Annual Report
2017-2018

ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan
Almora - 263 601, Uttarakhand (India)
(An ISO 9001:2015 Certified Institute)
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Almora - 263 601, Uttarakhand
www.vpkas.icar.gov.in
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Hill agriculture is being constantly challenged by deteriorating soil quality, change in climate and erratic rainfall. Even then, the invisible thread that binds the people across the mountain villages is agriculture—partly traditional and partly modern. Changing climate, soil property and market demand necessitates appropriate technological intervention to keep agriculture profitable. The government agencies, both at the central and state level, are working at their fullest strength to improve targeted agricultural production aiming at doubling farmers income by 2022. In this mission, the institute makes constant efforts to increase productivity of hill crops by introducing new varieties of various crops. ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora works under the aegis of Indian Council of Agricultural Research since 1974. The institute shoulders the responsibility of carrying out research and extension to uplift the status of hill agriculture in the North Western (NW) Himalayan region with the mission of enhancing productivity and ecological sustainability of hill agriculture through niche-based diversification. The various activities of the institute include development of high yielding varieties of different hill crops, their production and protection technologies, development of small machines, tools and their extension through commercialization and training to trainees as well as farmers on improved technologies. To fulfill the objectives, the institute has 21 institutional (18 core and 3 flagship) and other externally funded projects under DBT, AICRP, AMAAS, DUS, ICAR-ACIAR, Bio-diversity and Tribal Sub Plan. This annual report describes the project-wise salient research achievements of the institute for the year 2017-18.

Looking into the diversity of crops grown in hills, research efforts are being made to address problems in diverse field of agriculture. During the year, ten varieties or various crops were released/notified and suitable cultivation packages were developed. Efforts were also made for effective dissemination of suitable technologies to farmers under institute extension and TSP programmes. More than 42 training programmes/exposure visits/field days/farmers’ fairs were organized. These activities had exposed 1036 farmers of the region to latest technological advances. Besides, 60 training programmes were conducted by KVKs for more than 1462 farmers. Frontline demonstrations on various hill crops (89.4 ha, benefitting 2433 farmers) were also conducted at farmers’ field. The help line service and **Krishi Samridhi** programmes enlightened and awakened the farmers in sorting out their agriculture related problems. Development and dissemination of the technologies is expected to play a significant role in enhancing the productivity and sustenance of agricultural crops in NW Himalayan region. Based on the quality of research work, the scientists received prestigious awards and recognitions. Sincere efforts and hard work of scientists and staff and the valuable guidance and constant encouragement from the Council, in general, and Division of Crop Science, in particular, played a significant role in realizing the output.

I place on record my sincere thanks to the Secretary (DARE) & Director General, ICAR, Additional Secretary (DARE) and Secretary, ICAR, Financial Advisor (DARE), Deputy Director General (Crop Science) and Assistant Director General (Seeds) for their wholehearted support to ICAR-VPKAS. I also express my sincere appreciation to the Editorial Board, all my colleagues and staff members of the institute for their dedicated effort and cooperation in carrying out various activities of the institute and congratulate the staff of PME Cell for bringing out this publication in time.

Place: Almora  
Date: June 30, 2018

(A. Pattanayak)  
Director
In 1962, I had proposed to the Government of India (Ministry of Agriculture) through Dr B.P. Pal, the then director of IARI that we should launch a dynamic programme of dwarf wheat breeding and that for this purpose we should invite Dr Norman E Borlaug from Mexico to visit us and also provide seeds of his dwarf wheat varieties. Dr Borlaug visited India for a month in March 1963 and I took him to various wheat farms. As a result, he sent us a wide range of dwarf wheat in September 1963. Some of the Mexican wheat varieties like Lerma Rojo 64-A and Sonora 64 did very well under our conditions. They constituted the initial material for launching India’s wheat revolution (See, M.S. Swaminathan 1993, Wheat Revolution – A Dialogue, Macmillan & India Ltd, Madras pp. 164). The Rockefeller Foundation then offered to provide a wheat scientist to intensify our programme. I had met Dr Glen Anderson of Canada in 1963 in Lund, Sweden at a Wheat Genetics Symposium. I requested the Rockefeller Foundation to provide the services of Dr Anderson. Glen came on a preliminary visit to India in March 1964. I took him to various parts of Punjab, Harayana, Uttar Pradesh and Bihar.

Towards the end of our field visits, I took Glen to Almora and we stayed overnight with the Sens. In the evening, Boshi asked Glen whether he would like to join in the evening prayer. He did not want to leave him alone, since Gertrude and I were to be in the prayer room. Glen enthusiastically welcomed the invitation. Towards the end of the prayer session, Boshi suddenly took out a small box containing a few hair of Swami Vivekananda. He then placed it on our heads and said, “The wheat programme will be a great success”. Even today, I feel Boshi Sen’s blessings at the beginning of our intensive wheat research and production programme, constituted an important factor in ensuring its success on the lines envisaged in the IARI publication *Five Years of Dwarf Wheats - 1963 to 1968*.

*Dr. M.S. Swaminathan*

*(Excerpts from the Forward of the book – *Nearer Heaven than Earth – The Life and Times of Boshi Sen and Gertrude Emerson Sen* by G.N. Mehra. Printed with the permission of the author)*
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Enhancement in the Productivity of Major Hill Crops

During the year, three hybrids/varieties have been released and notified vide [S.O. 1007(E)]. Among these, Central Maize VL Baby Corn 2 which registered an average yield advantage of 24.6% over the best check HM4 was notified for cultivation in the states Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Punjab, Haryana, Delhi, Uttar Pradesh, Maharashtra, Karnataka, Andhra Pradesh, Telangana, Tamil Nadu, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh. The Normal corn hybrid Central Maize VL 55 was notified for cultivation in the states of Jammu & Kashmir, Himachal Pradesh, Uttarakhand, North East Hills, Andhra Pradesh, Telangana, Maharashtra, Karnataka and Tamil Nadu. It recorded an average yield of 7547.5 kg/ha and exhibited yield advantage of 19.5% over the best hybrid PMH 5. The rice variety VL Dhan 158 was notified for the states of Himachal Pradesh and Uttarakhand. It has an average yield potential of 2242.5 kg/ha and exhibited yield advantage of 39.9% over the best variety VL Dhan 154. In addition, four varieties in two crops have been released for cultivation in Uttarakhand through SVT. These include three varieties in garden pea (Vivek Matar 13, Vivek Matar 14 and Vivek Matar 15) and one variety of black soybean (VLB 202). The three garden pea varieties exhibited yield advantage of 9.2, 21.5 and 23.5% respectively over their best checks. Likewise, the black soybean variety VLB 202 recorded yield advantage of 36.0% over the best check VLB 65. Besides, six entries in five crops have been identified for release from AICRP/SVT trials. These include wheat (VL 2014 and VL 2015), finger millet (VL Mandua 379), field pea (VL Matar 61), lentil (VL Masoor 148) and soybean (VL Soybean 89).

In maize, double haploid breeding programme was initiated. Under this program, putative hybrid seed obtained from haploid inducer line EC 805127 with hybrids Vivek QPM 9, FQH 106, CMVL55, FSCH 41, RASI 4212, HIBRIX 39, US Agri 103, Sugar 75 and VMH 45 were treated with cochinine following the standard protocol. Out of a total of 864 colchicine treated seedlings transferred to the field, seed from 139 plants were harvested and further research is under progress. In maize biofortification program, foreground selection and biochemical evaluation for high tryptophan and low phytate was carried out in F4 populations of five crosses between elite QPM lines using trait specific markers. Agronomically superior genotypes carrying desired trait combination (high tryptophan (>0.6%) + low phytate (<8 mg/g) were selected for further advancement. In finger millet, a hill gene pool comprising local finger millet accessions representing twelve districts of Uttarakhand was assembled and evaluated for agronomic traits and blast resistance and promising accessions were identified. In garden pea, the shelling percentage normally ranges from 45 to 50% and the edible podded pea (Pisum sativum var. macrocarpon) has the advantage of use of whole pod. Three edible pod pea advance breeding lines VPSp 1301, VPSp 906-1 and VPSp 1332 developed at the institute were evaluated at experimental
farm, Hawalbagh (1250 amsl) and at HATS, Mukteshwar (2250 amsl). All the three lines were found suitable as edible pod pea due to missing parchment layer in their pod walls.

During the year, 192.5 q breeder seed of 50 released varieties/inbreds was produced. A total of 140.9 q breeder seed was supplied to different seed producing agencies to take up further multiplication. Around 11.9 q nucleus seed of 39 released varieties was also produced following standard methods of maintaining genetic purity. In addition, 13.2 q truthfully labelled (TL) seed of 33 varieties was produced to meet the demand of the institute extension activities. Under farmer participatory seed production program, 118.8 q TL seed of wheat, soybean and finger millet was produced, and 83.2 q was supplied from the seed procured.

Natural Resource Management for Enhancing the Productivity

Sowing time of irrigated wheat was found highly dependent on the amount of rainfall during the crop growing season. At the years of deficit rainfall, early sowing has an advantage in terms of grain yield. Further, spraying of Folicur® (Tebuconazole) @ 0.1% at the first node and flag leaf stage enhanced the tiller number of wheat and subsequently produced 13% higher grain yield. Analysis of grain yield data of rainfed soybean–wheat crop rotation under long term (44 years) fertility management of experimentation confirmed that only FYM applied plots provided an increase in the wheat equivalent grain yield than the first year (1973-74). The average yield (6,784 kg/ha) with application of 10 t/ha FYM along with the recommended NPK recorded 105% higher wheat equivalent grain yield of the system than recommended NPK, which confirmed that the application of chemical fertilizer only is not sustainable. The potential wheat equivalent yield of wheat (VL 804; 4,060 kg/ha), lentil (VL 126; 3,144 kg/ha) and toria (VL 3; 2,735 kg/ha) through P-enriched compost (PEC) could be achieved with application of 116, 120 and 111% of recommended P and inoculation of seed with *Pseudomonas fragi* CS11RHI, which were 33, 29 and 35% higher than the recommended P through SSP, respectively. Comparative influence of organic and chemical amendments on rainfed wheat–soybean cropping system revealed that the potential wheat equivalent yield through FYM and vermicompost of 10,248 and 10,622 kg/ha from wheat-soybean cropping system could be achieved with application of 57 and 54 kg P/ha, which were 56 and 62% higher than the recommended NPK, respectively. Among crop management systems, application of 100% N requirement of crop through organic manure and 50% N requirement of crop through organic manure + 50% N requirement through inorganic produced highest wheat equivalent grain yield of 3160 and 5509 kg/ha for finger millet + black soybean–wheat + toria and grain amaranth–wheat + lentil, respectively.

The normal date of onset of monsoon is 2nd fortnight of June in the Shivalik range of Himalaya and most of the *kharif* crops are being sown by 15th June in this region. However, the region is experiencing early season drought (late onset of monsoon by 2-3 weeks), for which contingency planning is required. Therefore, an experiment was carried out in which six crops, viz., finger millet (VL Mandua 347), buckwheat (VL Ugal 7), soybean (VLS 73), okra (VL Bhindi 2), amaranth (VL Chua 44), and horsegram (VL Gahat 19) were evaluated in 3 dates of sowing (10 July, 20 July and 30 July) under rainfed condition to screen their suitability for delayed monsoon. The highest finger millet equivalent yield was recorded by okra (5312 kg/ha) followed by finger millet (3228 kg/ha) and amaranth (3514 kg/ha) in a delayed sowing. Highest grain
yield of wheat and finger millet was recorded with 50% FYM + 50% RDF (1385 kg/ha and 1,744 kg/ha, respectively), however, there is no effect of sesbania mulching in finger millet to succeeding wheat yield.

In wheat–ragi cropping system in case of wheat, seed drill resulted into 9.0% higher grain yield than manual line sowing (1,460 kg/ha) and 21.2% higher than traditional method (farmer’s practice) of sowing (1,313 kg/ha). Wheat sowing with seed drill under zero tillage using mulch fetched highest net returns (Rs 14,785/- per ha) with BC ratio of 1.62. However, transplanting in finger millet with mulch during kharif under zero tillage fetched highest net returns (Rs 25,547/- per ha) with B:C ratio of 1.81.

The highest wheat and rice yields (36.0 q/ha and 18.6 q/ha, respectively) was recorded with four irrigations. Zero tillage (ZT) evolved significantly (p <0.05) ~15 and 18% higher cumulative CO2-C than conventional tillage (CT) (638 and 440 mg CO2-C/kg) in 0–15 and 15–30 cm soil layers, respectively. ZT had significantly ~9 and 6% higher carbon sequestration as compared to CT (22.78 and 20.50 Mg CO2-C/kg) in the 0–15 and 15–30 cm soil layer respectively. The mean onion (238.3 q/ha) and garlic (118.3 q/ha) yield under drip irrigation was higher in comparison to check basin irrigation (153.4 & 73.7 q/ha, respectively) in 2016. The highest onion yield (271.1 q/ha) was obtained under drip irrigation scheduled at 1.2 IW: CPE followed by drip irrigation scheduled at 1.0 IW: CPE.

Single inoculation of cold tolerant Pseudomonas sp. NARs9 enhanced lentil grain yield by 13.9 per cent followed by Pseudomonas putida PGR4 (12.3%) over uninoculated control (1,060 kg/ha) in field conditions. Inoculation with PGP bacterial consortium C2, C4 and C8 enhanced lentil grain yield by 11.4, 11.0 and 8.1%, respectively (average of four years) over uninoculated control (1,205 kg/ha) under field conditions. Cold tolerant ‘P’ solubilizing bacterial consortium C2, C1 and C3 significantly enhanced lentil ‘P’ content by 16.2, 12.6 and 11.7%, respectively over uninoculated control (1.1% P content) at 90DAS. ‘P’ solubilizing bacterial consortium C4 enhanced lentil grain yield by 15.8% followed by C3 (13.9%) and C2 (7.9%) over uninoculated control (1,162 kg/ha) under field conditions. Composting of farm wastes using Pleurotus sajorcaju, Trichoderma harzianum, Aspergillus niger, biomineralizer of P and Zn, Azotobacter and PGPR enhanced 11, 32 and 119% C, N and P compared to control, respectively. In one of the outreach programmes of the institute, a total 1230 composite soil samples from three soil layers (0-15, 15-30 and 30-45 cm) has been collected from Balta, Shama and Badethi cluster along with the GPS coordinates for analysing 12 soil parameters (pH, EC, OC, N,P,K, Fe, Cu, Mn and Zn).

In oat AVT, entry IVTO MC-1-10 produced a significantly higher green fodder (11,170 kg/ha) than rest of the entries except IVTO MC-1-5 (10,540 kg/ha) in multi-cut oat in IVT entries. In initial varietal trial of maize entries, AVTM-12 produced significantly higher green fodder (46,019 kg/ha) than rest of the cultivars. In cowpea AVT, entry AVT2C-2 produced significantly higher green fodder (22,099 kg/ha) than rest of the cultivars. Among the various cutting management, pollarding at 3 m height stored highest carbon (14.87 t/ha), which was significantly higher than other cutting management. S. kazungula yielded the highest green biomass (7,000 kg/ha) under Q. leucotrichophora. In dual purpose wheat, seed treatment with Azotobacter and Pseudomonas sp. produced 13% higher green forage than control (4,730 kg/ha) in forage cut treatments. Grain yield was 11% higher in uncut with normal N
dose than seed treatment with bacteria and its combination (4,666 kg/ha). Keeping in view the acute shortage of quality green fodder during winter months, wastage of fodder and straw resulting from direct feeding and erratic electricity supply, a pedal operated chaff cutter suitable for hills was developed with an output capacity of about 170 kg/hr for green fodder and 29.4 kg/hr for dry fodder.

Plastic mulch laying roller suitable for hills has also been developed, which requires only two labours (draft of 32.2 kg) for operating the machine. This machine performed multiple operations in a single run with a field efficiency of 20.3%. It also makes small holes for transplanting of crops at a particular spacing. Facility of laying inline drip pipe beneath the plastic mulch has also been provided in the machine.

