RESEARCH ACHIEVEMENTS DURING RABI-2021-22

AND

RESEARCH PROGRAMMES FOCUSING RABI 2022-23

Rainfall Pattern

During *kharif* 2021, the monsoon withdrew from the state on 8th October though the normal date of withdrawal i.e. 21st September. During *rabi* 2021-22 (1st October 2021 to 31st May 2022) the total rainfall received in the state of Himachal Pradesh was 390.2 mm which was 26 % lower than the normal rainfall received during this period (527.7 mm). The trend was similar to that observed during *rabi* 2020-21 during which a total rainfall of 353.6 mm was received which was 33% lower than the normal. There were significant variations in the monthly rainfall received all over the state during this *rabi* season. Of the eight months of the season, the state received excess (+20%) rainfall during two months of October 2021 and January 2022; February 2022 & May 2022 received deficit (-20 to -59%) rainfall while the remaining months of November 2021, December 2021, March 2022 and April 2022 received scanty (-60 to -99%) rainfall.

In October 2021, all the districts received either excess (+20%) or normal (-19 to +19%) rainfall while during November 2021, all districts received either scanty (-60 to -99%) or no (-100%) rainfall. During December, 2021 eight out of 12 districts viz., Bilaspur, Chamba, Hamirpur, Kangra, Shimla, Sirmaur, Solan and Una received scanty (-60 to -99%) rainfall whereas Kinnaur, Lahaul & Spiti and Mandi received deficit (-20 to -59%) rainfall. Kullu was the only district that received normal (-19 to +19%) rainfall in the month of December 2021.

During January 2022, all the districts received either excess (+20%) or normal (-19 to +19%) rainfall. During February 2022, 7 out of 12 districts (Bilaspur, Kullu, Mandi, Shimla, Sirmaur, Solan and Una) received either excess (+20%) or normal (-19 to +19%) rainfall while the remaining five districts (Chamba, Hamirpur, Kangra, Kinnaur and Lahaul & Spiti) received deficit (-20 to -59%) rainfall. During March 2022, all the twelve districts received scanty (-60 to -99%) rainfall. Since most of the cultivated area in Himachal Pradesh has limited or no assured irrigation facilities, the scanty rain and/or snow in the state in the season had an adverse effect on various crops viz., wheat, barley, peas, cauliflower, garlic, tomato, apple, almond, plum, apricot, cherry and pear. The wheat crop also experienced forced maturity in low hills due to above normal temperature and prolonged dry spell. As a result of this farmers in some pockets were forced to harvest their crop before maturity.

During April 2022, all the districts received scanty (-60 to -99%) rainfall. During May 2022, five districts of Kangra, Mandi, Shimla, Sirmaur and Solan received excess (+20%) rainfall, Bilaspur and Kullu received normal (-19 to +19%) rainfall, four districts of Chamba, Hamirpur, Kinnaur and Una received deficit (-20 to -59%) rainfall while Lahaul & Spiti was the only district to have received scanty (-60 to -99%) rainfall. Excess rainfall and hailing in most of the districts of the state adversely affected the wheat crop with the worst affected districts been Hamirpur, Bilaspur, Mandi, Kangra and Una.

Lecture delivered by Dr. S.P. Dixit, Director of Research, CSK HP Krishi Vishvavidyalaya, Palampur in the Agricultural Officers' Workshop on Rabi Crops held at CSK HPKV, Palampur on September 28, 2022.

Table 1: Monthly rainfall during Rabi 2021-22 as compared to Rabi 2020-21 in Himachal Pradesh

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Seasonal total
Actual (mm)									
2021-22	56.9	1.1	17.6	172.6	78.1	5.4	7.3	51.2	390.2
2020-21	0.4	43.1	34.3	37.6	19.3	41.7	113.4	63.8	353.6
Normal (mm)	27.5	20.3	43.8	89.9	102.8	110.9	65.7	66.8	527.7
Departure (%) from normal									
2021-22	107	-95	-60	92	-24	-95	-89	-23	-26
2020-21	-99	112	-22	-58	-81	-62	73	-4	-33

