a DST funded project on Village Information System. http://14.139.224.135:6090/cgrtgis/vis_hp/.
- Five days forecasts on different weather parameters viz. rainfall, temperature, cloud cover, relative humidity and weekly cumulative rainfall for the districts Chamba, Kangra, Hamirpur and Una were validated and weather based agro-advisory prepared
- A total of **64** Agro advisory bulletins based weather forecast were prepared and published in English and Hindi for Chamba, Una, Hamirpur and Kangra districts of H.P. during Rabi 2017 for October to May, 2018 **and** also uploaded on the university website (www.hillagric.ac.in) /kisanokeleye and www.imdagrimet.gov.in. Kisan Portal (www.farmers.gov.in);

www.weathershimla.gov.in and mkisan.gov.in and www.cropweatheoutlook.com of CRIDA (ICAR) websites.

- 9 SMS were sent to 2.79 lakhs registered farmers of Chamba, Una, Hamirpur and Kangra districts through MKisan Portal of MOA, GOI, New Delhi during Rabi 2017 for October to May, 2018 farmers.
- The genetic coefficients for Info Crop and DSSAT models were developed from the fields experiments conducted during 2016-17 for wheat. In wheat crop, range of values of Genetic Coefficient derived varied between P1V (0t0), P1D (5.36-5.40), G1 (1.85 to 1.9), G2 (10.1 to 10.2), G3 (3.6 to 4.0) and PHINT (75 to 78) for Palampur agro-climatic conditions for both varieties HPW-42 and HPW-155. The Leaf areas of Wheat of different sites periodically were collected.

Agricultural Economics

- A study on vegetable marketing in Kangra district showed that the producer's share in consumer's rupee varied from 61 to 71 per cent in summer vegetables and 58 to 62 per cent in winter vegetables when the commodities were sold through commission agents (channel-II). However, the producer's share was fairly high (90 to 91%) in channel-IV (direct sale) for both summer and winter vegetables.
- A study of climate change impacting agrarian economy in Western Himalayas revealed that the climatic factors have positively impacted the production of most of the crops except for significant negative impact in maize crop. The benefit:cost ratio for expected profits over cost incurred on adaptation strategies were 7.22, 1.94 and 1.75 in Zone I, Zone II and Zone III, respectively.
- Economic analysis of tomato under protected and open environment in Kangra District, H.P. showed that protected cultivation contributed 10.68 per cent in the total annual gross household income of the polyhouse growers, at overall level. Large polyhouse category earned higher proportion (14.52 %) as compared to small category (7.02 %). The income variability of polyhouse growers was found to be less in comparison to the open field growers.
- A study on post-harvest losses in marketing of vegetables in Chhota Bhangal area of District Kangra showed that total post-harvest losses of vegetables were 9.77 q/ household on all farms and varied from 5.74 q/ household on small farms to 19.28 q/ household on large farm category. The total physical post-harvest loss of 20.50 kg/ q valued at Rs 1201 was found to be highest in coriander crop. It was followed by broccoli with total loss of 18.97 kg/ q (Rs 462/ q), cauliflower with total loss of 18.96 kg/ q (Rs 331/ q), cabbage with total loss of 18.38 kg/ q (Rs 250/ q), potato with total loss of 15.02 kg/ q (Rs 157/ q) and 13.98 kg/ q (Rs 156/ q) of the losses in radish crop.
- A study on farm mechanization in Himachal Pradesh Crop Diversification Promotion (HPCDP) project districts revealed that out of the total investment on farm implements and tools only eight per cent was made on improved ones. The level of possession of usable power operated farm machinery and equipment to perform the major farm operations in the project area was quite low. Except chaff – cutter no other major machinery such as power tiller, potato digger, seedling transplanter, sprayer (power), field leveler etc. was in the possession of farmers both at the village level as well as in the project area.
- An evaluation study of medium lift irrigation project Bassi, Tehsil Shri Naina Deviji, district Bilaspur, Himachal Pradesh revealed that the gross household income of the project beneficiaries was estimated at Rs.5,82,714 of which farm

income accounted for about 33.51 per cent. This included 6.98 per cent from the agriculture, 22.42 per cent from livestock, 0.06 per cent from horticulture and 4.05 per cent from agro-forestry. Further, these results showed that the production of beneficiaries was higher than non-beneficiaries in the study area.