**Pest Management**

Yellow rust in wheat and blast in rice were the major diseases (moderate to severe during 2016-17) causing severe yield losses of the two important cereal crops grown in NW Himalayas. Severe infestation of turgicum leaf blight was observed in maize. Blast in finger millet and grain smut in barnyard millet were the major challenges of millet production. In case of vegetables, rust (15-25%) and angular leaf spot (25-30%) of French bean and root rot (10-15%) of garden pea were the major diseases. Pathotyping of yellow and brown rust pathogen in wheat and race profiling of blast pathogen in rice were carried out. Among the 24 ‘R genes’ in monogenic blast differentials against *Magnaporthe oryzae*, *Pi9* and *Piz5* were found to impart complete resistance. Altogether, 6 maize inbred lines *viz.*, V351, V402, V431, V 440, VSL-27 and CM 141 were found tolerant to bacterial leaf and sheath blight under artificial epiphytotic conditions. Among 225 hill collections of finger millet, VHC-3796, VHC-4085, VRB-MF-1217, VL 324, VR-MF-1516 and VL *Ragi* 149 were highly resistant to both neck and finger blast and with moderate resistance to leaf blast. Out of 551 accessions screened for loose smut in wheat, 120 lines were found free (0% infection) from loose smut and 259 lines were resistant to powdery mildew. Two popular wheat varieties *viz.*, VL *Gehun* 907 (timely sown conditions) and VL *Gehun* 892 (late sown condition) has started showing susceptibility to the new races of yellow rust pathogen were selected to pyramid durable rust resistance genes *viz.*, *Yr10* and *Lr24*. The foreground positive plants with more than 90% background recovery and agronomic suitability were selected in BC$_2$F$_1$ generation for attempting backcrosses with recurrent parents to generate BC$_3$F$_1$ and around 750 to 3000 seeds were produced. These were planted during *rabi* 2017-18 for intercrossing for pyramiding of *Yr10* and *Lr24* genes. Sixty-seven maize inbred lines were artificially screened for resistance to banded leaf and sheath blight disease and tolerant lines *viz.*, V 351, V 402, V 431, V 440, VSL 27 and CM 141 were identified.

Diseases and insect pests are the major limiting factors for crops grown in polyhouses. Effective management measures for soil borne pathogens on tomato were evaluated and soil amendment of mustard cake + *Parthenium* (1:1) @ 10 t/ha reduced the late blight severity (1.7%) and root rot incidence (2.3%) i.e., 85.4 and 69.7% reduction with respect to control, respectively. Spent mushroom compost @ 10 t/ha and mustard cake + neem cake (1:1) @ 20 t/ha were found effective by causing 96.3% reduction in nematode populations compared to control.

Among the insect pests, aphids in toria, bean beetle (*Platypria hystrix*) in soybean and leaf webber (*Hymenia recurvalis*) in amaranth were severe. Moderate infestation of fruit flies in cucurbits, sucking bug in soybean, cabbage...
butterfly and aphids in cabbage, grasshoppers and pink borer in rice were noticed. In polyhouses, high infestation of whiteflies in tomato during June and thrips in French bean during August were observed. White grubs were found to get reduced considerably than the previous years (520 beetles/trap), of which 65.6% were trapped during June-July. The total number of beetles caught during 2017 is the lowest among the last 5-year catches i.e., only 27.9% of 2016 and 9.6% of 2015. The insecticide, cartap hydrochloride was found effective in managing sucking bugs, *C. choprai* to a tune of 96.8% in soybean. Phosphine formulations (77.5% G and 55% Tab.) were found to be effective against storage pests of wheat in warehouses.

Altogether, 83 native chitinolytic bacterial isolates were characterized for supernatant protein content, enzyme activity, thermal stability etc. and UKCH6, UKCH32 and UKCH47 were found to have low temperature tolerance. Promising isolates were further characterized for chitinase gene and two isolates, UKCH17 and UKCH77 showed 99% identity to *B. licheniformis* chitinase and many others to *B. paralicheniformis, B. circulans, B. pumilus, B. subtilis* etc. Multiple sequence alignment of 120 amino acids showed 8 conserved, 19 semi-conserved, 22 non-conserved amino acids substitutions. Preliminary bioassay screening of chitinolytic bacteria revealed 8 isolates as effective against diamondback moth (*Plutella xylostella*), whereas none caused mortality to *Helicoverpa armigera* but caused significant growth reduction. Potent isolates were tested for synergism with Cry toxin of *Bacillus thuringiensis* strain HD1. The LC$_{30}$ concentrations of cry toxin along with 10$^3$ concentrations of UKCH27, UKCH29 and UKCH77 caused 85, 89 and 88% mortality of second instar *H. armigera*, respectively. A total of 26 different species of non-Apis bees which comprise of *Megachila*, *Andrena*, *Bombus*, *Ceratina*, *Nomia*, *Xylocopa*, *Lasioglossum* were identified from the region. Bio-ecology of small carpenter bees, *Ceratina* sp. and sand bees, *Andrena* sp. were studied. The foraging rate of sand bees was found to be 6.4 flowers/min. and the speed of processing is 5.4 sec/flower, revealing sand bees as a good pollinator of radish. Introduction of honey bees were not found to have negative impact on native bees visiting toria, whereas, honey bee introduction significantly reduced the presence of *Andrena* bees in radish. The honey bee introduced and control radish harboured an average of 0.23 and 0.73 sand bees/m$^2$/min., revealing a negative impact of honey bee introduction on native sand bees in radish.

**Socio-Economic Studies and Transfer of Technologies**

Migration is an important issue in hills of Uttarakhand. The pattern of migration was studied and lack of employment opportunities in hills along with lack of medical facilities were found to be the major reasons for migration, as perceived by farmers. Marketing chain of vegetables in hills is found to have many non-value adding activities which could be avoided to minimise the gap between the farm gate price of farmers and the market price. Good prices of produce (31.1%) and favorable climatic conditions (26.7%) were perceived as the most important motivational factors for vegetable cultivation in some pockets of Uttarakhand hills.

The impact of ICT enabled extension services to improve rice productivity was studied by addressing the most important disease of rice *i.e.*, rice blast using mobile services along with providing awareness through conducting trainings and demonstrations for disease management. Productivity of three main rice varieties grown in the area has increased by 10, 7.2 and 6.4% due to ICT based extension activities.
Perceived occupational health hazards in carrying out different activities in vegetable cultivation were studied. Transplanting (hazard score: 63.2) and manure loading (60.6) was perceived as the most hazard prone activities which needs interventions by creating awareness among women on the health risk factors and safety measures to reduce health hazards. Knowledge test was administered to study knowledge level of farm women on nutritional security and it was found that women had medium level of knowledge on preservation of nutrients (Mean Percent Score: 53), nutritional deficiency (MPS: 51) and source of nutrients (MPS: 47). Dietary consumption pattern of farm women was studied. Pulses was found to be the major source of protein in their diet but majority of the women (64.6%) consumed pulses only twice or thrice a week which shows their diet was protein deficient. Food groups like meat products and eggs which are rich source of protein and micro nutrients are consumed by only 1.5 and 6.2% farm women, respectively on once in a week basis.

A significant gender difference was observed in knowledge level on vegetable cultivation practices. Farm women had the lowest knowledge in practices like pest management (MPS: 11.7) and application of fertilizer (MPS: 18.9). Highest training need was required in pest management practices followed by application of manures and fertilizers. Application of insecticides and pesticides and marketing of produce is male dominated activities in vegetable cultivation. Weeding and application of manure/fertilizer jointly done but is mainly found female dominated activity.

The newly initiated Farmers’ Producer Organisation (FPO) “Vivekananda Krishi Utapadan Swayatt Saharakita” with nearly 100 members started collective marketing of vegetables in local markets. Besides marketing, FPO is instrumental in collective purchase of farm inputs like quality seeds, fertilizer and pesticides.

Farm advisory services are provided regularly through toll-free Farmers’ Helpline Service (Telephone No. 1800-180-2311) and Krishi Samridhi Radio programme. Presently more than 4000 and 550 farmers are registered in m-Kisan portal and institute initiated Need Based SMS services, respectively. Information are sent to farmers on different contents like varieties, crop protection measures, nutrient management, farmers fairs/field days, seed production, government schemes etc benefiting registered farmers.
INTRODUCTION
ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan (ICAR-VPKAS), Almora, is a premier institution conducting agricultural research for the hilly region of North-Western (NW) Himalayan states of India, viz., Jammu and Kashmir, Himachal Pradesh and Uttarakhand. The growth and development of the institute over the years has been phenomenal. Being the brain-child of Padamabhusan Professor Boshi Sen, the institute originally functioned as a ‘one man’ institute with limited resources. In 1959, the laboratory was transferred to U.P. Government, and subsequently to ICAR in 1974. The institute headquarters is located at Almora (29°33' N and 79°39' E and 1,600 m amsl) in Uttarakhand. The Research Farm is located at Hawalbagh, 13 km away from Almora on Kausani/Ranikhet Road at an altitude of 1,250 m amsl (29°56' N and 79°40' E).

Being a multi-crop and multi-disciplinary research institute, research work is carried out under four divisions/sections, viz., Crop Improvement, Crop Production, Crop Protection and Social Sciences.

The ICAR-VPKAS, in the last 94 years of service to the nation, has several pioneering achievements to its credit. The most notable ones are:

i. Development of first hybrids of maize (VL Makka 54), onion (VL Piaz 67) and extra early grain and baby corn (VL Makka 42).

ii. Development of dual purpose wheat varieties (VL Gehun 616 and VL Gehun 829) for grain and fodder.

iii. Conversion of normal maize inbreds into quality protein maize through molecular marker assisted selection and consequent release of Vivek QPM 9.

iv. Development of Vivek thresher-cum-pearler for finger and barnyard millet, which has helped in reducing drudgery of the hill farmwomen.

v. Devising a two-pronged strategy for managing the adult beetles and subterranean larvae of the menacing pest ‘white grub’.

vi. Development of completely metallic plough VL Syahi Hal, which is helping in checking deforestation.

1.1 Mission
Enhancing productivity and ecological sustainability of hill agriculture through niche-based diversification

1.2 Mandate
- Basic, strategic and adaptive research for improving productivity and quality of important hill crops with emphasis on conservation and efficient utilization of natural resources.
- Development of post-harvest technologies and value addition.
- Dissemination of technology and capacity building on hill agriculture.
1.3 Historical Perspective & Salient Accomplishments

The institute has made outstanding contribution to improve productivity of crops in this region, by developing 148 improved varieties of 26 crops. The most popular varieties are Vivek Dhan 154, Vivek Dhan 62 and Vivek Dhan 82 of rice; VL Sankul Makka 31, Vivek Maize Hybrid 9, Vivek QPM 9, VL Amber pop corn, VL Baby Corn 1 of maize; VL Gehun 616, VL 804, VL Gehun 829 and VL Gehun 892 of wheat; VL Barley 56 of barley; VL Mandua 352, VL Mandua 149 and VL Madira 172 of small millets; VL Soya 47 of soybean; VL Masoor 126, VL Masoor 129 of lentil, VL Ageti Matar 7, Vivek Matar 10, Vivek Matar 11 of garden pea, VL Rajma 63 of rajmash, VL Chua 44 of Amaranth, VL Arhar 1 of pigeon pea and VL Ugal 7 of buckwheat. The institute has also developed matching production and protection technologies for these varieties.

Since 2013-14, 19 improved varieties of various crops like, wheat (VL Gehun 953), maize (Vivek Maize Hybrid 45, Vivek Maize Hybrid 47, Vivek Maize Hybrid 51, Vivek Maize Hybrid 53, Central VL Maize Sweet Corn 1), barley (VL Jau 118, VLB 94), rice (VL Dhan 68, VL Dhan 157, VL Dhan 156), millets (VL Mandua 352, VL Mandua 348), oilseeds (VL Soya 77, VL Bhat 201) and vegetable (Vivek Matar 12, VL Shimla Mirch 3), Ricebean [Him Shakti (VRB3)] were released for cultivation. During these five years, around 1,366 q of breeder, 98 q of nucleus and 416 q of truthfully labeled seeds were produced for various agencies and farmers.

These varieties recorded potential yield improvement ranging from 9.3 to 26.1%. In addition, some value addition (like sweet and babycorn, high calcium grain millet) were done through these varieties. Working towards quality improvement, two inbreds (CM 212 and V 373) were converted to QPM and sweet corn successions. Both the hybrids (QPM & QPM+sweet corn) are in the final year of AICRP trial. Similarly, through marker assisted selection in maize, 22 inbreds for kernel β carotene (<10 ppm), 10 inbreds for high Fe content (<50 ppm) and 20 inbreds for low phytate (phy 55-63% of total P) have been developed. In wheat, Yr10 and LR24 genes have been pyramided in VL Gehun 907 and VL Gehun 892. More than 14,000 native and exotic accessions of different crops are being maintained at the institute.

The matching agro-techniques for realizing full potential of improved varieties of crops and managing the constraints were standardized. Cropping sequences, spring rice–wheat–finger millet–toria attained 200% cropping intensity against 150% of the traditional spring rice–wheat–finger millet–fallow sequence in two-year cropping system. Among one-year crop sequences, soybean–lentil, maize–pea, maize–wheat, rajmash-french bean–toria, pigeon pea–wheat, colocasia–coriander–tomato, soybean–pea and soybean–wheat was found more remunerative. Intercropping of soybean or groundnut in maize, soybean in finger millet and pea, lentil or toria in wheat were found more profitable than pure crops.

Longterm fertility management, being studied since 1973, revealed that use of FYM (10 t/ha) along with the recommended dose of inorganic fertilizers was capable of rectifying nutritional problems of crops and the deterioration of soil physical conditions. The institute was awarded “Kribhco Barani Kheti Award – First Prize” during 1988 for this work.

Under fodder and grassland management, suitable agro-forestry systems, species of grasses (including winter grasses), fodder legumes, and grass composition under pine and deodar trees were identified. Technologies for production of grasses on risers, steep slopes, degraded and marshy land were also developed.

Low cost polyhouse technology has been developed for protected cultivation. Crops and seedlings can successfully be grown during winter in the polyhouses, which, otherwise, is not possible outside due to prevailing low temperature. Package and practices for growing vegetables under low cost polyhouse have been
developed and standardized. Low cost LDPE film-lined water storage tank, conveyance system and drip irrigation system have been developed for growing off-season high value vegetables.

Survey of Kumaon and Garhwal regions show prevalence of yellow and brown rusts, loose smut, powdery mildew and hill bunt in wheat; stripe disease and covered smut in barley; blast, brown spot and false smut in rice; neck and finger blast in finger millet; turcicum leaf blight in maize; powdery mildew and white rot in pea; buckeye rot in tomato, root rot and anthracnose in bean; root rot and wilt in lentil, and frogeye leaf spot as well as anthracnose. Viral diagnosis, based on symptomatology, showed presence of nearly 50 viral diseases affecting different crops grown in hills. Indigenous \textit{Trichoderma} strains have also been isolated from the NW Himalayan region and found effective against the soil borne pathogens.

White grub, a polyphagous pest, which devastates several rainfed \textit{kharif} crops, is the most menacing insect of the region. More than 75 species of this insect have been recorded in Uttarakhand. VL White grub beetle trap (\textit{Patent No.: IN 290170}) and the entomopathogenic \textit{Bacillus cereus} WGPSB2 are the potential alternatives to manage the white grubs. In addition, stem borer and leaf folder in rice and small millets; hairy caterpillar and sucking bug in soybean; leaf miner in garden pea and pod borer in pea and gram; fruit borer in tomato; blister beetle in beans and pigeon pea are other major pests. Management technologies have been evolved for major diseases and insects in important crops with emphasis on evaluation of germplasm for resistance/tolerance, manipulation of cultural practices, use of locally available plant extracts and need-based application of pesticides.

Demonstration of improved agricultural production technology was the major programme for agricultural development of the hilly states. More than 2,000 field demonstrations were conducted to demonstrate the benefits of latest agro-technology in the villages adopted under various programmes.

A survey of the economics of off-season vegetables indicated that producer receives only 13-21% of consumer's money in different vegetables and the lion's share is siphoned to the middlemen in the prevailing marketing system, which indicates the need to develop marketing system by the farmers themselves, e.g., by forming a cooperative marketing society.