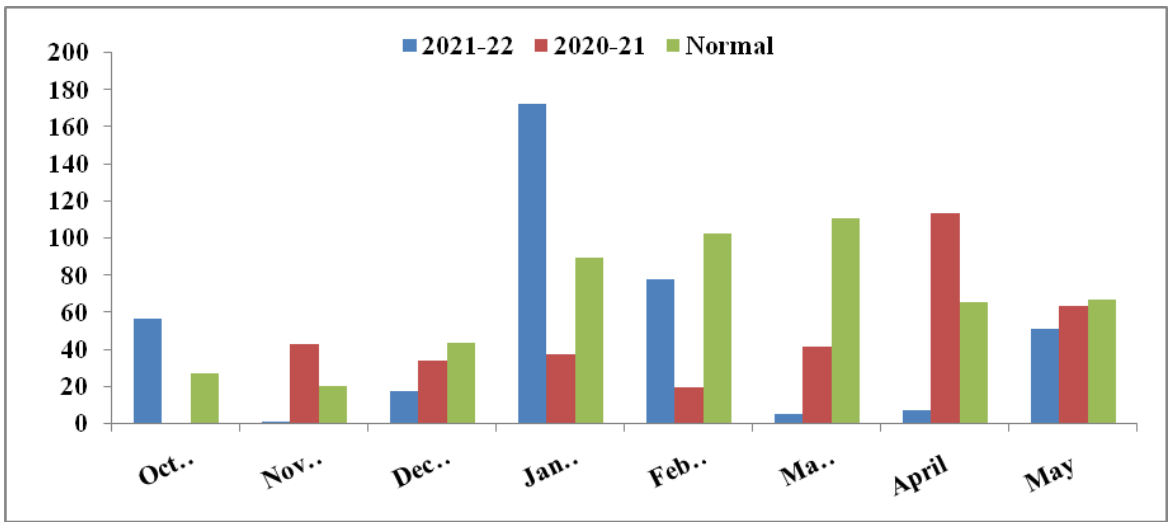

Fig 1. Rainfall (mm) during *rabi* season 2018-19 and 2019-20

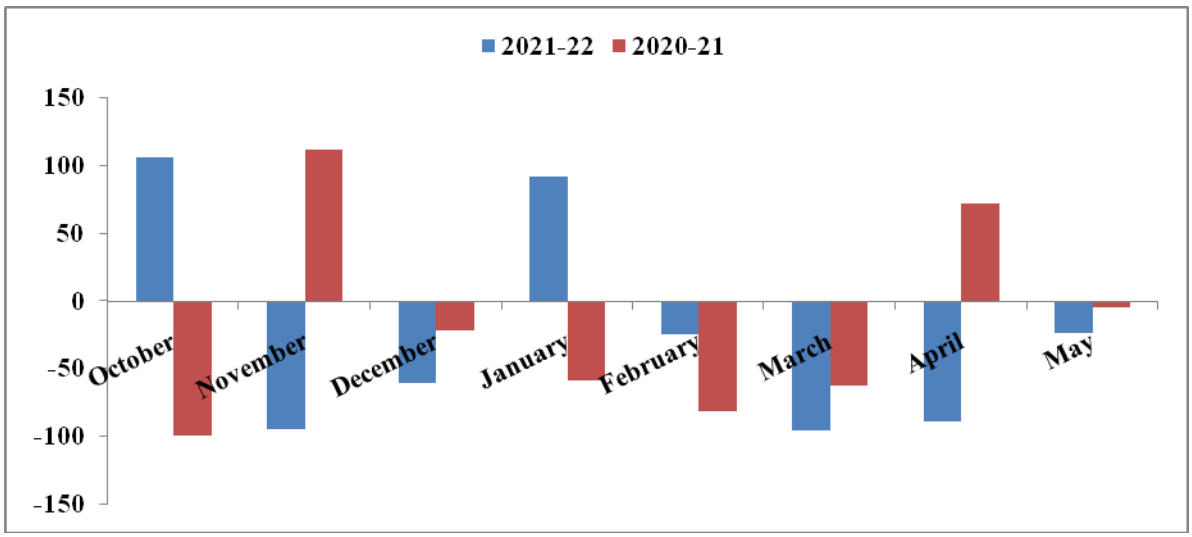

Fig 2. Rainfall departure (%) during *rabi* season 2018-19 and 2019-20

RESEARCH HIGHLIGHTS: *RABI* 2021-22

Significant research accomplishments for different ongoing programmes of the University during *rabi* 2021-22 are given as under:

CROP IMPROVEMENT

Cereals

Wheat

- Him Palam Gehun 3 (HPW 373), a promising wheat variety having average grain yield of 25-30 q / ha under late sown rainfed conditions of mid and low hills of Himachal Pradesh with high degree of resistance to yellow rust and brown rust has been approved in the 88th meeting of Central Sub Committee on Crop Standards on 17-06-2022 for notification.
- A high yielding yellow rust resistant genotype HPW 484 (Trombay Him Palam Gehun 4) having highest zonal mean grain yield (35.1 q/ha) has been found to be significantly superior to the best check variety HS 562 (33.1 q/ha) under timely sown rainfed conditions of NHZ in the All India Coordinated Trials.
- High yielding yellow rust resistant genotype HPW 481 having high zonal mean grain yield (26.2 q/ha) was found to be significantly superior to the check variety HS 490 (22.3 q/ha), while statistically at par with the check variety VL 892 (25.1 q/ha) under late sown restricted.

Barley

- The dual purpose barley variety HBL 804 (Him Palam Jau 2), 6 rowed developed at HAREC, Bajaura found suitable for cultivation under timely sown rainfed conditions in low and mid hills of Himachal Pradesh having medium bold spikes with good tillering capacity with an average green fodder yield of 25-30 q/ha and grain yield of 20-25 q/ha, high degree of resistance to stripe and brown rust and desirable quality with crude protein content of 9.9% has been approved in the 88th meeting of Central Sub Committee on Crop Standards on 17-06-2022 for notification
- Two entries of barley namely HBL 876 and HBL 875 developed by HAREC, Bajaura ranked 2nd and 3rd, respectively in AICRP-IVT-RFTS dual purpose trials in North Hill Zone, whereas, HBL 877 ranked 1st in overall fodder yield.

Oilseeds

Gobhi Sarson

- Him Palam Gobhi Sarson-1(AKMS 8141) variety of Gobhi Sarson has been approved in the 87th meeting of Central Sub Committee on Crop Standards held on 18-10-2021 for release and notification. It is suitable for cultivation in Himachal Pradesh, Punjab and Jammu and Kashmir. This variety has the potential to yield 15-16 q/ha. It is earlier in maturity and shorter in height than the existing varieties of Gobhi sarson GSC 7 and Him Gobhi Sarson 1. It exhibited 7- 8 % erucic acid and less than 30 micro moles of glucosinolates/gram in defatted seed meal.
- Him Palam Gobhi Sarson 2 composite variety having an average yield of 18.47 q/ha, resistant to white rust and downey mildew has been identified for Himachal Pradesh, Punjab, Jammu & Kashmir during 29th Annual Group Meeting of AICRP on rapeseed mustard held at Rajasthan Agricultural Research Institute (RARI), Durgapura, Jaipur w.e.f. August 1-3, 2022.

Mustard:

- Trombay Him Palam Mustard-1(THPM-1) variety of mustard has been approved in the 87th meeting of Central Sub Committee on Crop Standards held on 18-10-2021 for release and notification. The variety is suitable for cultivation in low and mid-hill areas of

Himachal Pradesh under timely sown irrigated conditions.This variety is an addition to the existing variety RCC-4 and has an average seed yield of 11.2 q/ha and oil content of 39.9%. The overall disease reaction against *Alternaria* blight (leaves) and white rust (leaves) under field conditions remained similar to RCC-4. The variety recorded mean minimum population of aphid complex (*Lipaphis erysimi* and *Brevicoryne brassicae*) per central twig in comparison to RCC-4.

- At Dhaulakuan, twenty eight entries of Mustard in IVT were tested along with three checks. Seven entries viz; JM 16-3, HUJM 20-9,KMR 21-4,KMR 21-3,SKM 1744, SKM 1934 and RH 1934 were found promising and significantly superior over checks.
- Twelve entries of Mustard in AVT were tested along with four checks. Only two entries viz. PBR 383 and SKM 1626 were found promising and significantly at par with checks.