- In a study on beekeeping, the cost of honey production was observed to be Rs. 136 per kg. The output-input ratio stood at 1.60 which clearly showed that it is a profitable enterprise. The contribution of beekeeping in household income was 35 per cent on small beekeepers to as high as 88 per cent on large beekeepers. However, at the overall level the contribution of beekeeping in household income was 69 per cent.
- In district Kullu, total per hectare labour requirement for pea, tomato, cauliflower and garlic was 126, 227, 231 and 215 man days in which the share of female labour was 60, 48, 50 and 61%, respectively, whereas, per hectare labour requirements for pea, potato and cauliflower in L&S was 123, 123 and 210 man days of which 28, 11 and 6% labour was hired-in and the share of female labour was 44, 52 and 48%, respectively.
- Total labour required for livestock management was 9.23 and 17 hours per day per farm of which 71 and 37% was provided by females respectively in Kullu and Lahaul-Spiti districts.
- In district Kullu only about 33% women had an access to the household capital as against 89% in Lahaul-Spiti. 49% and 47% of the women had an access to land, but, only 1% and 2.67% women had land registered in their own names, respectively. Only 40% of the sampled women in Kullu and 19% in Lahaul-Spiti had an access to technical/professional skills.

Future Research Priorities

Crop Improvement

- Continuation of breeding work for development of high yielding and disease resistant varieties of wheat, barley, oats, brassicas, chickpea and important vegetable crops.
- Development of horticulturally desirable hybrids of cauliflower, cabbage and broccoli by using different genetic mechanisms.
- Collection, evaluation, maintenance and conservation of germplasm of different vegetable crops.
- Identification of high yielding lines of minor vegetables like lettuce, fennel, faba bean etc.
- Nucleus and breeder seed production of different released varieties.

Crop Production

- Development and validation of On-Station Integrated Farming System Model
- Identification of need based cropping systems for different agro-climatic conditions.
- Weed management in potato and orchards
- Organic weed management in maize-pea sequence
- Optimizing nutrient requirements through innovative organic and inorganic fertilizer products in wheat

- To study long term effects of fertilizer treatments on soil health and productivity in wheat
- To study the effects of Zn, B and Mo application on soil health and productivity in wheat, cauliflower and tomato
- To develop target yield based fertilizer prescription equations in garlic

Crop Protection

- Survey and surveillance of insect pests and emerging pests infesting different crops
- Management of termites in wheat, cutworms in cabbage, lepidopteran pests in cole crops, pests of tea through biopesticides, natural products and newer insecticides
- Studies on residue dynamics of some insecticides on cole crops
- Evaluating impact of neonicotinoids on honey bees
- Monitoring of diseases of different rabi crops with special emphasis on yellow rust and Karnal bunt of wheat
- Management of important diseases of rabi crops (cereals, oilseeds, pulses and vegetable crops)
- Germplasm evaluation of different crops for resistance sources against different diseases

Protected Cultivation

- Production technology of important vegetable crops for protected environments
- Insect-pest and disease management technology
- Evaluation of natural products and biopesticides against greenhouse whitefly in cucumber under protected environment

Organic and Zero Budget Natural Farming

- Development & standardization of the cultivation technologies for different crops
- Evaluation of the quality of dung and urine of *Pahadi desi*, Sahiwal, mixed breed and Jersey cows *w.r.t.* the microbial population and nutrient status
- Technologies for management of insect-pest & diseases under ZBNF system.
- Comparative economics of Zero Budget Natural Farming, organic farming and inorganic farming
- Studies on the effect of different farming practices (including ZBNF) on the population dynamics of insect-pests infesting garden pea
- To work out the comparative economics of Zero Budget Natural Farming, organic farming and inorganic farming
- To enhance capacity building under Zero Budget Natural Farming

Farm Mechanization

- Evaluation of Garlic Planter for cultivation of garlic.
- Collection of strength parameters of agricultural workers in Himachal Pradesh.
- Construction and Evaluation of dry fermentation based 5 m³ biogas plant.
- Demonstration and ORP of solar gadgets and improved cook stove.

On Going Research Projects

<i>S. No.</i>	<i>Particulars</i>	<i>No. of Projects</i>	<i>Budget Outlay (in lakhs)</i>
<i>ICAR Funded Projects</i>			
<i>1.</i>	<i>AICRPs</i>	<i>33</i>	<i>1422.00</i>
<i>2.</i>	<i>Adhoc Projects</i>	<i>11</i>	<i>510.96</i>
<i>DBT Funded Project</i>		<i>6</i>	<i>236.32</i>
<i>DST Funded Projects</i>		<i>12</i>	<i>341.48</i>
<i>UGC funded projects</i>		<i>1</i>	<i>13.71</i>
<i>CSIR</i>		<i>1</i>	<i>3.99</i>
<i>Miscellaneous Adhoc Projects</i>		<i>68</i>	<i>1064.54</i>
<i>RKVY Projects</i>		<i>12</i>	<i>508.84</i>
<i>Total</i>		<i>145</i>	<i>4091.84</i>

New Recommendations

Programme area	Variety/ Recommendations
Crop Improvement	Release proposal of Indian Mustard variety Trombay Him Palam Mustard-172 (THPM-172) for cultivation in Low & Mid hills of H.P. under Timely sown, irrigated conditions