The institute has to its credit a technological options publication entitled, “उत्तर पश्चिमी पर्वतीय क्षेत्रों में कृषि उद्योग की वृद्धि के लिए उन्नत तकनीकें” which is very popular among farmers and extension workers. The publication was awarded prestigious Dr. Rajendra Prasad Purushkar of Indian Council of Agricultural Research in the year 2004. E-books have been created for important technological bulletins. Vivek Thresher-1 for pearling and threshing of Mandua/Madira won NRDC’s Meritorious Invention Award for the year 2006 by National Research Development Corporation (NRDC), New Delhi and Institute’s scientists won Hari Om Ashram Trust Award 2007 of ICAR for this invention. A team of scientists won Outstanding Team Award of ICAR as a recognition to the work in the area of enhancing productivity and profitability of rice-wheat system in NW Himalayan States. Scientists of the institute also received World Intellectual Property Organization (WIPO) Gold Medal in 2009, for development of “Eco-friendly novel technology for managing white grubs in North West Himalayas” which was identified as the best invention of the year 2008. This work also won the Societal Innovation Award of NRDC in 2008. In 2010, the institute scientists got ICAR Outstanding Team Research Award in the subject area of Natural Resource Management. The Institute received Mahindra Krishi Samridhi India Agri Award 2012 for its outstanding contribution in the development of agricultural technologies and their popularization among farmers. The
Institute has been judged as the best institute for Application of Plastics in Agriculture under AICRP and received appreciation from IIMR for its outstanding contribution in maize improvement. The institute has been honoured for the development of landmark varieties of maize (VL Makka 54 and HIM 128) and wheat (VL Gehun 421) during the Platinum Jubilee Celebration of ISGPB on February 11, 2017. These varieties contributed towards food and nutritional security of the country.

1.4 Institute Facilities

Laboratories and Research Farm

The institute has well-equipped facilities for plant breeding, molecular biology, plant Pathology, microbiology and agricultural chemistry at Almora and Boshi Sen field research laboratory with entomology, soil science, quality testing, agricultural engineering laboratories, seed processing plant and germplasm storage module at Hawalbagh.

Research Farm

Prof. Boshi Sen Field Research Laboratory and Research Farm is located at Hawalbagh about 13 km on Almora-Kausani/Ranikhet Road at an elevation of 1250 m above mean sea level. The Research Farm of the Institute has 92 ha of total land with about 44.5 ha (including fodder) of cultivable land. In addition, a number of new laboratories were developed to accommodate the activities of various disciplines in the Field Research Laboratory at Hawalbagh. These include short-term cold storage module, post-harvest technology unit, mushroom composting unit etc.

Institute Library

A total of 4178 books of various subjects related to the scientific activities of the institute are available in the library, besides reports and bulletins received on exchange/ complementary basis from other institutions of the country and abroad. The library subscribed 16 foreign and 57 Indian periodicals until 2016. At present the library subscribes to 10 Indian journals. There are about 4000 bound periodicals in the library. The library is also providing current awareness service to the scientists of the institute and other outside research and development professionals visiting the institute.

Agricultural Knowledge Management Unit

The institute has set up a LAN consisting of about 50 nodes at Almora campus and about 30 nodes at Experimental Farm, Hawalbagh, with 10 Mbps Internet leased line connection at both campuses. AKMU also maintains institute’s website, which can be accessed at the http://vpkas.icar.gov.in. AKMU also runs toll free Farmers’ Helpline Service and need based/tracking SMS services for farmers. Farm advisory services are provided regularly through toll-free Farmers’ Helpline Service (Telephone No. 1800 180 2311). Institute has initiated Need Based Mobile SMS service for farmers in July 2016. Farmers were registered for receiving SMS and were grouped based on crop grown, location and activities engaged in. Presently more than 550 farmers are registered for the service. Information are sent to farmers on different contents like varieties, crop protection measures, nutrient management, farmers fairs/field days, seed production, government schemes etc benefitting more than 550 farmers.

IPT&M Unit

To showcase institute technologies to industry and other stakeholder for further mass multiplication and commercialization, a meeting for techno-commercial assessment and preparation of standard terms of ICAR-VPKAS technologies was organized on Dec. 5, 2017 at Agri-innovate India Ltd, New Delhi. In addition, the MoA with M/s Punjab Agricultural Implements (P) Ltd., Saharanpur (U.P.) for Vivek Mandua Thresher 1 and with M/s Doon Trunk House, Jakhan Devi, Almora for VL-White Grub Beetle Trap- 1 was extended.
Staff
The staff position of the Institute as on 31.3.2018 is given below:

<table>
<thead>
<tr>
<th></th>
<th>Sanctioned</th>
<th>Filled</th>
<th>Vacant</th>
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Finance
The budget outlay for 2017-18 (Rs. in lakhs) is given hereunder:

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<th>Expenditure</th>
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</thead>
<tbody>
<tr>
<td>Grant-in-General</td>
<td>1852.76</td>
<td>1789.51</td>
</tr>
</tbody>
</table>

1.5 Weather and Crop Season
At Almora, the mean maximum daily temperature during *kharif* season (May to October) ranged from 25.5°C (October) to 28.5°C (June) and mean minimum daily temperature varied from 14.1°C (October) to 19.5°C (August). During *kharif* about 883.0 mm rainfall was received. The maximum rainfall was received during July (293.8 mm) followed by September (182.4 mm). The mean maximum daily temperature during *rabi* season (November to April) ranged from 17.5°C (January) to 27.6°C (April) and the mean minimum daily temperature from 5.1°C (January) to 12.7°C (April), respectively. During *rabi*, about 63.6 mm of rainfall was received with no rainfall in the month of November. The total rainfall for entire year was 946.6 mm.

However, at the Experimental farm Hawalbag, the mean maximum daily temperature during *kharif* season (May to October) ranged from 28.8°C (July) to 31.3°C (May) and mean minimum daily temperature varied from 10.5°C (October) to 21.5°C (August). During *kharif* about 791.1 mm rainfall was received. The maximum rainfall was received during July (287.4 mm) followed by September (152.2 mm). The mean maximum daily temperature during *rabi* season (November to April) ranged from 21.3°C (January) to 30.2°C (April) and the mean minimum daily temperature from -2.1°C (January) to 10.8°C (April), respectively. During *rabi*, about 52.8 mm of rainfall was received with no rainfall in the month of November. The total rainfall for entire year was 843.85 mm.
ACHIEVEMENTS

Finger Millet - VL 376
Patented Light Trap
Wheat - VL 2014
Siderophore Production
Bee Restaurants & Hotel
Chaff Cutter
2. Enhancement in the Productivity of Major Hill Crops

Research Projects

- Genetic Improvement of Maize for Higher Productivity, Quality, Biotic and Abiotic Stresses
  [Drs. R.K. Khulbe, D.C. Joshi (w.e.f. August 2017), D. Mahanta, & Rajashekara, H.]

- Genetic Improvement of Rice for Higher Productivity, Quality, Biotic and Abiotic Stresses
  [Drs. J.P. Aditya, B.M. Pandey, Rajashekara, H., J. Stanley & Anuradha Bhartiya]

- Genetic Improvement of Wheat and Barley for Higher Productivity, Quality, Biotic and Abiotic Stresses

- Genetic Improvement of Small Millets and Under-utilized Crops for Higher Productivity, Quality, Biotic and Abiotic Stresses
  [Drs. R.K. Khulbe (upto July 2017), D.C. Joshi (w.e.f., August 2017), B.M. Pandey & Rajashekara, H.]

- Genetic Improvement of Pulses and Oilseeds for Higher Productivity, Quality, Biotic and Abiotic Stresses

- Genetic Improvement of Vegetables for Higher Productivity, Biotic Stresses and Quality Traits
  [Drs. N.K. Hedau, Chaudhari Ganesh Vasudeo, K.K. Mishra & R.S. Pal]

- Basic and Strategic Research for Genetic Enhancement of Major Hill Crops for Biotic Stresses and Quality Traits using Molecular Tools
  [Dr. Rakesh Bhowmick (upto January 03, 2018)]

- Seed Production
  [Drs. L. Kant, R.K. Khulbe & Chaudhari Ganesh Vasudeo]
2. Enhancement in the Productivity of Major Hill Crops

2.1. Maize

Maize is an important cereal crop of North-Western Himalayas. By and large, maize is cultivated during the *kharif* season under rainfed conditions in the North-Western Hills. The states of Jammu & Kashmir, Himachal Pradesh and Uttarakhand (Hills) with a total area of 625 th ha and production of 1189 th tonnes, account for 7.2 and 5.5% of the national area and production, respectively. The productivity is 1,902 kg/ha compared to the national average of 2,509 kg/ha. Considering the short growing period and high cropping intensity in hills, emphasis was laid on the development of early and extra-early duration genotypes, which mature in 85-90 days in hills with high yield potential and resistance to prevailing diseases in general and *turcicum* leaf blight in particular. Thrust was also placed on the development of these specialty corn like sweet corn, popcorn and baby corn varieties, in view of the commercial potential of specialty corn in the region.

2.1.1. Varietal Improvement

2.1.1.1. Varieties Notified

**Central Maize VL Baby Corn 2**: Baby corn hybrid Central Maize VL Baby Corn 2 was notified [S.O.1007(E)] for cultivation in the states of Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh, Haryana, Delhi, Uttarakhand, Punjab, Haryana, Delhi, Uttar Pradesh, Maharashtra, Karnataka, Andhra Pradesh, Telangana, Tamil Nadu, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh. It registered an average babycorn yield of 1,725 kg/ha, 2,492 kg/ha, 1,064 kg/ha, 2,163 kg/ha and 2,216 kg/ha in all India Coordinated trials in Zone 1 (Northern Hill Zone), Zone 2 (North Western Plain Zone), Zone 3 (North Eastern Plain Zone), Zone 4 (Peninsular Zone) and Zone 5 (Central Western Zone), exhibiting yield superiority of 14.0, 46.7, 8.7, 19.9 and 34.0% over the check HM 4, respectively. It attains harvestable maturity (babycorn) in 52-54 days in hills and in 48-52 days in plains.

**Central Maize VL 55**: Normal corn hybrid Central Maize VL 55 was notified [S.O.1007(E)] for cultivation in the states of Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh, Haryana, North East Hills, Andhra Pradesh, Telangana, Maharashtra, Karnataka and Tamil Nadu. It registered an average yield of 7,071 kg/ha and 8,024 kg/ha in all India coordinated trials in Zone 1 (Northern Hill Zone) and Zone 4 (Peninsular Zone), exhibiting yield superiority of 15.2 and 23.9%, respectively, over the best check PMH 5.

2.1.1.2. Elite Lines under All India Coordinated Maize Improvement Programme

In IET, 63-64 [Extra early (85-90 days), Early (95-100 days)], FH 3823 (5,742 kg/ha) was
superior to the check DKC 7074 (5,535 kg/ha) in Zone V.

2.1.1.3. Elite Lines under State Maize Improvement Programme

In SVT (Hills), QPM hybrid FQH 106 (3,798 kg/ha) and QPM composite VL QPM composite 2 (2,954 kg/ha) were superior to their checks, Vivek QPM 9 (3,154 kg/ha) and Vivek Sankul Makka 31 (2,600 kg/ha), respectively. In SVT (Plains), FH 3703 (4,595 kg/ha) was superior to the best check PSM 1 (3,964 kg/ha).

2.1.1.4. Breeding Materials/Development of New Strains

Development of heterotic pools

Based on pedigree and heterotic pattern, F1s developed from existing elite inbreds (assorted into two groups of 20 inbreds each for synthesis of heterotic pools for inbred extraction) were inter-mated through chain-crossing and equal seed from each pair was bulked. The constituent lines include inbreds with early-medium maturity (50-60 days for 50% silking), turcicum leaf blight resistance (disease score <2.5), high tryptophan content (>0.6%), high provitamin A content (>8 ppm) and low phytate content (<8 mg/g).

Development of composites

QPM: Fifty-one high tryptophan (>0.80%) and agronomically superior progenies with high vigour, and good cob size of VL QPM composite 1 (synthesized from bulk seed of ten crosses obtained by chain crossing, ten converted QPM lines with high tryptophan content) were raised. Ear-to-row selection for plant height, uniformity, better yield and tolerance to turcicum leaf blight was practiced in the experimental QPM composite. A total of 135 progenies possessing high tryptophan (>0.80%) and desired agronomic traits (85-90 days maturity, 200-210 cm plant height, flint grain, good cob size) were selected.

Sweet corn: Mild selection for uniformity, better yield and tolerance to turcicum leaf blight and other prevailing diseases was practiced in sweet corn synthetic VL 15 and seed of 287 agronomically superior individuals (90-95 days maturity, 200-215 cm plant height, heavy tassel, 16-18 cm cob length, 14-16 kernel rows) were bulked.

Development of normal and specialty corn inbred lines

- To develop short duration productive inbred lines, inbreeding was initiated in 14 promising open pollinated populations identified during kharif 2016. Twenty-three progenies representing these base materials possessing early maturity (52-56 days to 50% silking), shorter plant height (200-215 cm) and tolerance to turcicum leaf blight (disease score <2.75) and banded leaf and sheath blight (disease score <2.5) were retained for further inbreeding and selection.

- Four hundred and five progenies of different homozygosity levels (45 S1, 109 S2, 62 S3, 61 S4, 65 S5, 40 S6, 8 S7 and 11 advance generation lines) were evaluated and 309 lines (40 S2, 102 S3, 46 S4, 63 S5, 46 S6, 12 S7 and 12 advance lines) possessing earliness (95-100 days), medium plant height (140-170 cm), good vigour, shorter anthesis-silking interval (1-2 days) and tolerance to biotic stress mainly H. turcicum (disease score <2.5) were retained for further selection and inbreeding.

- Six advance generation inbred lines (V 503, V 504, V 505, V 506, V 507 and V 508) possessing early maturity (52-56 days to 50% silking), short stature, high vigour and resistance to turcicum leaf blight (disease score <2.5) were established and used in hybridization.

- Inbreeding was initiated in two elite sweet corn populations and six promising S1 progenies possessing early maturity (52-56 days to 50% silking) and tolerance to turcicum leaf blight (disease score <2.5) were retained for further inbreeding.

- Selection and inbreeding was continued in 176 (6 S1, 46 S2, and 124 S3) different
homozygus inbred lines of sweet corn and 157 desirable lines (14 S, 34 S3 and 109 S6) with medium plant height (150-180 cm), earliness (52-56 days to 50% silking) and tolerance to TLB (disease score <2.75) were retained for further inbreeding, selection and use in hybridization.

- Six promising inbred lines (VSL 37, VSL 38, VSL 39, VSL 40, VSL 41 and VSL 42) were used to obtain new sweet corn hybrids.

- Advance generation progenies of two BC2F2 populations generated by crossing QPM versions of CM 212 and V373 with two sweet corn donors were evaluated. Promising progenies from each population were identified, maintained and used in hybridization programme.

**Development of new single-cross hybrids**

Forty-two new normal corn hybrid combinations were generated involving 20 existing elite lines and 8 new promising lines (V 503, V 504, V 505, V 506, V 507, V 508, V 509 and V 510) identified during the season. Fifteen new hybrid combinations of sweet corn were obtained involving 5 existing (VSL 7, VSL 20, VSL 30, VSL 31 and VSL 33) and 6 advance stage elite inbred lines (VSL 37, VSL 38, VSL 39, VSL 40, VSL 41 and VSL 42). Sixteen new QPM hybrids were generated by crossing among 14 new and converted QPM lines and tryptophan-enhanced parental lines of Vivek QPM 9 and Vivek QPM 21.

**2.1.1.5. Germplasm Resource: Evaluation and Maintenance**

Forty indigenous/exotic inbred lines received from Indian Institute of Maize Research (IIMR) Winter Nursery, Hyderabad were evaluated. Of these, 21 early-medium lines (54-60 days for silking) of normal corn possessing desirable agronomic traits [good yield potential, medium plant height (135-175 cm), medium to large tassel with prolonged pollen shedding ability] and resistance/tolerance to turcicum leaf blight (TLB) were maintained for their potential use in hybridization programme.

Eight accessions of local maize (Dhiari Local, Jaunsar Local Yellow, Jaunsar Local Purple, Hadonwala Local, Kwanu Local and three accessions, viz., MS 1-1, MS 4-1 and MS 8-1, from NEH) were evaluated. The Uttarakhand accessions except Kwanu Local were early (49-58 days for 50% silking) but susceptible to TLB. Segregation for grain colour was also observed in these accessions. NEH accessions were tall (>3 m) and of medium maturity (60-64 days to 50% silking).