Fodder

- Oat entry PLP-24 ranked first for green fodder yield (306.7 q/ha), dry matter yield (61.30 q/ha) and crude protein percentage (10.90%) in AICRP-AVTO (MC)-1 trial under hill zone and has been promoted to AVTO (MC)-2.
- White clover variety PWC-25 (Him Palam White Clover-1) has been approved in the 87th meeting of Central Sub Committee on Crop Standards held on 18-10-2021 for release and notification. It is suitable for pastures, grassland, wastelands and orchards of sub-temperate and temperate regions of hill zone comprising Himachal Pradesh, Uttarakhand and UT of Jammu & Kashmir. It is a fast growing legume, medium broad leaves, long leaf petiole, vigorous growth habit, better regeneration capacity and yields 450-475 q/ha of green herbage in 3-4 cuttings and moderately resistant to powdery mildew, tolerant to cold, lodging and frost and no major pest has been observed. It can be used as palatable fodder and has crude protein content of 19-20% on dry matter basis.

SEED PRODUCTION AND SEED TECHNOLOGY

NUCLEUS AND BREEDER SEED PRODUCTION

Nucleus seed production

- During Rabi 2021-22, a total of 3364.70 kg Nucleus seed of cereals, pulses, oilseeds and fodder crops was produced by the University.

Breeder seed production

- The University produced a total of 51150 kg breeder seed of cereals, pulses, oilseeds, fodder and vegetable crops during *rabi 2021-22 (*Table 2).

Table 2: Breeder Seed (kg) of cereals, pulses, oilseeds, fodder and vegetable crops produced during Rabi 2021-22.

Crop	Variety/Hybrid	Total Breeder Seed Produced (kg)
Cereals		
Wheat	HPW 249, HPW 349, HPW 360, HPW 368, HPW 373, DBW 88, HD 3226, WH 1080, Him Pratham (HD 114)	48538
Barley	HBL 276 (Harit), HBL 713 (Him Palam Jau 1), HBL 804 (Pusa Losar), HBL 113, HBL 391	1776
Total		**44366**

Pulses		
Gram	HC 2, HPG 17, GPF 2, DKG 986 (Him Palam Chana 1)	1391
Lentil	Vipasha (HPL 5), Markandey (EC 1)	461
Total		**1852**
Oilseeds		
B Sarson	KBS 3, HPBS 1	92
G Sarson	ONK 1 (HS 1), GSC 7	857
Karan Rai	Jayanti	57
Raya	RCC 4	44
Linseed	Himani (KL 214), Him Palam Alsi 1, Him Palam Alsi 2, Nagarkot, Surbhi (KL 1)	665
Total		**1715**
Fodder		
Fodder (Oats)	Plp 1, Kent	1793
White Clover	PWC-25	10
Tall Fescue Grass	Hima 14 (Palam Fescue Grass 2)	10
Rye Grass	Him Palam Rye Grass 1	30
Total		**1843**
Vegetables		
Palak	Pusa Harit	290
Broccoli	Palam Vichitra, Palam Samridhi	3
Chinese cabbage	Palampur Green	12
Radish	J. White	30
Pea	PB 89, Him Palam Matar 1, Him Palam Matar 2	300
Onion	Palam Lohit	6
Garlic	GHC 1	680
Fenugreek	Palam Saumya, Pusa Kasuri	53
Total		**1374**
Grand Total		**51150**

- A total of 15749 kg foundation seed of cereals, pulses, oilseeds , vegetables and fodder crops was also produced during *Rabi* 2021-22 (Table 3).

Table 3: Foundation Seed (kg) of cereals, pulses, oilseeds, vegetables and fodder Crops produced during Rabi 2019-20.

Crop	Variety/Hybrid	Total Foundation Seed produced (kg)
Cereals		
Wheat	HPW 360, HPW 368, HPW 373, HD 3086, HD 3226, PBW 343 Unnat, PBW 725, HS 562	12213
Barley	HBL 713 (Him Palam Jau 1), BHS 400	345
Total		**12558**
Pulses		
Gram	HC 2, HPG 17, GPF 2, DKG 986 (Him Palam Chana 1), GNG 2144, CSJ 515	1391
Lentil	Vipasha (HPL 5), Markandey (EC 1)	406
Total		**1797**
Oilseeds		
B. Sarson	KBS 33, Leafy Mustard, Chinese sarson	102
G. Sarson	Neelam/HPN 3, ONK 1, GSC 7	649
Mustard	Karan Raya	50
Linseed	KL 263, Surbhi	90
Total		**891**
Fodder		
Oats	Plp 1	245
Total		**245**
Vegetables		
Palak	P. Harit, All Green	258
Total		**258**
Grand Total		**15749**

Seed Technology Research

- Evaluation of early genotypes of garden pea revealed that the cross combination 14 x Mater Ageta -6 took minimum number of days to 50% flowering (88 days) in comparison to other cross combinations and commercial checks viz., Palam Triloki (91 days), Mater Ageta-6 (90 days) and Arkel (103 days).
- Experiment conducted on development of priming technologies in barley revealed that BHS 380 fresh lot hydroprimed for 6 hrs ($V_1L_2H_2$) showed higher first count (98.00%) and germination (98.00%) which was at par with BHS 400 fresh lot hydroprimed for 6 hrs. ($V_2L_4H_2$) for first count (97.67%) and germination (97.67%) as compared to untreated control i.e. $C_1V_2L_4$ - BHS 400 untreated fresh seed lot (95.33%) and higher SVI-I (3008.60) as compared to both the controls i.e. untreated control $C_1V_2L_4$ - BHS 400 untreated fresh seed lot (2736.06) and treated control i.e. $C_2V_2L_4$ - BHS 400 treated fresh seed lot (2816.03).
- Experiment conducted on seed quality assessment of breeder seed samples viz., wheat and mustard revealed that the seed samples of different varieties tested for genetic purity and other quality attributes possessed high quality standards. It was envisaged that such seeds can be utilized for the multiplication of other classes of seed in the supply chain.

- A study conducted on nutrient management through nano fertilizers in wheat during Rabi 2021-22 revealed that plant nutrition impacts the yield and seed quality. All the treatments where fertilizers were used recorded more yield and greater quality parameters than the control (No fertilizers). Treatment {100 % RDF including Zn + Fe (Soil application) + seed coating of nano Zn + Fe @ 62.5 ml per hectare + Foliar spray of nano Zn + Fe (Zinc + Iron) @ 250 ml per hectare (50% Seed coating + 50% Foliar)} was observed to be the best treatment for most of the agronomic, yield and economic traits.