**2.1.1.6. New Initiatives**

**Development of low phytate maize lines**

Phytic acid is the primary storage compound of phosphorous in seed. It accounts for up to 80% of total seed phosphorous but is an anti-nutritional factor. Phytic acid binds tightly to mineral cations like iron, zinc and calcium. Development of low phytate maize, therefore, is a potential strategy for increasing bioavailability of minerals in human and animal diet. A programme aimed at developing low phytate lines was, therefore, initiated in 2011. Inbreds CM 145 and V 334 were chosen as recurrent parents with Lpa1 and Lpa2 as respective donors for low phytate trait. Besides lines with low phytate genotypes in the background of CM 145 and V 334, the programme has yielded transgressive segregants for low phytate trait. The presence of low phytate in the lines was confirmed biochemically as per the standard protocol of Aaron et al. (2007) as well as using molecular markers (CAPS marker ZMF1302-ZMGSPR1580). The phytic acid content and important agronomic characters of some promising lines are given in Table 2.1.1.
Table 2.1.1. Phytic acid content and important agronomic characters of low phytate lines

<table>
<thead>
<tr>
<th>Lines</th>
<th>Days to 50% pollen shed</th>
<th>Days to 50% silk</th>
<th>Plant height (cm)</th>
<th>TLB (1-5)</th>
<th>Phytic acid (mg/g)</th>
</tr>
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<tr>
<td>CM 145</td>
<td>54</td>
<td>56</td>
<td>120</td>
<td>1.50</td>
<td>3.64</td>
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<tr>
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<td>56</td>
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<td>57</td>
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<td>V 334</td>
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<td>PB 14-01</td>
<td>60</td>
<td>60</td>
<td>145</td>
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possesses earliness as well. This set of lines, therefore, stands to widen the choice of donors for low phytate trait.

**Doubled haploid breeding programme**

One doubled haploid line was obtained from the cross QPM 9 x EC 805127 made during kharif 2015. Haploid genomic constitution of the line was confirmed using suitable foreground (phi057) and background markers. The line has been used as a parent for generation of new QPM hybrids. Putative haploid seeds generated during kharif 2016 by crossing haploid inducer line EC 805127 (obtained from IIMR, New Delhi) with hybrids Vivek QPM 9, FQH 106, CMVL55, FSCH 41, RASI 4212, HIBRIX 39, US Agri 103, Sugar 75 and VMH 45 were propagated during kharif 2017 following standard protocol. Out of a total of 864 colchicine treated seedlings transferred to the field, seed from 139 plants (86 with >5 seeds and 53 with <5 seeds) were harvested. New crosses between VMH 45, Vivek QPM 9, FQH 106, Sugar 75, FSCH 41 and VMH 53 were also generated.

**2.1.2. Germplasm Shared**

During 2017-18, more than 40 maize inbreds were shared with different all India coordinated maize improvement programme centres to strengthen their early and QPM breeding programme (Table 2.1.2).

**2.1.3. Crop Protection Investigations**

During kharif 2017, 396 maize genotypes from both station and coordinated entries were evaluated for turcicum leaf blight (*Exserohilum*...
Plants were inoculated with the pathogen in whorl after 30 days of sowing. Symptom expression was allowed, and disease data was taken on 0-9 scale and resistant sources were identified (Table 2.1.3).

### 2.1.4. Agronomic Investigations

**Performance of pre-release sweet corn genotypes under varying planting density and nutrient levels**

Three new genotypes of sweetcorn (AKSH 4, FSCH 75 and BSCH 6) were evaluated against three checks (Madhuri Sweet Corn, Priya Sweet Corn and WOSC) with two planting densities (60 cm x 20 cm and 50 cm x 20 cm) and two fertilizer levels (150-50-60 and 200-60-80 kg N-P₂O₅-K₂O/ha). Among genotypes, FSCH75 produced significantly higher cob yield (17,516 kg/ha) than the rest of the genotypes, except AKSH4 (16,590 kg/ha). Application of 200-60-80 kg N-P₂O₅-K₂O/ha provided significantly higher cob yield (17,924 kg/ha) than 150-50-60 kg N-P₂O₅-K₂O/ha (14,438 kg/ha). There was

### Table 2.1.3. Genotypes resistant to turcicum leaf blight

<table>
<thead>
<tr>
<th>Trial name</th>
<th>No of entries</th>
<th>Highly resistant entries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfed AVT-I</td>
<td>11</td>
<td>2814, 2818 and 2820 (1 score)</td>
</tr>
<tr>
<td>Trial 75, late AVT-I-II</td>
<td>24</td>
<td>2363, 2367, 2370, 2376, 2378, 2379, 2381 and 2382 (2 score in 0-9 scale)</td>
</tr>
<tr>
<td>NIVT-Medium</td>
<td>100</td>
<td>1807, 1804, 1837, 1829 and 1873</td>
</tr>
<tr>
<td>NIVT-Late</td>
<td>84</td>
<td>1538, 1548, 1561, 1608, 1545, 1501, 1526, 1573, 1600, 1574, 1552, 1578, 1568, 1533, 1555, 1542, 1593, 1607 and 1553</td>
</tr>
<tr>
<td>Early-extra early maturity</td>
<td>40</td>
<td>2105, 2116, 2109, 2118, 2111, 2123, 2106 and 2107</td>
</tr>
<tr>
<td>Trial 76, medium maturity AVT-I-III</td>
<td>26</td>
<td>2428 (1 score) and 2434 (2 score)</td>
</tr>
<tr>
<td>Trial 77, early AVT-I-II</td>
<td>15</td>
<td>2602, 2604 and 2608</td>
</tr>
<tr>
<td>QPM-I-II-III</td>
<td>40</td>
<td>2237, 2227 and 2235</td>
</tr>
<tr>
<td>Sweet corn trial I-II-III</td>
<td>15</td>
<td>2507 and 2509 (2 score)</td>
</tr>
<tr>
<td>Baby corn-I-II-III</td>
<td>11</td>
<td>2535, 2542 and 2545</td>
</tr>
<tr>
<td>Baby corn-I-III</td>
<td>14</td>
<td>2561 and 2573</td>
</tr>
<tr>
<td>Trap nursery</td>
<td>14</td>
<td>CM 119</td>
</tr>
</tbody>
</table>
no significant difference between two planting densities.

**Relative performance of pre-released early maturity genotypes at different planting density and nutrient levels**

Two new genotypes (DMRH 1305 and FH 3754) of early maturity maize (85-90 days maturity) were evaluated against two checks (PMH 5 and Prakash) with two planting densities (60 cm x 20 cm and 50 cm x 20 cm) and three fertilizer levels (150-60-60, 200-65-80 and 250-80-100 kg N-P₂O₅-K₂O/ha). Among the genotypes, DMRH 1305 produced significantly higher grain yield (10,445 kg/ha) than the rest of the genotypes, except FH 3754 (10,268 kg/ha). The planting density of 50 cm x 20 cm (7,696 kg/ha) provided 10% more grain yield than 60 cm x 20 cm (6,992 kg/ha). Application of 250-80-100 kg N-P₂O₅-K₂O /ha (8,390 kg/ha) produced 29% more grain yield than 150-60-60 kg N-P₂O₅-K₂O/ha (6,509 kg/ha).

### 2.2. Rice

Rice is one of the major food crops of the hill regions of India. The total area under hill rice in India is about 1.8-2.0 million ha, out of which 0.64 M ha is under North-Western Himalaya, producing about 1.41 million tonnes of rice. The productivity of rice in Uttarakhand was the highest (2,420 kg/ha) as compared to Himachal Pradesh (1,763 kg/ha); Jammu & Kashmir (2,123 kg/ha) and North Eastern States (2,057 kg/ha) during 2015-16, whereas the national average productivity was 2,400 kg/ha. Rigorous efforts have been made at the institute in the last few years to develop and identify superior genotypes of rice in terms of grain yield, resistance/tolerance to prevailing biotic/abiotic stresses, quality traits and development of production technologies for their suitability under rainfed upland (spring and summer sowing) and irrigated transplanted conditions.

#### 2.2.1. Varietal Improvement

**2.2.1.1. Varieties notified**

**VL Dhan 158 (VL 8657, IET 22982):** VL Dhan 158 is notified [S.O.1007(E)] for the states of Himachal Pradesh and Uttarakhand. It matures in 110-120 days with mean grain yield of 2,728 kg/ha in lower hills and 1,757 kg/ha in mid hills. It is developed from a cross between RCPL 1-45 and VL 3861. It has light yellow, short bold, awnless grain and the plant height is of 110-123 cm. It provided 39.9% yield advantage over Vivek Dhan 154 (national check).

**2.2.1.2. Elite lines under all India coordinated rice improvement programme**

Total five trials under the AICRIP [(AVT-E (H), IVT-E (H), AVT-M (H), IVT-M (H), IVT-U (H)] were conducted as a part of multilocalional trials. In irrigated early duration entry VL 32237 was promoted to third year of testing whereas, entries *viz.*, VL 32130, VL 32131, and VL 40387 were promoted to second year under irrigated medium duration. In rainfed upland June sown rice, four entries *viz.*, VL 20073, VL 20076, VL 20080 and VL 20083 were promoted to second year of testing.

**2.2.1.3. Elite lines under state rice improvement programme**

Under organic conditions, four ‘State Varietal Trials’ (Spring sown, June sown, irrigated early duration and Irrigated medium duration) were conducted as a part of multicitional trials. In spring sown rice, entries *viz.* VL 11532, VL 11534, VL 11574 and VL 11616 were promoted to third year; however, VL 11743, VL 11638, VL 11634 and VL 11631 were promoted to second year of testing. In June sown trial, entries *viz.* VL 20073 and VL 20083 were promoted to third...
year of testing whereas entry VL 8966 completed three year of testing and were found promising. In irrigated transplanted early duration, entry VL 32110 was promoted to second year of testing and in irrigated transplanted medium duration, entries viz. VL 32226 and VL 31194 were promoted to third year of testing; VL 32094 was promoted to second year of testing; VL 31745 completed fourth year of testing and found promising, whereas VL 31329 completed third year of testing and found promising.

2.2.1.4. Breeding materials/Development of new strains

Under rainfed upland spring sown conditions, entries VL 11718 (2,646 kg/ha) and VL 11704 (2,570 kg/ha) recorded yield advantage of 28.2 and 26.0% over the best check VL Dhan 209 (1,901 kg/ha). Under rainfed upland June sown conditions, VL 20250 (2,438 kg/ha) and VL 20229 (2,401 kg/ha) recorded yield superiority of 4.4 and 2.8% over the best check VL Dhan 157 (2,336 kg/ha). Likewise, under irrigated early sown conditions, VL 32292 (4,653 kg/ha) and VL 32308 (4,606 kg/ha) recorded yield advantage of 7.4 and 6.4% over the best check VL Dhan 86 (4,352 kg/ha). In irrigated medium duration, entries VL 32331 (5,394 kg/ha) and VL 32329 (5,116 kg/ha) exhibited yield superiority of 24.6 and 18.2% over the best check. VL Dhan 68 (4,329 kg/ha). All these selected lines were resistant to blast (1-3 score) and have acceptable agronomic traits like plant height (semi dwarf irrigated <110cm, upland <90cm to intermediate irrigated 110-130cm, upland 90-125cm) with different days to maturity (early 100-120 days under irrigated & rainfed upland June sown), medium (125-140 days under irrigated) and very late (>160 days under rainfed upland spring sown).

**Segregating breeding materials**

Based on the good phenotypic characters, drought tolerance (0-3 score of leaf drying), disease (0-5 score) and insect resistance (0-3 score), genotypes of desired maturity (early -100-120 days under irrigated & rainfed upland June sown), medium 125-140 days in irrigated and very late - >160 days under rainfed upland spring sown and plant height 90–130cm depending on ecology (semi dwarf 90–110cm to intermediate 110-130 cm, upland 90-125cm), a total of 5335 progenies derived from 952 crosses were selected in F1 to F5 generations under different ecosystems viz. rainfed upland (Spring and June sown) and irrigated transplanted conditions (Early & Medium maturity).

Under rainfed upland spring sown conditions, 436 plants were selected from 44 crosses of F2 generation. Two hundred forty-eight plant progenies from 25 crosses in F3 generation, 129 plant progenies from 16 crosses in F4 generation and 140 plant progenies from 14 crosses in F5 generation were selected for drought tolerance (0-3 scale), blast & brown spot (0-5 scale) resistance and better yielding ability (large panicle and more number of grains/panicle).
Under June-sown rainfed upland conditions, 342 plants were selected from 36 crosses of F\textsubscript{2} generation. Four hundred forty-four plant progenies from 46 crosses in F\textsubscript{3} generation, 418 plant progenies from 50 crosses in F\textsubscript{4} generation, 208 plant progenies from 21 crosses in F\textsubscript{5} generation were selected for drought tolerance (0-3 scale), short duration (110-120 days), blast resistance (0-5 scale) and better yielding ability (large panicle and more no. of grains/panicle).

For the irrigated ecosystem, 573 plants were selected from 74 crosses in F\textsubscript{2} generation, 522 plant progenies from 70 crosses in F\textsubscript{3} generation, 507 plant progenies from 53 crosses in F\textsubscript{4} generation and 569 plant progenies from 59 crosses in F\textsubscript{5} generation were selected. In this ecosystem, more emphasis was given to select short (100-120 days) to medium (125-140 days) duration plants with resistance against blast disease (0-5 scale).

In the breeding programme for the quality (aromatic/slender), 329 plant progenies from 34 crosses in F\textsubscript{2} generation, 80 plant progenies from 8 crosses in F\textsubscript{3} generation, 100 plant progenies from 10 crosses in F\textsubscript{4} generation and 260 plant progenies from 26 crosses in F\textsubscript{5} generation were selected in fine grain aromatic rice. All of them possessed fair level of resistance against blast (0-5 scale) and other biotic stresses (0-5 scale).

2.2.2. Crop Protection Investigations
Plant pathological experiments were carried out during kharif 2017 for disease resistance evaluation in rice lines received from rice breeder (station entries) and AICRIP entries and screened under Uniform Blast Nursery (UBN) for blast and brown leaf spot and the results are summarized as follows (Table 2.2.1).

<table>
<thead>
<tr>
<th>Trial/ Nursery</th>
<th>No. of Entries</th>
<th>Promising lines identified (0-3 scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advance station trial for spring rice (Brown spot disease)</td>
<td>10</td>
<td>none</td>
</tr>
<tr>
<td>Advance station trial for June sown rainfed condition</td>
<td>18</td>
<td>none</td>
</tr>
<tr>
<td>Advance station trial for transplanted rice</td>
<td>22</td>
<td>VL 32265, VL 32299, VL 32303, VL 32307, VL 32308, VL 32316 and VL 32330</td>
</tr>
<tr>
<td>VL rice blast screening nursery (VLRBSN)</td>
<td>79</td>
<td>Twenty-two entries</td>
</tr>
<tr>
<td>National Screening Nursery for hills (NSNH)</td>
<td>99</td>
<td>None</td>
</tr>
</tbody>
</table>
### Trial/ Nursery

<table>
<thead>
<tr>
<th>Trial/ Nursery</th>
<th>No. of Entries</th>
<th>Promising lines identified (0-3 scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Hybrid Screening Nursery (NHSN)</td>
<td>127</td>
<td>Brown leaf spot: None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leaf blast: None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Neck blast: None</td>
</tr>
<tr>
<td>Donor Screening Nursery (DSN)</td>
<td>90</td>
<td>Brown leaf spot: None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leaf blast: RP-Patho-7-5-9,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RP-Patho-8-1-55,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RP-Patho-9-12-9,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RP-Patho-10-6-1 and HWR-20</td>
</tr>
<tr>
<td>National Screening Nursery (NSN-1)</td>
<td>354</td>
<td>Brown leaf spot: None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leaf blast: None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Neck blast: None</td>
</tr>
<tr>
<td>National Screening Nursery (NSN-2)</td>
<td>743</td>
<td>Brown leaf spot: None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leaf blast: None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Neck blast: None</td>
</tr>
</tbody>
</table>

### 2.3. Wheat

Wheat is the most important cereal crop of *rabi* season in the North Western Himalaya with an average productivity of 1,609 kg/ha, which is much below the national productivity of 2,750 kg/ha in 2014-15. It is grown over an area of 0.99 million ha in N-W Himalayas with an average productivity of 1,967; 979 and 1,881 kg/ha in the states of Himachal Pradesh, Jammu & Kashmir and Uttarakhand, respectively. The present status of production and productivity can be raised by the adoption of high yielding varieties having resistance/ tolerance to biotic (yellow, brown rust and loose smut) and abiotic (drought and cold) stresses along with suitable production and protection technologies.

#### 2.3.1. Varietal Improvement

##### 2.3.1.1. Varieties identified

**VL 2015:** It is identified for rainfed timely sown organic conditions of Uttarakhand hills and has an average yield potential of 1,988 kg/ha. This variety has shown yield advantage of 23.5% over the best check VL Gehun 907 (1,610 kg/ha). Besides high yield, VL 2015 possess high degree of resistance to yellow (5MS) and brown rust (0) under field conditions.

**VL 2014:** It is identified for irrigated timely sown conditions of Uttarakhand plains. It has an average yield potential of 5,207 kg/ha. This variety has shown yield advantage of 19.0% over the best check UPA 2628 (4,375 kg/ha). It also possesses high degree of resistance to yellow (0) and brown rust (0) under field conditions.

#### 2.3.1.2. Elite lines under all India coordinated wheat improvement program

**Rainfed conditions**

Four yield evaluation trials were conducted to assess the adaptability of new wheat strains with respect to grain yield, disease resistance and other desirable attributes under the rainfed early sown, rainfed as well as irrigated timely sown and restricted irrigation late sown conditions. Under the rainfed situations, the early sown IVT/AVT trial included 12 entries of which, two entries VL 1011 (1,190 kg/ha) and HS 645 (1,080 kg/ha) yielded numerically higher than the best check HS 542 (1,020 kg/ha). Twenty-four entries were tested in timely sown IVT trial and HS 634 (3,870 kg/ha) was found significantly superior to the best check HPW 349 (1,556 kg/ha). Under the late sown restricted irrigation IVT/AVT
(pre-sown irrigation only) trial, 11 entries were evaluated and two entries VL 3014 (1,820 kg/ha) and HS 648 (1,800 kg/ha) yielded better than the best check HS 490 (1,720 kg/ha).

**Irrigated conditions**

Under the irrigated conditions, 24 entries were evaluated under IVT trial, where HPW 441 (5,160 kg/ha), HPW 444 (4,960 kg/ha), HS 631 (4,890 kg/ha) and HS 634 (4,790 kg/ha) yielded numerically superior to the best check HS 507 (4,790 kg/ha).

### 2.3.1.3. Elite lines under state wheat improvement programme

#### Rainfed organic conditions

Twelve entries were tested under SVT organic timely sown trial, in which VL 2015 (3,667 kg/ha) and VL 2029 (3,533 kg/ha) recorded a yield advantage of 33.0% and 21.9% over the best check VL Gehun 907 (2,757 kg/ha).

#### Irrigated organic conditions

Under the irrigated conditions, 11 entries were evaluated under SVT organic timely sown trials, and none was superior to the latest variety VL Gehun 953 (3,505 kg/ha).

### 2.3.1.4. Elite lines under station trials

In yield evaluation trials, one trial each under rainfed early sown, rainfed timely sown, irrigated timely sown and restricted irrigation late sown conditions was conducted to assess the adaptability of new wheat strains with respect to grain yield and disease resistance. Under the rainfed situations, the early sown trial had 15 entries and VW 1609 (2,388 kg/ha) was found significantly superior to the best check HS 542 (1,671 kg/ha). Forty entries were tested under timely sown trial and VW 1645 (2,529 kg/ha), VW 1617 (2,080 kg/ha) and VW 1635 (1,882 kg/ha) were found significantly superior to the best check HPW 349 (1,556 kg/ha). Under the late sown restricted irrigation (pre-sown irrigation only) trials, 14 entries were evaluated, of which VW 1660 (2,639 kg/ha) was better than the best check VL Gehun 892 (2,628 kg/ha). Under the irrigated conditions, 40 entries were evaluated under timely sown trial and VW 1633 (6,908 kg/ha), VW 1613 (6,731 kg/ha), VW 1617 (6,676 kg/ha), were significantly better than the best check HPW 349 (6,440 kg/ha).

Out of 61 new bulks evaluated in different station trials under the rainfed as well as irrigated conditions, 10 promising strains entered in different All India Coordinated Trials of Northern Hills Zone.

### Development of new strains/breeding materials

The major objective of the programme is to develop high yielding disease resistant (yellow and brown rust and loose smut) genotypes suitable for rainfed early sown, rainfed and irrigated timely sown and restricted irrigation late sown conditions of Northern hill zone. Diverse donors of winter and spring wheat were used and 319 fresh crosses [107 spring x spring (S×S) and 212 winter x spring (W×S) wheat] including direct, back crosses and three way crosses were successfully made. Four hundred and fifty F₁ hybrids were evaluated and 137 better performing F₁ hybrids, consisting of 79 S×S and 58 W×S were identified.

The breeding materials were handled following selected bulk pedigree method. F₂ and F₄ generations were grown under low fertility and rainfed conditions. A total of 169 F₂’s (i.e. 80 S×S and 89 W×S), and 289 bulk progenies of 289 crosses (156 W×S and 133 S×S) in F₃; to F₅ generations and 335 single plant progenies (150 S×S) and (185 W×S) of 81 crosses in F₆ and subsequent generations were subjected to rigorous selection. The infector rows planted in and around the breeding materials were inoculated following syringe-inoculation method of rust inoculation. Finally, 336 bulk and 361 individual plant progenies from F₆ generations onward were selected for further evaluation during the ensuing season.

### 2.3.1.5. Breeding for quality wheat

Efforts have been made to incorporate the desirable quality traits viz. high protein content,
high micro-nutrients, good *chapati* and biscuit making quality *etc.* through hybridization with the proven donors. The donors like BWL 1660, BWL 1664, BWL 991 and QLD 11 (protein >16%), QLD 70, BN 959, QLD 71 and QLD 85 (protein yield 45-52 g), VL 858 (*chapati* quality), HD 3216 and UP 2927 (sedimentation value) and 8th EBWYT 510 have been crossed with well adapted genotypes. During rabi 2016-17, twenty fresh crosses were attempted. A total of 72 F<sub>6</sub> bulks derived from crosses were analyzed for quality traits. The quality parameters of promising F<sub>6</sub> bulks are given in Table 2.3.1.

Based on the rust resistance, parents were further selected for attempting crosses. In addition, three-way cross was also attempted with the F<sub>1</sub> of the previous year by crossing them with selected spring wheat. A total of 90 crosses were attempted during rabi 2016-17.

In addition to this, 93 F<sub>5</sub>s made during rabi 2015-16 were planted and 80 were retained for growing their F<sub>2</sub> generation during next crop season. A total of 60 F<sub>2</sub>’s retained during the last season were raised during rabi 2016-17. The high incidence of yellow and brown rust facilitated the selection and to reduce the numbers of susceptible crosses. In fact, only negative selection was practiced in these materials. Finally, 55 F<sub>2</sub>’s was bulked.

Forty-six F<sub>2</sub> bulks were supplied during rabi 2016-17 to IIWBR, Karnal for further distribution to different coordinating and cooperating centers. The seeds of these 46 F<sub>2</sub> bulks were shared with 6 cooperators in three major wheat growing zones Northern hill zone, North Eastern plain zone and

### Table 2.3.1. Quality parameters of promising F<sub>6</sub> bulks

<table>
<thead>
<tr>
<th>Breeding No.</th>
<th>Pedigree</th>
<th>Protein (%)</th>
<th>Wet gluten (%)</th>
<th>Sedimentation value (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BN-675</td>
<td>QLD 31/ VL 900/ VL 900</td>
<td>15.8</td>
<td>29.5</td>
<td>62.6</td>
</tr>
<tr>
<td>BN-883</td>
<td>VL 824/ F81513/ MILAN</td>
<td>15.8</td>
<td>38.6</td>
<td>60.4</td>
</tr>
<tr>
<td>BN-967</td>
<td>PBW521/ KLEIBER/ 2* FL80/ DONSK/POLL/ VW0865/ Raj4132</td>
<td>15.8</td>
<td>39.1</td>
<td>59.4</td>
</tr>
<tr>
<td>BN-984</td>
<td>UP 2742/ QLD 39</td>
<td>15.8</td>
<td>39.2</td>
<td>58.6</td>
</tr>
<tr>
<td>BN-836</td>
<td>F81513/ MILAN/ VL 907</td>
<td>15.6</td>
<td>36.4</td>
<td>64.5</td>
</tr>
<tr>
<td>BN-580</td>
<td>QUAIU#1/3/ PBW343<em>2/ KUKUNA/ PBW343</em>2/ KUKUNA</td>
<td>15.4</td>
<td>38.7</td>
<td>60.0</td>
</tr>
<tr>
<td>BN-742</td>
<td>LBPY 05-2/ VL 876/ VL 876</td>
<td>15.2</td>
<td>36.2</td>
<td>64.0</td>
</tr>
<tr>
<td>BN-599</td>
<td>PAURAQ/ 6/ TRAP31/ BOW/ 3/ VEE/ PJN/ 2* TUI/ 4/ BAV 92RAYON/ 5/ KACHU#1</td>
<td>15.1</td>
<td>37.9</td>
<td>55.4</td>
</tr>
<tr>
<td>BN-748</td>
<td>VL 900/ DAULATKHANI AMB. BMED/ VL 900</td>
<td>15.0</td>
<td>35.6</td>
<td>56.3</td>
</tr>
</tbody>
</table>

#### 2.3.1.6. Improvement of spring wheat through introgression from winter wheat gene pool

Thirty-five winter and facultative wheats, selected for their high grain yield, tillering, ear length, grain number per ear and disease resistance were crossed to spring wheat genotypes known for their high yield potential, disease resistance (rust resistance in particular) and adaptation to the major wheat growing regions of the country.

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Table 2.3.2. Detail of utilization of crosses

<table>
<thead>
<tr>
<th>Name of Centre</th>
<th>Crosses Selected</th>
<th>Utilization %</th>
<th>Plants selected</th>
<th>Main characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>RVSKVV, Gwalior</td>
<td>46</td>
<td>100</td>
<td>356</td>
<td>Yield components and morphological traits</td>
</tr>
<tr>
<td>CSKHPKV, Malan</td>
<td>43</td>
<td>93.5</td>
<td>951</td>
<td>Resistance to yellow rust and powdery mildew and yield components</td>
</tr>
<tr>
<td>SDAU, Vijapur</td>
<td>14</td>
<td>30.43</td>
<td>17</td>
<td>Rust resistance, yield components, morphological traits and seed characteristics</td>
</tr>
<tr>
<td>NDUAT, Faizabad</td>
<td>12</td>
<td>26.1</td>
<td>12</td>
<td>Yield components, leaf blight resistance and seed characteristics</td>
</tr>
<tr>
<td>CSAUAT, Kanpur</td>
<td>11</td>
<td>23.9</td>
<td>40</td>
<td>Yield components, morphological and seed characteristics</td>
</tr>
<tr>
<td>BHU, Varanasi</td>
<td>5</td>
<td>10.9</td>
<td>39</td>
<td>Yield components and leaf blight resistance</td>
</tr>
</tbody>
</table>

central zone) of the country for selection under different biotic and abiotic stresses and diverse agro-ecological conditions. The utilization report from cooperating centers is given in the following Table 2.3.2.

2.3.1.7. Genetic Resources - Evaluation and Maintenance

A total of 336 entries comprising of 4 national nurseries were evaluated. In National Genetic Stock nursery (NGSN), the entries were selected for rust resistance & tiller per m²; rust resistance & test weight (3); rust resistance, grain yield & grain number (2); test weight (3); rust resistance, grains per spike & test weight (2); and thirteen genotypes in Yield Component Screening Nursery (YCSN) for high tillers and grains per spike, high grain number and grain weight, rust resistance and yield components. Similarly, 8 genotypes, having high protein, high protein yield, good chapati and biscuit quality were selected from Quality Component Screening Nursery (QCSN). Nineteen genotypes were selected from Elite International Germplasm Nursery (EIGN) for evaluation and utilization for introduction.

Evaluation of Uttarakhand wheat collections from hills for yellow rust resistance

Fifty-five hill collections having field resistance to yellow rust were screened at Flowerdale, Himanchal Pradesh for seedling test under glass house conditions against 4 yellow rust pathotypes namely, 46S119, 78S84, 110S119 and 238S119. The SRT results revealed that only 12 hill collections (VHC(BD) 88 Amb-A, VHC(BD) 79, VHC 6161, VHC 6211, VHC 6225-A, VHC 6265, VHC 6285, VHC(BD)6, VHC(BD)7Red, VHC(BD) 31, VRS-CW-1892 and VHC 6202) were resistant against all the four pathotypes.

Off-season nursery

During kharif 2017, 222 advance lines of wheat were planted at Lahaul Spiti, Himachal Pradesh as well as Wellington, Tamil Nadu for screening against yellow and brown rust, respectively. Yellow rust severity upto 80S was recorded and finally, 72 lines having yellow rust score <20S were selected for evaluation in the ensuing season. In CRP molecular breeding wheat project, 282 F₁s and their parents were planted. Leaf samples were collected and F₁s were screened using gene specific markers for Yr 10 (Xpsp 3000) and Lr 24 (Sr 24 # 12). The positive plants backcrossed and 871 seeds in population A (VL Gehun 907/ Yr 10/ 5*Datatine), 646 seeds in population B (VL Gehun 907/ FLW 1), 406 seeds in population C (VL Gehun 892/Yr 10/ 5* Datatine) and 340 seeds in population D (VL Gehun 892/FLW 1) were obtained.
2.3.2. Plant Pathological Investigations
About 1465 wheat entries of different coordinated and station nurseries were screened under natural and artificial epiphytotic conditions. These include TRAP Nursery, SAARC, Loose Smut Expression Nursery (LSEN) and Hill Bunt Screening Nursery (HBSN). The promising lines identified are given in the Table 2.3.3.

Table 2.3.3. Promising lines of wheat in different disease screening nurseries

<table>
<thead>
<tr>
<th>Nursery</th>
<th>Promising lines with score range</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRAP</td>
<td>WL 711, 1562, C 306, HW 2021 against yellow rust (0 to 5S). Susceptible check: Agra local (40S)</td>
</tr>
<tr>
<td>SAARC</td>
<td>HD 2189, PBW 660, WL 1562 and Bakhtawar 94 (0 to 5S). Susceptible check: Sonalika (60S)</td>
</tr>
<tr>
<td>LSEN</td>
<td>HD 3086, VL 829, VL 3002, UAS 446, HD 4728 (0%) Susceptible check: Sonalika (65%)</td>
</tr>
<tr>
<td>HBSN</td>
<td>HS 542, UP 2992, VL 1012 (0%) Susceptible check: Girija (54.7%)</td>
</tr>
</tbody>
</table>

Multi-location testing of wheat genotypes under co-ordinated trials showed that VL 1011, VL 1012, VL 3013, VL 3014, VL 3012 were resistant to all the three rusts with ACI up to 10 in AVT I\textsuperscript{a} year of testing. VL 3013 was found to be resistant to all pathotypes of black and brown rusts, whereas VL 1012 is resistant to black and yellow rusts. Based on rigorous screening of multiple diseases screening nursery at multi-locations, VL 3002 and VL 3012 showed resistant to all three rusts and VL 3011, 4001 to stem and leaf rusts.

2.3.3. Agronomic Investigations

Management of lodging and yield maximization in wheat

Two growth regulators, namely lihocin and folicur were applied in combination with different nutrient management to manage lodging in wheat (cultivar: HS 562). Two sprays of Folicur\textsuperscript{®} @ 0.1% at first node and flag leaf stage provided significantly higher grain yield (6,573 kg/ha) than the rest of the treatments, which was 13% higher than without application (5,833 kg/ha). There was no lodging with or without application of growth regulators. But, the application of Lihocin\textsuperscript{®} (88.1 cm) and lihocin + folicur (86.0 cm) significantly reduced the plant height compared to the rest of the treatments (the reduction was 6.3 and 8.4 cm with spraying of lihocin and lihocin + folicur compared to without application, respectively). Application of folicur alone or with lihocin provided significantly higher effective tiller per m\textsuperscript{2} (430 tiller/m\textsuperscript{2}) than other treatments compared to control (395 tiller/m\textsuperscript{2}).