CROP PRODUCTION

Identification of need based cropping systems for different agro-climatic conditions

Among different cropping systems evaluated in 2020-21 and 2021-22, Okra- turnip-tomato resulted in significantly highest maize grain equivalent yield (32.89 q/ha). This cropping system was followed by babycorn- broccolli- frenchbean with maize grain equivalent yield of 24.34 t/ha and hybrid sorghum + hybrid bajra – oats + *sarson* with maize grain equivalent yield of 24.32 q/ha.

Development and validation of On-Station Integrated Farming System Model

In on station IFS model at Badhiarkhar Farm, gross returns of Rs. 4,45,658/- and net returns of Rs. 2,16,691/- were obtained during 2020-21. The highest net return of Rs. 88,376/- was received from Livestock unit and was followed by crops followed forage crop unit.

Effect of IFFCO-nano sources of nutrients on productivity of paddy and wheat

One season study indicated that application of Nano - Urea and Nano – Zinc can enhance the grain yield of wheat. Foliar application of Nano – Urea can reduce the requirement of prilled urea by about 25 %.

Soil, Water and Nutrient Management

- Application of 125% of the recommended dose of nitrogen (N) to wheat crop along with 3 foliar sprays of IFFCO –N plus B @ 0.034% through B-metalosate at critical growth stages significantly increased the grain yield by about 40.5 % over control (100% PK as recommended), respectively.
- In long-term fertilizer experiment, highest productivity of wheat (24 q/ha) was recorded under the treatment comprising continuous application of 10 t FYM ha^{-1} only to maize crop along with 100 % recommended dose of NPK to both the crops.
- Amelioration of soil acidity with periodical application of lime along with 100% recommended dose of NPK also recorded higher yield of wheat (22 q/ha) which was comparable to 100 % NPK + FYM.
- Recommended N (conventional) + two spray of nano urea at tillering and jointing recorded 10.7% higher grain yield (56.72 q/ha) in wheat compared to recommended N (conventional).
- In rice crop, irrigating the crop at critical stages and integrated nutrient management practices was found to be most effective for enhancing the crop and water productivity whereas in case of wheat, irrigation at 1.0 CPE and integrated nutrient management practices was best for obtaining higher crop and water productivity. In a holistic approach, irrigation at 1.0 CPE and integrated nutrient management proved to be the best in enhancing the crop quality and soil health parameters.
- Economically, in rice, irrigation at critical stages and inorganic nutrient management gave higher gross returns, net returns and benefit-cost ratio. However, in case of wheat , irrigation at 1.0 CPE and inorganic nutrient management gave higher economic returns.
- Sulphur applied @ 60.0 kg ha^{-1} produced significantly higher gobhi sarson productivity, with a 19.3% increase over treatment with no S application.
- The study in tomato and cucumber under protected conditions indicated that the

marketable yield was significantly higher under sub surface vermicompost (VC) + 100 % NPK fertigation (6.73 and 6.65 kg/sqm, followed by sub surface VC + vermicompost fertigation (6.51 and 6.42) kg/sqm.

- Application of Mo @ 5.0 kg ha^{-1} registered a significantly higher curd yield in broccoli compared to other Mo levels (0, 0.5, 1.0, 2.5, 5.0, 10.0, and 20.0 kg ha^{-1}), with an increase of 43.3% over control.
- The optimum molybdenum dose of cauliflower for acid soils was worked out to be 5.69 kg/ha against the general recommendation of 1.0 kg/ha.
- The study in cabbage indicated that the marketable yield was significantly higher under surface 0.8 PE fertigation treatment (3026 kg/ha), followed by sub surface 0.4 PE fertigation (2916 kg/ha), surface 0.8 PE conventional (2672 kg/ha) and lowest was under absolute control (1614 kg/ha).
- Under fertigation trial for open cultivated strawberry, it was observed that the crop matures early with 0.8PE irrigation and under black polythene mulch (15-17 days) with higher yield and quality parameters. Although higher yield was obtained under fertigation schedule of 25% NPK basal and 75% NPK but quality was better with integrated nutrient management.
- For marigold under protected condition, 25 % NPK basal + 75 % NPK fertigation+ sub surface drip @ 0.6PE gave better yield and WUE compared to surface and 0.8 PE drip irrigation.
- For cucumber + lettuce intercropping under protected condition an integrated fertigation schedule viz .VC @ 5 t/ha +50 % NPK +75 % NPK and vermiwash in cucumber + Lettuce and surface drip @ 0.6 PE gave higher yield, returns and water productivity as compared to the sole crop of cucumber and lettuce.
- A study for four kuhls (Perennial gravity streams) covering about 5000 ha area in Panchrukhi, Baijnath, Nagrota Bagwan and Kangra blocks of Kangra district indicated that from January to June months, the average discharge rate was 4.09, 4.38 and 2.45 m^3/sec and water depth remained 0.09, 0.08 and 0.16 m respectively. During July to December months, the average discharge rate of 4.23, 2.24 and 2.24 m^3/sec and water depth of 0.19, 0.15 and 0.18 m depths were recorded, respectively.

CROP PROTECTION

Insect –Pest-Management

- For the suppression of termites in wheat, seed treatment with clothianidin 50 WDG @ 1.5 g/ kg seed was found most effective in reducing tiller damage (3.9%) as compared to 10.9 per cent in untreated control.
- The incidence of wheat aphid varied from 4 to 52 per cent (mean 30.8 %) at Kangra. At Palampur, the mean incidence of 40% was observed under natural farming system, being more than that observed under conventional farming (34.7%).
- Mustard aphid infestation varied from 2 to 40 % with seasonal mean of 19%. Infestation was relatively more under conventional farming system (23.7%) as compared to that observed under natural farming system (20.2%) at Palampur.
- Incidence of gram pod borer, *Helicoverpa armigera* recorded at Rampur (Una), Palampur and Jawali (Kangra), Berthin (Bilaspur) and Sundernagar (Mandi) revealed the population levels of 6.5 to 26.8 larvae/ 10 plants at these locations with maximum incidence occurring at Sundernagar. The plant infestation varied from 10 to 79 per cent at different locations.
- For the management of gram pod borer, the insecticidal treatments namely, chlorantraniliprole 18.5% SC (0.25ml/l) and novaluron 5.25% + indoxacarb 4.5% SC (1.65 ml/l) were found to be most effective in checking larval population.