Performance of wheat varieties at different dates of sowing under irrigated conditions

Different dates of sowing were evaluated for five years with four timely sown varieties of Northern hill zone (VL 804, VL 907, HS 507 and HS 240)
for highest productivity of wheat at experimental farm, Hawalbag, ICAR-VPKAS, Almora. The maximum grain yield of irrigated wheat (mean of 5 years) can be achieved by sowing on November 4 (Fig. 2.3.1) and the sowing date can span from October 25 to November 15. Yield loss of 28 kg/ha/day for sowing during second fortnight of November was recorded. The sowing date providing maximum grain yield during different years varied from October 25 to November 10. The less was the rainfall during crop growing stage, the earlier was the date of sowing to provide maximum grain yield and vice versa (Fig. 2.3.2).

2.4. Small Millets & Potential Crops

Small millets are the integral part of hill and tribal farming in drylands across the country. These traditional rainfed crops are grown in North-Western Himalayan region from time immemorial because of their ability to provide assured harvest even under harsh and stressed conditions. Small millets are cultivated in over 196.8 thousand hectares in North-Western Himalayas with maximum area in Uttarakhand (175.0 thousand hectares) and productivity ranging from 360 kg/ha (other small millets in J&K) to 1,380 kg/ha (finger millet in Uttarakhand). Development of short duration, high yielding and disease resistant varieties of small millets is the main activity of the research program.

2.4.1. Varietal Improvement

2.4.1.1. Varieties identified for release

Central Finger millet VL Mandua 379: It is identified for release in rainfed kharif conditions of Uttarakhand, Bihar, Jharkhand, NE states and Madhya Pradesh by varietal identification committee during the year 2017. This is an early maturing (103-111 days), blast resistant high yielding genotype with mean grain yield of 3,131 kg/ha. It showed yield advantage of 18.3% over the best check VL Mandua 352. It was derived from a cross between an early maturing (95 days) genotype (GEC 440) selected from global core collection of finger millet and blast resistant high grain yielding variety VL Ragi 149. It has been found resistant to neck and finger blast disease and recorded lesser mean score of neck blast (2.2%) and finger blast (3.2%) as compared to check VL Mandua 352 (neck blast 5.0%, finger blast 4.0%) in coordinated trials.

2.4.1.2. Elite lines under all India coordinated small millets improvement programme

Finger Millet

A total of 46 finger millet genotypes were evaluated for yield and yield contributing characters in two coordinated trials. In Initial Varietal Trial, VR 1101 (3,446 kg/ha) and GPU 96 (3,132 kg/ha) were the top-ranking entries and recorded yield advantage of 11.3% and 9.7% respectively over the best check. Similarly, in advanced varietal trial (AVT) (early and medium duration), VL 387 (4,784 kg/ha) and BR 14-3 (4,196 kg/ha) recorded highest yield followed by VL 503 (3,582 kg/ha) and recorded yield advantage of 29.4%, 24.5% and 6.6% over the best check VL Mandua 352 (3,370 kg/ha) respectively.

Barnyard Millet

Barnyard millet initial and advanced varietal trial (BIAVT) comprising eight entries were evaluated for yield and yield contributing
traits. Entry VL 249 recorded the highest grain yield (2,092 kg/ha) followed by DHBM 19-7 (1,918 kg/ha). Both the entries recorded yield advantage of 11.4% and 9.07% over the best check VL 207 (1,880 kg/ha). Entry VL 249 was found resistant to grain smut disease and recorded lesser mean score (2.1%) to grain smut compared to check VL 207 (4.0%) and VL 172 (3.5%).

2.4.1.3. Elite lines under state varietal improvement programme

Finger Millet

In the state varietal trial (SVT) under organic conditions, VL 391 (2,666 kg/ha) followed by VL 392 (2,614 kg/ha) were the top-ranking entries in terms of grain yield. Both the entries showed yield advantage of 39.6% and 36.8% over the best check VL 352 (1,817 kg/ha). Both the entries were found resistant to neck and finger blast disease and recorded the lesser mean score of neck blast (2.8% and 2.3%) and finger blast (2.4% and 2.9%) compared to check VL Mandua 352 (neck blast 3.5%, finger blast 3.5%).

Barnyard Millet

In barnyard millet SVT trial, all the entries except VL255 recorded yield superiority over the best check VL 207 and were promoted to second year of testing. Entry VL 256 (1,802 kg/ha) and VL 259 (1,708 kg/ha) were the top-ranking genotypes in terms of grain yield. Both the entries showed yield advantage of 28.9% and 22.2 % over the best check VL 207 (1,398 kg/ha).

2.4.1.4. Breeding Materials/Development of New Strains

Finger Millet

Yield evaluation of superior bulks in station trial

During the rainy season 2017, 42 superior bulks identified in F$_6$ and F$_7$ generations of different crosses were evaluated in Initial Station Trial (IST) for yield and yield attributing traits along with three national checks (VL Madua 352, VL Mandua 324 and GPU 45). Entry VR-15-10 (3,971 kg/ha), VR 16-6 (3,022 kg/ha) and VR-16-11 (3,590 kg/ha) were superior to the best check VL 352 (2,552 kg/ha) and VL 324 (2,318 kg/ha). These bulks were also evaluated for resistance to neck and finger blast disease under natural conditions. Entry VR-15-10 was found to be resistant to neck (mean score 1.8%) and finger blast (mean score 2.2%) whereas VR 16-6 and VR-16-11 were moderately resistant to both the diseases.

Development of new strains

During kharif 2017, 22 new cross combinations were attempted involving high yielding blast resistant released varieties (VL 379, VL 376, GPU 45, GPU 48 and GPU 28); early maturing (<100 days), locally adapted lines (VL 149, VL 340, VL Mandua 347, and VL Mandua 352); white grained lines (VL 384 and TNEC 1234). In addition, local promising hill collections (VHC 3581, VHC 36610, VHC 3618, GPHCPB 52) as well as ICRISAT core germplasm lines (IE 4673) were also included in the crossing program.
Out of 22 crosses attempted during *Kharif* 2016, 17 crosses were identified to be true hybrids. The breeding materials were handled following selected bulk pedigree method. Plant progenies of different segregating generations were subjected to rigorous selection. The infector rows for neck and finger blast were planted in and around the breeding materials. The detail of the breeding material and single plant selections (SPS) made are given in Table 2.4.1.

**Table 2.4.1. Details of finger millet breeding material**

<table>
<thead>
<tr>
<th>Generation</th>
<th>Number of crosses</th>
<th>Number of progenies</th>
<th>Single Plant selections</th>
<th>Basis of selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>F₁</td>
<td>22</td>
<td>-</td>
<td>-</td>
<td>Early maturity (&lt;105 days), resistance to neck and finger blast, ear head shape, number of fingers and grain colour</td>
</tr>
<tr>
<td>F₂</td>
<td>22</td>
<td>-</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>F₃</td>
<td>14</td>
<td>93</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>F₄</td>
<td>27</td>
<td>238</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>F₅</td>
<td>10</td>
<td>49</td>
<td>86</td>
<td></td>
</tr>
<tr>
<td>F₆</td>
<td>4</td>
<td>38</td>
<td>52</td>
<td></td>
</tr>
</tbody>
</table>

**Barnyard Millet**

*Yield evaluation of superior bulks in station trial*

Forty superior bulks identified from *F₆* and *F₇* generations of different crosses were evaluated for yield and yield contributing traits in barnyard millet initial station trial along with three national checks (PRJ 1, VL *Madira* 172 and VL *Madira* 207). Entries VB 16-2 (3,419.2 kg/ha), VB 16-5 (3,192.3 kg/ha) and VB-16-16 (3,018.5 kg/ha) recorded yield advantage of 28.0, 19.6 and 13.0% respectively, over the best check VL *Madira* 207 (2,669.2 kg/ha).

**Development of new strains and details of breeding material**

During *kharif* 2017, 15 new cross combinations were attempted involving locally adapted genotypes (VL 172, VL 29, VL 207, VL 251, VL 252 and VL 137); high grain yielding genotypes (>1.2 kg/plot) selected from national barnyard germplasm (GECH 127, GECH 1, GECH 13, GECH 271, GECH 388, GECH 768, GECH 746, TNEF 206 and ACM 333); promising line from ICRISAT core collection lines (IEc 552 and IEc 566) and genotypes picked from advanced breeding material based on yield components (DHBMV 93-3, VB 410 and VB 464. The details of segregating breeding materials are presented in Table 2.4.2.
### 2.4.1.5. New initiatives

**Assembling a hill gene pool of finger millet**

A hill gene pool of finger millet comprising two hundred and twenty-five accessions was assembled at the institute. The hill gene pool is comprised of local finger millet accessions collected from twelve districts of Uttarakhand. The hill gene pool was evaluated along with four checks viz., VL *Mandua* 149, VL *Mandua* 324, VL *Mandua* 352 and GPU 45 in augmented block design for four qualitative and eighteen quantitative traits. The accessions VHC 3603, VHC 4087, VHC 3572, VHC 3624 and VHC 3603 were promising for grain yield along with the better check VL *Mandua* 352 and VL *Mandua* 324. The genetic variation observed for important agronomic traits in hill gene pool is depicted in Fig. 2.4.1.

### 2.4.2. Potential Crops (Amaranth and Buckwheat)

#### 2.4.2.1. Elite Strains in Coordinated and State Varietal Trials

A total of thirty-one entries were evaluated in amaranth and buckwheat Advanced Varietal Trials (AVT) and State Varietal Trial (SVT). In amaranth AVT, highest yield was recorded in the check variety Durga (1,166 kg/ha). All test genotypes were very poor in comparison to the check. In SVT, entry VL 115 (882 kg/ha) was the top yielder followed by VL 110 (812 kg/ha) and

### Table 2.4.2. Details of barnyard millet breeding material

<table>
<thead>
<tr>
<th>Generation</th>
<th>Number of crosses</th>
<th>Number of progenies</th>
<th>Single Plant selections</th>
<th>Selection criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_1$</td>
<td>22</td>
<td>-</td>
<td>-</td>
<td>Early maturity (&gt; 100 days), resistance to grain smut, panicle length and width, grain yield</td>
</tr>
<tr>
<td>$F_2$</td>
<td>10</td>
<td>-</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>$F_3$</td>
<td>14</td>
<td>111</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>$F_4$</td>
<td>18</td>
<td>113</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>$F_5$</td>
<td>12</td>
<td>43</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>$F_6$</td>
<td>12</td>
<td>89</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>$F_7$</td>
<td>2</td>
<td>10</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

---

Fig. 2.4.1. Box and Whisker plots depicting variation for agronomic traits in hill gene pool of finger millet
recorded yield advantage of 22.5 and 12.8% over the best check PRA-1 (720 kg/ha). In buckwheat AVT trial also the check variety VL-Ugal 7 (1,334 kg/ha) was the top-ranking entry followed by Sangla B-464 (1,250 kg/ha) and Shimla B-1 (1,113 kg/ha).

### 2.4.2.2. Development of New Strains and Breeding Material

During *kharif* 2017, five new cross combinations were attempted involving locally adapted genotypes (VL Chua 44 and VL Chua 101); high yielding national genotypes (> 1.3 kg/plot) and promising accessions for yield components selected from germplasm evaluation (IC 95250 and IC 42407). In F2 generation, three crosses were planted, and seven single plant selections were made based on phenotypic superiority. In F3 generation, thirty-four progenies of five crosses were planted and twenty-one single plant selections were made. In F4 generation, twenty-nine progenies of two crosses were planted and seventeen single plant selections were made from forty-four progenies of two crosses in F5 generation. Eighteen bulks from homozygous and homogeneous F6 progenies of a cross between IC-42334 × PLP 1 were made for their evaluation in initial station trial.

### 2.4.3. Crop Protection Investigations

A total of 673 genotypes were evaluated for disease resistance to leaf, neck and finger blast of finger millet (Station Trial-42, AVT-I & II-15, IVT-I-29 and DSN-20). A RIL population (500 lines) derived from the cross between VR 708 × GPU 48 was screened for blast resistance under field conditions. Barnyard millet genotypes (67) were screened for grain smut disease (Station trial-40, BAVT-08 and DSN-22). During *kharif* season, neck and finger blasts were observed in moderate to high severity and during initial stages of the crop, high leaf blast severity was observed. In barnyard millet, grain smut disease was observed in moderate to high severity. The most prominent genotypes identified based on one season data are given in Table 2.4.3.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nurseries</th>
<th>Entries</th>
<th>Disease</th>
<th>Highly resistant entries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finger millet</td>
<td>Station trial</td>
<td>42</td>
<td>Leaf, neck and finger blast</td>
<td>VR-13-33, VR-13-34, VR-15-8, VR-15-11, VR-16-3, VR-16-10, VR-16-14, VR-16-16, VR-16-17, VB324 and VL376</td>
</tr>
<tr>
<td></td>
<td>Advanced Varietal Trial (AVT-I &amp; II)</td>
<td>15</td>
<td>Leaf, neck and finger blast</td>
<td>VL 386 &amp; VR 708 (FB), VL 386 &amp; VL 379 (NB and FB) and VL 386 &amp; VL 379 (FB) with moderate resistance to leaf blast</td>
</tr>
<tr>
<td></td>
<td>Initial Varietal Trial (IVT)</td>
<td>29</td>
<td>Leaf, neck and finger blast</td>
<td>VR 936 and VL 503</td>
</tr>
</tbody>
</table>
2.4.4. Agronomic Investigations

Response of pre-release finger millet varieties to different nutrient levels under rainfed conditions

Three pre-release short duration varieties (VL 386 under Central AVT and VL 380 and VL 382 under SVT) along with two checks (GPU 45 and VL 352) were evaluated to different nutrient levels (75% NPK, 100% NPK and 125% NPK) under rainfed conditions. The variety VL 386 and VL 380 recorded higher yield (4,316 kg/ha and 4,151 kg/ha) as compared to all other varieties. Among different fertility levels, the highest yield of finger millet was recorded with 125 per-cent NPK (3,665 kg/ha).

Response of pre-release barnyard millet varieties to different levels of fertilizer under rainfed conditions

Three pre-release varieties of barnyard millet (VL 249 and DHBMV-23-3 under Central AVT and VL 250 under SVT) along with two checks (GPU 45 and VL 352) were evaluated at different nutrient levels (75 per-cent NPK, 100 per-cent NPK and 125 per-cent NPK) under rainfed conditions. The variety VL 250 recorded the highest yield (2615 kg/ha), which was at par with VL Madira 172. However, there was no difference due to different nutrient levels.

Response of pre-released amaranth varieties to different levels of fertilizer under rainfed conditions

One pre-released variety of Amaranth (VL 101) along with two checks (VL Chua 44 and Durga) was evaluated to different nitrogen levels (0 kg, 30 kg, 60 kg, and 90 kg N/ha) under rainfed conditions. No significant difference was found among all three varieties however, the highest grain yield was recorded with 60 kg N/ha, which was at par with other fertility levels except control.

2.5. Barley

Cultivation of barley is restricted to some of the traditional areas of North-Western Hills, covering only a small area of 49.7 thousand ha with an average productivity of 1,163 kg/ha (2014-15). Crop improvement work in barley is focused mainly on the development of high yielding and disease resistant varieties suitable for rainfed conditions.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nurseries</th>
<th>Entries</th>
<th>Disease</th>
<th>Highly resistant entries</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIL Population</td>
<td>500</td>
<td>Leaf, neck and finger blast</td>
<td>Sixty-one RIL lines showed highly resistant reaction to neck and finger blast but moderately resistance to leaf blast</td>
<td></td>
</tr>
<tr>
<td>Donor Screening Nursery (DSN)</td>
<td>20</td>
<td>Leaf, neck and finger blast</td>
<td>DSN-4 and DSN-8 for finger blast resistance with moderate resistance to leaf blast</td>
<td></td>
</tr>
<tr>
<td>Barnyard Advanced varietal trial (BAVT)</td>
<td>08</td>
<td>Grain smut disease</td>
<td>DHBM 18-6 and VL 249</td>
<td></td>
</tr>
<tr>
<td>Station trial</td>
<td>37</td>
<td>Grain smut disease</td>
<td>VB-16-6, VB-16-2 and VB-17-6</td>
<td></td>
</tr>
</tbody>
</table>

2.5.1. Varietal Improvement

2.5.1.1. Elite lines in all India coordinated/ state/station trials

To identify high yielding disease resistant genotypes, 75 new barley strains were evaluated in 4 different trials. In AVT timely sown rainfed, VLB 150 (1,623 kg/ha) yielded significantly higher than the best check BHS 352 (1,152 kg/ha). In SVT (organic) timely sown rainfed trial, VLB 154 (3,221 kg/ha) surpassed the best check VL Jau 118 (2,858 kg/ha). Out of 32 new bulks
generated through institute breeding programme and evaluated in station trials under rainfed condition, 6 promising strains with yield potential from 1,847 to 2,177 kg/ha were nominated in to the All India Coordinated Trials of Northern Hill Zone.