- For the management of cutworm in cabbage, application of clothianidin 50WDG resulted in minimum infestation (2.1%) as compared to untreated control (17.13%) after two weeks of application.
- Monitoring of leaf miner and aphids using yellow water trap and yellow sticky trap in garden pea revealed aphids to be attracted more towards yellow pan trap . Whereas, leaf miner adults were attracted more towards yellow sticky traps.
- For the management of pea leaf miner, insecticide treatment with spinosad 45% SC (0.30 ml/l)was found to be most effective resulting in minimum leaf infestation (3.0%) and higher green pod yield(144.80 q/ha) followed by oxydemeton methyl @ 1.5 ml/l (Metasystox 25 EC) with 5.5 per cent leaf infestation and a yield of 140.70 q/ha green pod.

Disease Management

- For the management of wheat powdery mildew fungicides; azoxystrobin 18.2% w/w + cyproconazole 7.3% w/w SC, tebuconazole 50% + trifloxystrobin 25% WG (Nativo 75 WG) and azoxystrobin 18.2% w/w + difenoconazole 11.4% w/w SC proved to be highly effective in reducing powdery mildew severity with more than 40 per cent reduction over control while all the fungicides enhanced the grain yield by 37-42 per cent over control.
- New fungicide Propiconazole 13.9% + Difenconazole 13.9% w/w (15% w/v) EC) was found effective for the control of yellow rust of wheat as the fungicide provided 92.9 - 93.1 per cent control of yellow rust with 71.5 – 89.2 percent increase in yield at doses 350 ml/ha and 500 ml/ha, respectively.
- Twenty two *Trichoderma* isolates (bioagent) were evaluated against the pathogen *Fusarium oxysporum* causing wilt of tomato under protected cultivation and among all the tested bioagents TI-4 isolate was found to be most effective resulting in 72.60 per cent mycelial inhibition of pathogen followed by TI-7 isolate (60.71 per cent).
- For the management of onion diseases, the fungicide; Metalaxyl-M 3.3 % + Chlorothalonil 33.1 % SC @ 2.0 g/l was found effective as it significantly reduced the purple blotch, downy mildew and stemphylium leaf blight diseases (85.2-87.2, 86.9-91.3 and 86.9-90.9%, respectively) and considerably increase the bulb yield (86.4%).
- Mango + Poplar was considered as the best substrate for making synthetic logs and cultivation of shiitake mushroom because of maximum yield and biological efficiency (100 g/300 g) which was significantly superior from all other individual substrates and their combinations.
- The organic inputs *viz;* Tamarlassi, Bijamrit, Biosol, Vermiwash, Jeevamrit and Eucalyptus ark evaluated under *in vitro* conditions against *Stemphylium* leaf blotch pathogen. Eupatorium ark was most effective with complete mycelium inhibition at 10 per cent concentration followed by Jeevamrit with 88.78 per cent mycelial inhibition at 25 per cent concentration.
- New fungicide GLOIT 30% w/v EC [Propiconazole 13.9% (15% w/v) + Difenconazole 13.9% w/w (15% w/v) EC] was tested for its bioefficacy and found effective for the management of yellow rust in wheat.

Weed Management

Evaluation of new herbicides for weed control in linseed

Post emergence application of clodinafop + metsulfuron-methyl 60 g+4 g/ha at 2-3 leaf stage of weeds gives significantly lower count of all major weeds *viz. Lolium temulentum, Phalaris minor, Avena ludoviciana, Tulipa asiatica, Spergula arvensis* and, *Plantago lanceolata* proved effective for the control of mixed weed flora in linseed. It has been recommended at national level this year too.

Diversity of weeds in different cropping systems under natural farming

Weed flora was composed of 15 species during *kharif* and 13 species in *rabi*. *Cyperus sp* during *Kharif* and *Lolium temulentum were* most important weed during the *rabi* season. Higher weed diversity was observed in maize + soybean –lentil system and followed by maize + cowpea – *sarson*; black gram – wheat + gram; okra – wheat + pea systems. Maize + okra – pea was promising in terms of system productivity and economic returns.

BIOTECHNOLOGY

Cold Tolerance during the reproductive phase in chickpea (*Cicer arietinum* l.) is associated with superior cold acclimation ability involving antioxidants and cryoprotective solutes in anthers and ovules

Chickpea is sensitive to cold stress, especially at reproductive stage, resulting in flower and pod abortion that significantly reduces seed yield. We evaluated (a) whether cold acclimation imparts reproductive cold tolerance in chickpea; (b) how genotypes with contrasting sensitivity respond to cold acclimation; and (c) the involvement of cryoprotective solutes and antioxidants in anthers and ovules in cold acclimation. Cold acclimation remarkably reduced low temperature-induced leaf damage (as membrane integrity, leaf water status, stomatal conductance, photosynthetic pigments, and chlorophyll fluorescence) under cold stress in the four genotypes evaluated in the study. It reduced anther and ovule damage only in cold-tolerant genotypes but not in col sensitive genotypes due to improved antioxidative ability, measured as enzymatic (superoxide dismutase, catalase, ascorbate peroxidase, and glutathione reductase) and non-enzymatic (ascorbate and reduced glutathione), solutes (particularly sucrose and -aminobutyric acid) leading to improving reproductive function and yield traits, whereas cold-sensitive genotypes were not responsive. The study concluded that cold tolerance in chickpea is related to the better ability of anthers and ovules to acclimate, involving various antioxidants and cryoprotective solutes. This information will be useful in directing efforts toward increasing cold tolerance in chickpea.