**Development of new strains**

To develop high yielding disease resistant genotypes, 222 introduced materials were evaluated, and 114 high yielding disease resistant genotypes were selected based on their agronomic score, yielding ability and yellow rust resistance (<20S score) for their further evaluation during the ensuing season.

**Off-season nursery**

During kharif 2017, 114 advance lines were grown at the off-season facility at Lahaul Spiti, Himanchal Pradesh for screening against yellow rust. Out of these, 31 lines having desirable rust reaction (<20S) were selected.

### 2.5.2. Crop Protection Investigation

- In the coordinated National Barley disease screening nursery (NBDSN), out of 194 entries, entries NBDSN 1, 2, 6, 8, 9, 12, 15, 24, 25, 44, 51, 57 were resistant to rust.
- In the elite barley disease screening nursery (EBDSN), out of 66 entries, entries BCU 7594, 7615, 7621, 7719, 7758, 7821, BH 1000, VLB 130, VLB 140 were resistant to yellow and leaf rust.

### 2.5.3. Agronomic Investigations

**Performance of timely sown dual-purpose barley under rainfed condition**

Fourteen new genotypes of dual purpose barley were evaluated against three checks (BHS 380, BHS 400 and HBL 276) under rainfed condition. Among the new genotypes, VLB 153 (2,216 kg/ha) produced highest grain yield, which provided 12% higher grain yield than the best check BHS 400. BHS 453 provided the highest green fodder yield (4,399 kg/ha), which was significantly higher than all genotypes.

**Standardisation of row spacing in feed barley**

It was estimated that maximum grain yield of 1,900 kg/ha could be achieved with row spacing of 14.6 cm (Fig. 2.5.1). It was estimated that a maximum of 35.4 kg increase in grain yield per cm can be achieved by decreasing row spacing from recommended spacing (22.5 cm) up to 14.6 cm. Further reduction in spacing would decrease the grain yield.

### 2.6. Pulses & Oilseeds

Pulses and oilseeds are traditional and most suited crops for rainfed agriculture in hills. In North-Western Himalayas, the total pulse production is 101.4 thousand tonnes from an area of around 104.6 thousand hectares with an average productivity of 969 kg/ha against national productivity of 656 kg/ha. However, the total oilseed production in the North-Western Himalayas is 74.7 thousand tonnes from an area of 99.4 thousand hectare and the average productivity of oilseed is 810 kg/ha against the national productivity of 751 kg/ha (DAC 2015-16). Development of high yielding varieties suitable for hill cropping system with matching production technology is a challenging area of research for increasing the area and productivity of pulse and oilseed crops in hills.
2.6.1. *Kharif* Legumes (Horse gram, Rajmash and Bhat)

2.6.1.1. Elite lines under state varietal trials

In horsegram, two entries viz., VLG 44 (950 kg/ha) and VLG 46 (955 kg/ha) were tested under rainfed organic conditions of Uttarakhand during *kharif* 2017. Both genotypes showed yield superiority of 2.81%, and 3.31% respectively, over the best check VL *Gahat* 15(924 kg/ha).

Breeding materials/Development of new strains

Nineteen new cross combinations were obtained involving 12 diverse parents selected on the basis of yield (>15 g/plant) and component traits (number of branches/plant, plant height, number of pods per/plant, number of seeds per pod etc.), plant type (erect to semi-erect), earliness (<100 days) and resistance to anthracnose disease. Sixty-two F₁ crosses were advanced to F₂ generation and progenies from 126 crosses from F₂ to F₅ generations were selected and advanced to subsequent generation.

A total of 54 phenotypically superior bulks of horsegram were tested in initial and advance station trials. In initial station trial, entries viz., VLG 2016-11 (315 kg/ha) and VLG 2016-14 (222 kg/ha) were found superior to the best check VL *Gahat* 15 (185 kg/ha). Likewise, entries VLG 2013-4 (247 kg/ha) and VLG 2014-49 (217 kg/ha) were superior to the best check VL *Gahat* 19 (202 kg/ha) in advance station trial and reported superiority of 22.28 and 7.43%, respectively over the best check.

Biochemical investigations

Eight pulses comprising three lesser-known pulses viz., horse gram, black soybean (*Bhat*), rice bean and five common pulses viz., rajma (kidney beans), cowpea (white), cowpea (black), lentil and chickpea from North-Western Himalaya were analyzed for nutritional factors viz. protein, lipid, sugars, tryptophan, starch, antinutritional factors viz., phytic acid, tannins, trypsin inhibitors), antioxidant metabolites and activities viz., Gallic acid, DPPH, ABTS, TAA, FRAP and fatty acid composition. The crude protein ranged from 7.6 (rice bean) to 40.8% (black soybean), total lipid 1.2 (rice bean) to 17.3% (black soybean), total sugars 8.9 (black soybean) to 24.6% (cowpea), starch 5.6 (black soybean) and 29.6% (lentil) and tryptophan 0.22% (lentil) to 0.47% (black soybean). Lowest content of phytic acid and trypsin inhibitor were recorded in black soybean. Results showed that horse gram and lentil had higher free radical scavenging and antioxidant activities. The fatty acid profiles revealed that, the studied pulses contained higher concentration of unsaturated fatty acids. Principal component analysis (PCA) revealed that the first factor F₁ represents 38.0% of variability, whereas the second factor F₂ represents 32.83% of variability among the data. Maximum biochemical parameters were occupied on the right side of the biplot and among the parameters starch, total soluble sugars, linoleic acid, phytic acid, trypsin inhibitor activity and palmitic acid were observed on the right upper side of the biplot with high positive loading for both factors I and II, whereas stearic acid, oleic acid, DPPH, ABTS scavenging activity and O/L ratio were grouped together with slightly lesser positive loadings on the right side of the biplot (Fig. 2.6.1).

Fig. 2.6.1. PCA analysis of nutritional factors and antioxidant properties of different pulses

2.6.2. *Rabi* Legumes (Lentil and Field pea)

2.6.2.1. Variety identified for release

VL *Matar* 61 (VL 61): This high yielding field pea variety has been identified for timely sown rainfed organic conditions of Uttarakhand hills. It is developed from the cross between an early maturing and short statured genotype DDR 23...
and a high yielding, tall statured genotype VL 1. VL Matar 61 (1,129 kg/ha) has shown significant yield superiority (11.54%) over the best check Pant P 14 (1,012 kg/ha) over three years in SVT and matures in 150-155 days.

**VL Masoor 148 (VL 148):** This small brown seeded variety has been identified for timely sown rainfed conditions of Northern Hill Zone (Uttarakhand, Himachal Pradesh, J&K) and NE hills and yielded 1,148 kg/ha with superior yield of 18.32% over the best check PL 4 (970 kg/ha). Its yield potential ranges from 11-12 q/ha and it matures in 147-163 days. It also shown moderate resistance to wilt, rust, pod borer damage and aphids in coordinated trials.

### 2.6.2.2. Elite Lines under all India coordinated programme

In lentil, 3 yield evaluation trials were conducted comprising IVT (small seed), IVT (Large seed) and AVT I & II (small seed). In IVT (small seed), entry VL 152 (1,005 kg/ha) recorded 13.0% yield superiority over the best check PL 4 (889 kg/ha) and promoted to AVT I.

In field pea, a total of three yield evaluation trials were conducted under AICRP comprising IVT (tall), IVT (dwarf) and AVT I (tall). In IVT (tall) entry VL 64 (1,694 kg/ha) reported 12.9% superiority over the best check VL Matar 42 (1,500 kg/ha) and has been promoted to AVT I.

### 2.6.2.3. Elite lines under state varietal trial

In SVT, small seeded lentil entries VL 150 (1,105 kg/ha) and VL 153 (1,153 kg/ha) has been promoted to II<sup>rd</sup> and III<sup>rd</sup> year of testing, respectively. Both the entries reported 13.9% and 18.9% yield superiority over the best check VL Masoor 125 (970 kg/ha). One large seeded lentil entry VL 527 (1,234 kg/ha) was promoted to II<sup>nd</sup> year of testing as it showed yield advantage of 21.9% over the best check VL Masoor 514 (1,012 kg/ha) under organic conditions.

In field pea, entry VL 64 (1,202 kg/ha) showed yield advantage of 24.6% over the best check VL Matar 47 (965 kg/ha) and was promoted to II<sup>nd</sup> year of testing under organic conditions.

**Breeding materials/Development of new strains**

Eighty-seven new cross combinations were obtained from 30 diverse parents of *macrosperma* and *microsperma* type lentil. Seventy-five F<sub>1</sub> crosses were advanced to F<sub>2</sub> generation. Based on desirable phenotypic traits, disease and insect pest resistance 229 crosses from F<sub>2</sub> to F<sub>6</sub> generations were selected and advanced to subsequent generation. Sixteen uniform bulks in small seeded and 18 in large seeded lentil were selected for further evaluation in station trial for yield, component traits, quality and other characters.

Four station trials were conducted comprising initial station trials (2) and advance station trials (2) for small and large seeded lentil separately. In initial station trial (small), entries viz., VLM 2016-17 (682 kg/ha), VLM 2016-18 (665 kg/ha) and VLM 2016-22 (615 kg/ha) were best performing entries and showed superiority of 34.52%, 31.16% and 21.30%, respectively over the best check VL Masoor 129 (507 kg/ha). In initial station trial of large seeded entries VLM 2016-110 (784 kg/ha), VLM 2016-109 (712 kg/ha) and VLM 2016-111 (688 kg/ha) were best performing entries, which had shown superiority of 60.3, 45.6 and 40.7% respectively, over the best check VL Masoor 514 (489 kg/ha). In advanced station trial (large), entries viz., VLM 2014-141 (744 kg/ha) and VLM 2014-109 (715 kg/ha) performed better than the best check VL Masoor 507 (667 kg/ha) and in advanced station trial (small), entries viz., VLM 2014-24 (1,217 kg/ha) and VLM 2015-4 (1,005 kg/ha) performed better than the best check VL Masoor 129 (740 kg/ha).

In field pea, forty-one new cross combinations were made involving 16 diverse parents with high grain yield (1,800 – 2,000 kg/ha), powdery mildew resistance (<10%) and semi leafless traits. Forty-five F<sub>1</sub> crosses were advanced to F<sub>2</sub> generation. Based on desirable phenotypic traits, disease and insect pest resistance; 126
crosses were selected from $F_2$ to $F_6$ generation. Twenty uniform bulks were selected in field pea for further evaluation of yield, component traits, quality and other characters.

Two station trials were conducted comprising initial station trials and advance station trials. Entries viz., VP 2015-15 (2,567 kg/ha) and VP 2015-32 (2,382 kg/ha) were superior to the best check VL Matar 42 (1,983 kg/ha) in advance station trial whereas, entries viz., VP 2016-17 (1,154 kg/ha), VP 2016-19 (1,147 kg/ha) and VP 2016-27 (1,221 kg/ha) were best performing entries and superior to the best check VL Matar 42 (1,043 kg/ha) in initial station trial.

**Agronomic Investigations**

Among four AVT-II lentil genotypes, LL 1320 gave the highest seed yield (934 kg/ha) closely followed by VL 148 (914 kg/ha) whereas among seed rates, 50 kg/ha produced highest seed yield (838 kg/ha) across the varieties.

Field pea genotype VL Matar 61 recorded highest seed yield (1,329 kg/ha), which was 5.3 and 10.8 percent higher than VL Matar 47 and VL Matar 42, respectively. Among fertility levels, 150% of recommended dose (30:90:60 kg NPK/ha) recorded the highest seed yield (1,307 kg/ha).

2.6.3. Oilseed Crops - Soybean

2.6.3.1. Variety released

**VL Bhat 202 (VLB 202):** Black soybean ($Bhat$) entry VLB 202 has been released for rainfed timely sown organic conditions of Uttarakhand hills. VLB 202 was developed from a cross between VLS 1/ EC361362. VLS 1 black seeded and high yielding parent whereas EC 361362 as medium plant height with determinate and erect growth habit. It has an average yield of 1,596 kg/ha which was 36.0% higher than the black soybean ($Bhat$) check VL Soya 65 during 3 years of testing under SVT. It was found resistant to frog eye leaf spot (11.1%) disease and aphids with less incidence of soybean beetle (<1) under organic conditions.

2.6.3.2. Variety identified for release

**VL Soya 89 (VLS 89):** It is suitable for timely sown rainfed conditions of Uttarakhand and Himachal Pradesh. It has been developed from the cross “VLS 47/EC 361364”. VLS 89 (2,324 kg/ha) showed significant yield superiority of 12.01% over the best check VL Soya 59 (2,075 kg/ha). It has 19.1% oil content as compared to the best check VL Soya 59 (19.0%) with moderate resistance against frog eye leaf spot (<11.1%), pod blight diseases (3), *Chauliops* (10-30%) and resistance against defoliators.

2.6.3.3. Elite lines under State Soybean Improvement Program

In SVT, soybean entries namely VLS 94, VLS 95, VL 504 and VLS 505 were tested during kharif 2017. Among them, VLS 504 (601 kg/ha) and VLS 505 (710 kg/ha) were found earliest in maturity (105 and 106 days, respectively) than the early check JS 95-60 (853 kg/ha) with 122 days maturity duration. VL Soya 92 (1,428 kg/ha) has shown yield superiority of 7.6% over the best check PS 1092 (1,328 kg/ha).

2.6.3.4. Breeding Materials/Development of New Strains

Forty-five new cross combinations were made involving 24 diverse parents. These parents were selected based on yield (>25g/plant) and component traits (number of branches/plant, plant height, number of pods/plant, number of seeds/pod), plant type (determinate), earliness (<85 days) and resistance to frog eye leaf spot (<11.1%) and bacterial pustule (score <3) diseases. Forty-six $F_1$ crosses were advanced to $F_2$ generation and progenies from 103 crosses were selected from $F_2$ to $F_5$ generation of soybean based on desirable phenotypic traits (yield and component traits), diseases (frog eye leaf spot and pod blight) and insect (*Chauliops* and defoliators) resistance.

A total of 5 station trials were conducted comprising Initial Station Trials, Advance Station Trials for soybean and Bhat separately as well as Early Station Trial. In Initial Station Trial of soybean, entries viz., VS 2016-46 (3,130 kg/ha)
kg/ha), VS 2016-1 (3,093 kg/ha) and VS 2016-2 (2,852 kg/ha) were found superior to the best check VL Soya 47 (2,179 kg/ha) and in Station Trial (Bhat), entries viz., VS 2016-101 (2,000 kg/ha) and VS 2015-101 (1,906 kg/ha) were top performing entries found superior to the best check VL Bhat 201(1,654 kg/ha). In Advance Station Trial, soybean entries viz., VS 2015-60 (2,588 kg/ha) and VS 2015-15 (2,563 kg/ha) were found superior to best check VL Soya 47 (2,420 kg/ha). In Early Station Trial entries viz., VS 2015-40 (1,886 kg/ha), VS 2015-4 (1,864 kg/ha) and VS 2015-10 (1,805 kg/ha) surpassed the best check JS 95-60 (1,514 kg/ha).

Agronomic Investigations

In soybean, highest seed yield (1,979 kg/ha) was obtained in entry VLS 89 which was 5.2 and 31.3 per cent higher than VLS 63 and VLS 59, respectively while among the three sowing dates, normal sowing recorded highest seed yield (2,265 kg/ha) followed by 1,969 kg/ha in second sowing (10 days after normal sowing) and lowest (1,132 kg/ha) in third sowing (20 days after normal sowing).

Crop Protection Investigations

In the kharif 2017 season, major diseases observed at Hawalbagh farm (Almora) and in farmers’ fields in Almora district were Frog eye leaf spot (FLS), bacterial pustules and pod blight. FLS appeared during first week of August. The severity increased only at the end of September and reached up to 68% infection index in few entries. Bacterial pustule (BP) and pod blight (PB Ct) were observed with low-moderate intensity.