Disruption of carbohydrate and proline metabolism in anthers under low temperature causes pollen sterility in chickpea

Chickpea (*Cicer arietinum* L.) is highly sensitive to cold stress resulting in large scale yield losses. Clod stress induces flower abortion in chickpea by disruption of gamete development and induction of pollen sterility. However, molecular mechanisms governing cold induced pollen sterility in chickpea are unknown. Using anthers of a specific stage, we discovered that (i) Under cold stress, GPF2 (cold-sensitive) had higher pollen sterility than ICC 16349 (cold-tolerant), (ii) Under cold, starch and proline contents decreased in anthers of GPF2 with no (starch) or slight (proline) change in ICC 16349, (iii) Immediately after cold exposure, transcription lowered in both the genotypes and reactivated differentially at 30 min, (iv) Major genes associated with pollen sterility/viability were *UDP glucose pyrophosphorylase*, *cell wall invertase* and *proline transporter 1* and (v) Enzymatic antioxidants were not the major players in the cold tolerance by anthers.

VEGETABLE CROPS

- **Varieties developed and notified by the Central Variety Release Committee**

Nine varieties of different vegetable crops viz. Him Palam Mattar-1 (DPP-SP-22) and Him Palam Mattar-2 of garden pea; Him Palam Meethi Phali-2 of edible pod pea/ snow pea; Him Palam Mirch-1 and Him Palam Mirch-2 of chilli; Him Palam Kheera-1 of parthenocarpic cucumber; Him Palam Cherry Yellow of cherry tomato; Him Palam Mooli-

1 of radish and Him Palam Shweta of onion developed by the University have been notified by the Central Variety Release Committee vide Gazette Notification No. S.O.3254 (E) dated 20-07-2022:

Other achievements

- Garden pea genotype**‘‘**DPPMR-09-1’ developed and has been registered as unique germplasm with identity number INGR21221 by Plant Germplasm Registration Committee (PGRC).
- Two private companies namely, Super Seeds Private Limited, Hisar and Krishma Seeds signed Memorandum of Agreement for non-exclusive rights/license to produce seed of garden pea variety ‘Him Palam Matar-1’.
- Radish variety Him Palam Mooli-1 (DPR-1) has been identified for Zone-I of the country in 40th Group Meeting of All India Coordinated Research Project on Vegetable Crops.
- Garden pea line DPP-SP-6 (146.6 q/ha) produced maximum pod yield followed by Him Palam Matar-1 (139.50 q/ha) & both superseded check Pb-89 (105.5 q/ha) under convenional farming (CF) under protected conditions while they produced 122.2, 116.2 and 88.0 q/ha pod yield under Natural Farming (NF) polyhouse conditions, respectively during winter 2021.
- Snow pea variety Him Palam Meethi Phali-1 (181.3 and 137.3 q/ha) produced the maximum yield under protected conditions using CF and NF, respectively followed by Him Palam Meethi Phali-2 (157.34 and 128.5 q/ha) which was better than check Meethi Phali (136.06 and 105.0 q/ha) and Arka Apoorva (142.02 and 115.6 q/ha), respectively.
- CMS based hybrids in cauliflower were evaluated during winter 2021-22 under natural ventilated polyhouse conditions following conventional and natural farming conditions. Hybrid combinations namely, CMS PU × DPCafW 4 (1199 and 751 g), CMSPU × DPCafS-121(1292 and 920 g), CMS PU ×DPCafW 131 (1001 and 610 g) and CMS PU × DPCaf18 (1084 and 697 g) produced better market able curd yield per plant than check Pusa Snow Ball Hybrid 1 (714 and 555 g), Maharani (753 and 543g)and Pusa Hybrid 301 (680 and 598 g) under both CF and NF, respectively**.** Marketable curd yield under Natural Farming (NF) conditions were recorded to be 30-35% less than conventional farming (CF) in cauliflower**.** These hybrids also showed better performance in the field conditions (1058, 1048, 858.5 and 926.8 g), respectively as compared to check Pusa Snow Ball Hybrid 1 (953.8 g), Maharani (687.6g) and Pusa Hybrid 301 (731g).
- Similarly, varieties of chilli, and garden pea responded better under field conditions following INM (FYM+ synthetic fertilizers) followed by organic farming while NF showed the lowest yields in chilli and garden pea**.** Chilli variety Him Palam Mirch-2 produced the highest yield irrespective of fertility levels i.e at 125% (231.25 q/ha), 100% (202.68 q/ha) and 75% (161.61q/ha) of recommended NPK (75: 50: 50 kg N: P_2O_5: K_2O ha^{-1}) which was better than organic farming (148.98 q/ha) and natural farming (102.94 q/ha). Similarly, garden pea genotype DPP-SP-6 produced highest pod yield of 193.5, 172.3, 145.5, 108.45 and 85.2 q/ha followed by Him Palam Matar-1 (185.8, 163.25, 138.65, 102.6 and 81.5 q/ha) at the respective fertility levels of 125, 100 and 75% of recommended NPK (50: 60:60 kg N: P_2O_5: K_2O ha^{-1}), organic farming and natural farming, respectively. Both chilli and garden pea varieties responded to high fertility levels of 125% of recommended dose of NPK followed by 100% NPK.
- A unique chilli genotype DPCh-38-12-3 with erect fruit bearing and purple black colour fruits has been isolated that may act as a good source of anthocyanin and unique germplasm. In addition, yellow fruited genotype DPCh-9Y has been submitted for registration with NBPGR as unique germplasm.
- Amongst the 40 hybrid combinations synthesized by involving 4 GMS inbred lines and 10 open pollinated inbred lines, GMS-9-2 × Him Palam Mirch 2 (935.2 g) produced the highest fruit yield per plant during summer 2021 followed by hybrid combinations GMS-

9-2 × DPCh-10 (888.97 g), GMS-9-2 × DPCh-40 (790.32 g) and GMS-9-2 × DPCh-101 (876.3 g) besides they also showed better performance for economic yield attributes.

- Multilocation testing of GMS based chilli hybrids at Palampur, Bajaura, Berthin, Sundernagar and Dhaulakuan under JICA project revealed that Hyb-10 (573.86, 757.92, 643.29, 448.63 and 550.0 g) significantly produced highest fruit yield per plant, respectively significantly better than check hybrid CH-27 and OP varieties HPM-1, HPM-2 and Surajmukhi. Pooling data over locations construed that DPCHYB 10 (627.68 g) followed by DPCHYB 5 (583.50 g) and DPCHYB 12 (533.04 g) had yield advantage of 66.11, 54.42 and 41.06 % over best check Him Palam Mirch 2 (377.86g).
- Five GMS lines namely, DPCh-MS-29-2 (drooping, light green and medium sized fruits), DPCh-MS-26-1 (drooping, dark green and long fruits), DPCh-MS-9-2 (erect, medium sized and yellowish green fruits), DPCh-11-2 (erect, light green and slender fruits), DPCh-18-1 (drooping, green and medium fruits) and DPCh-MS-23-1 (erect fruits bearing, dark green and small-medium fruits) were maintained and also utilized in heterosis breeding.
- Garlic genotype GN-20-17 produced highest yield 107.4q/ha as compared to check 96.0q/ha

ORGANIC AGRICULTURE AND NATURAL FARMING

1.Varietal Evaluation

Wheat

- Out of eighteen genotypes evaluated, HPWO-5 (17.83 q/ha), MCTLH-21 (16.66 q/ha), Kanku (16.51 q/ha) were found to be promising genotypes.

Barley

- Nine varieties were evaluated under natural farming conditions out of which BHS-352 (16.04 q/ha) followed by BHS-400 (14.58 q/ha) and VLB-118 (13.32 q/ha) were the promising varieties and at par with each other.

Lentil

- Among fifteen genotypes of Lentil evaluated, HPLO-3 (7.90 q/ha) and DKL-13-3 (7.86 q/ha) and DKL-13-6 (7.73 q/ha) were superior to that of other genotypes.

2. Plant production

- In **wheat+gram** and **wheat+lentil** intercropping system, the organic package produced the higher wheat grain yield, wheat equivalent yield (15.20 q/ha) and lentil grain yield (4.21 q/ha). Whereas, the natural farming system system was found to be the most economical in getting the higher gross returns (Rs. 76331.60), net returns (Rs. 29521.60) and B:C (1.63) as compared to the organic production system.
- In **wheat+pea** and **wheat+sarson** intercropping systems, organic farming treatment produced higher wheat equivalent yield (44.13 q/ha) and grain yield of peas (15.9 q/ha). However, natural farming treatment resulted in higher net returns and B:C as compared to the organic farming treatment.
- Among two varieties of **oats** *i.e.* Kent and Palampur-I, both the varieties produced significantly higher grain yield, net returns and B:C ratio under natural farming treatments as compared to the organic farming treatments.

3. Soil & microbial studies

- Application of Ghanjeevamrit showed the highest value for percent organic carbon and available N. Whereas, the microbial properties and available P & K were maximum when mulching was applied alongwith Ghanjeevamrit.
- In wheat+gram+spray of jeevamrit at 14 days interval treatment, chemical and microbial properties were highest, whereas, the Dehydrogenase Activity (DHA) was maximum in wheat+lentil+ spray of jeevamrit at 14 days interval treatment.

- In wheat based cropping system (wheat+pea+spray of jeevamrit at 14 days interval) general microbial count, Nitrogen fixing, Phosphate solubilizing bacteria showed the highest value.
- In oats spray of jeevamrit at 14 days interval showed the maximum value for all the parameters

AGRICULTURAL ENGINEERING

Energy auditing in maize-wheat cropping system:

- A survey was conducted for 30 villages having total 600 land holds farmers of different categories (on the bases of land classification) in three different zones of Himachal Pradesh. The results of analysis showed that there is a need to promoting and providing power tillers facility to the farmers of H.P.

Adoptive trials on solar operated gadgets:

- Department has testing, demonstrated and promoting various solar powered gadgets such as the solar powered insect trap and spray pump (Knapsack) in each training and melas' conducted by our university. The solar powered insect traps were installed and evaluated to test the efficiency during night.

Assessment of biogas production in 50m^3 Biogas plant in hills:

- 50m^3 biogas plant was installed and evaluated at CSK Himachal Pradesh Krishi Vishvavidyala, Palampur under Gobardhan Scheme. Further, the mixing unit was developed and installed on the inlet mixing tank of biogas plant.

Adoptive trials on the pea planter

- Mechanized intervention of pea sowing was done and economic cost and the rate of drudgery involved was assessed. The planter had one vertical disc with 12 spoons on the plate for seeding mechanism. It included a 2.5 kg capacity seed box and weighed 13.5kg. The farmers gave a very positive feedback for its performance and also evaluated it profitable in terms of reduction in sowing time and labour requirement as well.

Assessment of health issues in workers engaged in animal rearing activities in hilly region:

- Information was gathered from *gaddi* tribes of Himachal who are involved in migratory sheep & goat husbandry and are mainly dependent on this type of farming for their livelihood. Assessment of health hazards revealed that they frequently suffer with noise hazards (100%) as they have to manage large herd of animals. On their way to highland pastures, they often slip, trip, and fall (90%).
  Agricultural accident survey was conducted in the districts of Kangra, Kullu and Bilaspur. Assessment of occupational health hazards of livestock farmers.

Renewable energy based poly-house (green house)

- The renewable energy operated 100 m^2 green house was designed and installed in the department of Agricultural Engineering. The inner environment and cooling system is operational with solar and geo-thermal energy respectively. The use of renewable energy will reduce the operational cost of high-tech green house as well as the dependency on non-renewable sources like electricity.Consultancy to farmers regarding soy processing, rice milling, power tiller, thresher, paddy transplanter and other agriculture machinery. Transfer of technology on irrigation system, poly-house construction and maintenance, biomass cook stove, and different gender friendly farm tools and implements to farmers of Himachal Pradesh**.**

AGRICULTURAL ECONOMICS

- The economic analysis of production and marketing of exotic vegetables in Lahaul valley of district Lahaul & Spiti of Himachal Pradesh revealed that exotic vegetables

occupied 51.54 per cent of total cropped area. In case of exotic vegetables lettuce accounted for 28.46 per cent of total cropped area. In case of other vegetables, cauliflower accounted for 25.38 per cent of total cropped area. The cropping intensity was found to be 125 percent.

- The short duration of exotic vegetables enabled double cropping sequence in the study area. The lettuce-lettuce cropping sequence covering nearly 15 per cent of operational holding was followed by 55 per cent of farmers. Whereas, the pea-lettuce cropping sequence was followed by more than 41 percent of farmers which covered 25 per cent of operational holding. The broccoli-broccoli cropping sequence was followed by 36.67 percent of farmers and accounted about 12 per cent of operational holding.
- The production per farm of lettuce (crisp head) was highest (115.62 q) followed by broccoli (60 q) and lettuce (leafy). Among other vegetables grown, cauliflower production was nearly 95 quintals per farm followed by potato (47.25 q) and pea (16.25 q).
- The total household gross income per annum, on an average farm, was estimated to be Rs. 14,91,352. The share of farm income was 84.31 per cent, in which crops contributed 81.49 per cent and livestock contributed 2.82 per cent. Exotic vegetables provided the most to farm income (53.58%), followed by other vegetables which contributed 21.91%.
- Broccoli gave highest net returns per hectare (Rs 18,25,811) followed by lettuce (Rs. 5, 65,935). The net returns per farm were also found to be highest in case of broccoli (Rs. 4, 38,196) followed by lettuce (Rs. 2, 09,396). Broccoli had the highest returns over variable cost (Rs. 18, 73,898) and total cost (Rs. 18 25,811) than lettuce (Rs. 6, 14,016 and Rs. 5, 65,935). The broccoli gave significantly higher output-input ratio of 7.10 as against of3.62 in lettuce.
- The influence of area on output was found to be positive and significant in both lettuce and broccoli crop. The chemical fertilizers, on the other side, had negative influence on output of both of these vegetables. The adjusted coefficient of multiple determination explained about 91 to 96 per cent of variation in output of lettuce and broccoli.
- Among the crops grown by polyhouse owner's tomato, cucumber, capsicum (yellow) and cauliflower were the main commodities grown inside polyhouse units in study area. The marketed surplus of these commodities varied from 95 to 99 per cent of total quantity produced. There were only two channels selected by the growers for marketing of polyhouse commodities. These were direct sale to consumers and sale through local traders/ commission agents.
- The total income accruing from polyhouse was estimated to be Rs. 1,64,451 out of which about 95 per cent was contributed by output and five per cent by nursery production. Among commodities capsicum (yellow) accounted for about 52 per cent of total polyhouse income followed by cucumber (14.43%) and cauliflower (12.99%).

FUTURE RESEARCH PRIORITIES

Crop Improvement

- Collection, evaluation, documentation and conservation of genetic resources of various hill & vegetables crops from different regions of the State
- Development of high yielding, early and mid maturing varieties of various hill crops with resistance to biotic and abiotic stresses coupled with improved nutritional attributes using conventional and non-conventional techniques
- Development and evaluation of promising genotypes of various crops under zero budget natural farming

- Strengthening of pre-breeding programmes in different crops to generate variability
- Development of innovative protocols for precision and speed breeding in different crops
- Strengthening of nuclear and breeder seed production programme
- Development of hybrids of rice, maize & vegetable crops by utilization of Himalayan gene pools
- Development of high yielding, horticulturally desirable and disease resistant varieties of important vegetable crops namely, garden pea, cauliflower, okra, capsicum and cabbage
- Development of horticulturally desirable CMS based hybrids in cabbage, cauliflower and broccoli
- Identification and development of varieties/technologies for protected cultivation suitable during winter season
- Grafting technology by using resistant root stocks to manage soil borne diseases and pests
- Collection, evaluation, maintenance and conservation of germplasm of different vegetable crops.
- Standardization & refinement of production technology of important vegetable crops for open and protected environments.
- Strengthening domestic seed system through community/ farmers participation.

Crop Production

- Nutrient management in crops and cropping systems with the use of macro and micro nutrients containing nano-fertilizers
- On-Farm evaluation of farming system modules, diversification of existing farming systems and assessment of on-farm crop response to plant nutrients in predominant cropping systems in Kullu district
- Impact analysis of Agromet. Advisories formulated on the basis of block level weather forecast
- Studies on the comparative performance of organic, inorganic and natural farming systems on productivity, quality, soil health and sustainability of different crops and cropping systems.
- Weed management studies in organic & conservation agriculture system as well in non-cropped area
- Biofortification and yield enhancement of grain and forage crops with micronutrients, PGRs and bio-stimulants.
- Optimization of micronutrients for different crops.
- Use of Artificial Intelligence for nutrients and water management.
- Spatial distribution of molybdenum in soils of HP.
- Standardization of drip fertigation schedule for high value cash crops under sub surface conditions
- Development of IPNS based fertigation schedule for open and protected conditions in high value cash crops
- Development of target yield based prescription equation for pea crop.

Crop Protection

- Survey and surveillance of insect-pests and development of forecasting models.
- Studies on population dynamics and management of invasive pests in Himachal Pradesh.
- Standardization of mass production technology for important biological control agents and their utilization in biological control of insect-pests..
- Identification of new products from plants and soil microorganisms for use in the management of insect-pests and nematodes and natural farming practices.Impact of climate change on arthropods (insect-pests, honey bees and other beneficial arthropods). Management of root knot and potato cyst nematode.

- Study of epidemiology of new emerging diseases viz., yellowing/wilting complex of Cole crops, rice stunting etc. and development of IDM technologies for the management of potential diseases of main crops (vegetables, cereals and pulses).
- Devising eco-friendly management strategies against pea root rot wilt complex.
- Standardization of production technology of Shiitake mushroom.
- Evaluation of plant protection practices (inputs and formulations) in organic and natural farming for the management of different plant diseases.

Organic and Natural Farming

- Seed production of identified crops (wheat, lentil and barley) under SPNF conditions at ZBNF farm and through farmer participatory mode
- Surveillance of key insect pests of targeted crops
- Development of Package of Practices of targeted crops under natural farming conditions
- Soil analysis and microbial studies on monitoring of soil health at farmers fields
- Development of Model SPNF Nodal Unit at CSKHPKV, Palampur for capacity building

On Going Research Projects

Particulars	***No. of Projects***	***Budget Outlay (in lakhs)***
AICRPs	*34*	*1650.00*
ICAR Adhoc funded Projects	*6*	*2380.96*
DBT Funded Project	*8*	*427.50*
DST Funded Projects	*8*	*349.43*
HPCDP-JICA ODA, Hamirpur	*15*	*1315.21*
Govt. of H.P.	*11*	*1550.89*
RKVY Projects including HIM PALAM RABI	*09*	*386.19*
Miscellaneous Adhoc Projects	*35*	*452.11*
NABARD	*04*	*54.82*
Total	***130***	***8567.11***