In soybean disease screening nursery, out of 16 entries evaluated against frog eye leaf spot (FLS), KHSb 2 and NRC 7 showed resistant reaction (1 score on 0-9 scale). Yield losses due to FLS varied from 9.9% (VLS 89) to 53.06% (AMS-MB5-18) among 26 entries evaluated under protected and unprotected conditions. Out of 51 soybean entries previously found resistant against FLS, 43 maintained their resistance. In advance station trial of soybean, VS 2013-16, 2013-50, VS 2015-15, 2015-55, 2015-9 and VS 2015-20 showed resistant reaction against FLS (1 score on 0-9 scale) and in black soybean station trial, VS 2014-101, VS 2015-110, VS 2016-101, 103 and VS 2016-103 were found resistant to FLS (0-1 score on 0-9 scale). In the advance station trial, out of fifteen horse gram entries, entries VLG 2013-4, 2013-14, 2013-23, VLG 2014-6, 2014-48, 2014-15 and VLG 2015-26 were most promising against anthracnose (1 score on 0-9 scale).

2.7. Vegetable Crops

Vegetable farming, principally off-season and temperate ones are recognized as practicable and lucrative ventures, due to niche potentials of hills. The total area under vegetable cultivation in Uttarakhand is around 100.92 thousand ha with an average productivity of 11.0 t/ha, which is much below the national productivity of 17.4 t/ha (NHB 2015-16). Development of HYVs specific to quality, market demands and resistant to biotic stress along with package of practices is an important area of research activity for the improvement of vegetable scenario of north-western Himalayas.

2.7.1. French Bean

Elite lines under all India coordinated french bean improvement program

Three yield evaluation trials were conducted with 66 genotypes to evaluate their green pod yield performance against checks viz., Arka Anoop, Arka Suvridha, Swarn Priya and VL Bean 2. Entry 2016/FEBVAR -2 (10,209 kg/ha) recorded significantly high green pod yield in AVT-I.
Breeding materials/development of new strains

Emphasis was given to develop high yielding (>100 q/ha), stringless pod with resistance to rust. In this endeavor, 16 new F₁s were developed using diverse parents. Three hundred twenty-two progenies derived from 46 crosses were advanced in F₂ to F₆ generations. Ten new bulks were also made based on phenotypic uniformity. VLFB 1613 (17,779 kg/ha) & VLFB 1614 (15,560 kg/ha) were found promising and showed 31.0 & 14.7% high green pod yield, respectively in station trials.

2.7.2. Tomato

Elite lines under all India coordinated tomato improvement program

Nine yield evaluation trials were conducted to evaluate 82 entries against checks to identify high yielding genotypes in determinate and indeterminate group. Entries 2016/TOHYB-4 (32,570 kg/ha), 2015/TOHYB-1 (43,871 kg/ha), B.S.S.-488 [C] (39,850 kg/ha) recorded significantly high fruit yield in Hyb. Det. IET, Hyb. Det. AVT I, Hyb. Det. AVT II, respectively. Lines, 2016/TODVAR-1 (25,630 kg/ha), 2014/TODVAR-3 (23,955 kg/ha), 2015/TOINDVAR-6 (34,119 kg/ha), Local check (VT-95) (22,050 kg/ha) and 2015/TOCVAR-5 (22,341 kg/ha) recorded significantly high fruit yield in Station Trial.

Breeding materials/Development of new strains

In tomato station trial, 35 promising F₁’s were evaluated against and suitable checks, VTG 805 X VTG 1303 (37,390 kg/ha) was found to be promising hybrid and shown 15.1% high fruit yield over the best check.

2.7.3. Capsicum

Elite lines under all India coordinated capsicum improvement programme

Three yield evaluation trials were conducted to evaluate 33 entries to identify early maturing, high yielding genotype. The check variety, Kt-1 (29,652 kg/ha and 31,463 kg/ha) recorded significantly high fruit yield in AVT-I Hybrid and AVT-I, respectively.

Breeding materials/Development of new strains

In capsicum, emphasis was given to develop high yielding hybrids (>300 q/ha) with medium dark green fruits (100-150 g), thick skin and 3-4 lobes, suitable for protected and open field cultivation. Ten F₁’s was developed involving diverse parents. Six F₁ and twelve progenies derived from 11 crosses were advanced (F₂ to F₅ generations) for further selection. VLCP-2016-88 X VLCP-2016-1 (31,000 kg/ha) recorded significantly high fruit yield (10.7% over best check) in Station Trial.

2.7.4. Cowpea (Yard long bean)

Development of new strains

Emphasis was given to develop high yielding early maturity (<60 DAS) and tender green pods suitable for vegetable purposes. Six F₁’s and 75 progenies of one F₄ cross were advanced. Fifteen progenies (F₅) were retained for further generation advancement.

Breeding materials/development of new strains

Emphasis was given to develop high yielding hybrids (>500 q fruit/ha) having market acceptability regarding size (80-100 g), round to oblong and pericarp thickness (>6 mm). Ten F₁’s were made using diverse parents with respect to desirable horticultural traits. Three F₁ and 5 F₂ crosses were advanced.

2.7.5. Garden pea

2.7.5.1. Varieties Released

Vivek Matar 13 (VP 907): It is an early maturing (120-125 days in mid hills) variety developed through hybridization (VP 272 / Arkel) followed by pedigree method. VP 272 for long pod length with high shelling per cent and Arkel for early and attractive pod shape were used as parents in hybridization. It has shown 19.3% mean green pod yield superiority over the Check VL Ageti Matar 7. Its average green pod yield is 11,500 kg/ha in the mid hill conditions. Besides high yield,
being early in maturity it escapes incidence of powdery mildew disease. It possesses long pod length with 8-9 seeds/pod and high shelling per cent (>46).

**Vivek Matar 14 (VP 1018):** It is a medium maturing (130-135 days in mid hills) variety developed through hybridization (PC 531/Pusa Pragati) followed by selection using pedigree method. PC 531 for pod yield with high shelling per cent and Pusa Pragati for long pod length and attractive pod shape were used as parents in hybridization. It has shown 21.5% mean green pod yield superiority over the best check, **Vivek Matar** 11. It takes around 126-132 days for first green pod harvest in mid hill conditions. The average green pod yield is 12,500 kg/ha. Besides high yield, this entry possesses resistance against powdery mildew disease.

**Vivek Matar 15:** It is a medium maturing (128-132 days in mid hills) variety developed through hybridization (PC 531/Arkel) followed by selection using pedigree method. PC 531 for pod yield with high shelling per cent and Arkel for early and attractive pod shape were used as parents in hybridization. It has shown 23.5% mean green pod yield superiority over the Check **Vivek Matar** 11. It takes around 126-130 days for first green pod harvest in mid hill conditions. An average green pod yield is 12,800 kg/ha. Besides high yield, this entry is moderately resistance against powdery mildew disease. The pods are long with high shelling per cent (>50).

**Elite lines under all India coordinated garden pea improvement programme**

Seven yield evaluation trials were conducted to evaluate 73 entries to identify early & medium maturing and high yielding genotypes. Entries 2016/PEVAR-8 (10,175 kg/ha), 2015/PEVAR-5 (10,690 kg/ha), 2014/PEVAR-4 (11,815 kg/ha), 2016/PMVAR-4 (13,650 kg/ha) and 2014/PMVAR-3 (13,650 kg/ha) recorded statistically better green pods yield in IET (Early), AVT-I (early), AVT-II (early), IET (medium) and AVT-II (medium), respectively. In pea AST I, VP 1620 (13,380 kg/ha) and VP 1618 (12,510 kg/ha) showed 19.3 & 11.5% yield superiority, respectively and in AST II, VP 1446 (14,000 kg/ha) and VP 1445 (13,260 kg/ha) showed 21.5 & 15.3% yield superiority, respectively under medium maturity group whereas in early maturity group VP 1511 (11,810 kg/ha) and VP 1423 (11,440 kg/ha) gave 13.6 and 10% high green pod yield over best check, respectively.

**Elite lines under state garden pea improvement program**

In SVT, VP 1436 (13,960 kg/ha) in medium maturity and VP 1305 (11,280 kg/ha) in early maturity group gave 34.9 and 16.3% high green pod yield over check, respectively.

**Breeding materials/Development of new strains**

Emphasis was given to develop early (< 126 DAS) and medium (>126 - 135 DAS) duration genotypes with high green pod yield (>130 q/ha in medium and >110 q/ha in early maturity group), high shelling per cent (>50), attractive long green curved pod and resistance to powdery mildew. In this endeavor, 61 new F₁’s were made and better performing F₁’s (96) was advanced for growing their F₂ generation in next season. Besides, selection was practiced in the segregating materials derived from 40 F₁’s, 7 F₃’s, 24 F₄’s, 7 F₅’s and 21F₆’s crosses. Based on desirable traits, 307 progenies derived from 99 crosses were advanced in F₂ to F₆ generations and 65 crosses were retained (28 F₃’s, 7 F₄’s, 18F₅’s, 4F₆’s & 8F₆’s) for further selection. Twenty new bulks were made based on phenotypic uniformness in ensuing crop season in early and medium maturity group.

**2.7.5.2. New initiatives**

**Whole pod edible dual-purpose garden pea genotypes**

Three edible pod lines were planted at experimental farm, Hawalbagh and Mukteshwar. Pods were harvested from both the locations and tested for parchment layer and all three lines viz., VPSp 1301, VPSp 906-1 and VPSp 1332 were suitable as edible pod pea due to missing parchment layer in pods.
2.7.6. Onion

**Elite lines under all India coordinated onion improvement programme**

Three all India network research project and one station trials (Onion Hyb.) on long day onion were conducted with 57 genotypes to evaluate their yield performance against checks. ON16-54 (39,822 kg/ha) ON15-06 (42,474 kg/ha) and ON14-06 (44,674 kg/ha) VL In. 31-1A / Vلون16-1 (49,720 kg/ha) recorded significantly high bulb yield in IET, AVT I and AVT II, respectively. In station trial of onion hybrid, VL In. 31-1A/ Vلون16-1 (49,720 kg/ha) recorded 11.2 % high bulb yield over check i.e., VL Pia 3.

**Development of new hybrids using CMS line**

CMS lines (VL In. 31-1A) were maintained with the help of their maintainer line VL In. 31-1B. Crosses were attempted between CMS line (VL In. 31-1A) and 12 diverse lines as male parents for the development of F₁ hybrids.

2.7.7. Garlic

**Elite lines under all India coordinated garlic improvement programme**

Two all India network research project trials on long day garlic were conducted with 19 genotypes to evaluate their yield performance against checks. GN 14-19 (30,619 kg/ha) in IET and GN 14-11 (23,846 kg/ha) in AVT II recorded significantly high bulb yield with big clove size.

**Genetic resources: evaluation & maintenance**

Three hundred eighty-eight accessions of different vegetable crops viz., Chilli (86), Capsicum (63), Tomato (115), Colocasia (33), Turmeric (23), Garlic (64), Vegetable type mustard (04) was maintained during rabi 2016-17 and kharif 2017.

**Crop Protection Investigations**

**Screening of advanced lines of vegetable pea against powdery mildew at hot spot (Research station, Majhera GBPUAT, Pantnagar)**

Thirty-six advanced lines including two resistant and two susceptible checks were evaluated at powdery mildew hot spot (GBPUA&T Research station, Majhera. Genotypes VP 1401, VP 1419, VP 1421, VP 1434, VP 1510, VP 1515, VP 1516, Arka Ajeet I and VL Matar 11 exhibited resistance against powdery mildew whereas 50 and 40 per cent disease incidence were recorded in susceptible checks i.e. VL Matar 7 & Arkel, respectively.

**Powdery mildew screening in tomato**

Seventy genotypes (exotic and advance lines) of tomato were grown in the polyhouse at
Experimental farm, Hawalbagh. Genotypes showing resistance against the powdery mildew were screened following the whole plant resistance screening method. The disease incidence of powdery mildew ranged from 0-70 per cent in different genotypes. VTG 13 (EC 752693) and one advance line i.e. VTG 1327-2 showed 0 disease incidence scale on 0-5 scale.

**Biochemical Investigations**

*Study for important nutritional and physiochemical traits in pea (Edible pod)*

Ten garden pea (edible pod or without parchment) samples [VPSp1301, VPSp1332, VPSp1201, VPSp 906-1, VPSp1303, VPSp1304, VPSp1305, VPSp1306, VPSp1307, VPSp1308] were collected. Seed and the covers were separated and studied for various nutritional and physiochemical traits.

- Seed of VPSp 1301 showed significantly higher TSS (Brix %) than other cultivars.
- Seed of VPSp 1306 and VPSp 1201 showed higher amount of protein content (8.79 & 8.87 % respectively) than other cultivars
- Phytic acid content was found lowest in VPSp 1305 in both seed (6.26 mg/g) and cover (6.69 mg/g).
- In seed, total chlorophyll and carotenoid contents were highest in VPSp 1307 (1.63 & 3.17 mg/g, respectively).
- In both seed and cover, the total chlorophyll and carotenoid contents were found comparable to each other.

**2.8. Flax - A New Introduction in Hills**

Flax, *Linum usitatissimum* L., belongs to the family Linaceae, is one of the oldest fibre crops and its fibres have been in use for some thousand years. Linen is a historic, economically important cloth made from the fibre of flax. In India, flax is commonly known as Alsi, Tisi, etc and grown primarily for linseed oil. At present India imports large amount of flax fibre from European countries to the tune of 6000 tonne every year as the Indian flax does not match with the quality standards of imported flax.

Flax is a crop of the temperate zone and long day plant. It requires a cool humid climate with temperature ranging from 10°C to 27°C, rainfall ranging from 155-200 mm with high humidity (60-65%) during growing season. Flax can be suitably grown in various part of Uttarakhand hills and introduction of flax may enhance the socio-economic condition of the hill farmer. Besides, it is a deterrent crop to monkey.

Seven flax cultivars were evaluated for grain and fibre yields and no significant differences in grain yield and total biomass was recorded. The flowering and maturity of the crop ranged between 78-82 days and 129-131 days, respectively.
For exploring the possibilities of Flax cultivation in Uttarakhand hills work initiated on fibre flax and ramie (another important fibre crop) was carried out in the institute. A total of 30 kg seed of flax variety JRF 2 (Tiara) was produced in the institute and 5.55 quintals seed was procured from GBPUAT, Pantnagar for large scale demonstrations in govt. and farmers fields. Several demonstrations were laid out in Government Gardens of Horticultural Department in Almora district, farmer’s fields in Almora, Champawat, Tehri, and Pithoragarh.

2.9. Seed Production Programme

The institute produces four types of seed to cater to its clientele. These types are – Nucleus Seed, Breeder Seed, Truthfully Labeled Seed and Hybrid Seed of elite hybrids. Besides the seed production of field crops, the institute produces seeds of vegetable crops. Production of breeder seed of important hill varieties is the mandate of the institute. Besides, the institute also produces TL and Nucleus seed of various hill crops.

During the period under report, 192.56 q breeder seed of 50 released varieties/inbreds (14 varieties and 12 inbreds of cereals, 4 varieties of finger millet, 1 of barnyard millet, 9 of pulses, 3 of oilseeds and 5 of vegetable crops and one each of buckwheat and amaranth) was produced. A total of 140.60 q breeder seed was supplied to different seed producing agencies to take up further multiplication.

A total of 11.94 q nucleus seed of 39 released varieties was also produced following standard methods of maintaining genetic purity. In addition to this, 13.17 q Truthfully Labeled seed of 33 varieties (10 cereals, 3 finger millet, 1 barnyard millet, 4 of pulses, 3 of oilseeds, 10 of vegetable crops and one each of buckwheat and amaranth) was produced to meet the demand of the institute extension activities. A total of 3.13 q (Table 2.9.1) and 9.08 q (Table 2.9.2) of TL seed were supplied during kharif 2017 and rabi 2017-18. Under farmer participatory seed production programme, 118.81 q TL seed of wheat (VL Gehun 907, VL Gehun 829, VL 804, VL Gehun 953), Soybean (VL Soya 63) and finger millet (VL Mandua 352) was produced, and 83.17 q was supplied from the seed procured (Table 2.9.3).

Table 2.9.1. Seed Production kharif 2016 and Supply during 2017

<table>
<thead>
<tr>
<th>Crop</th>
<th>Breeder Seed (q)</th>
<th>TL Seed (q)</th>
<th>Nucleus Seed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Production</td>
<td>Supply</td>
<td>Production</td>
</tr>
<tr>
<td>Rice</td>
<td>9.70</td>
<td>7.03</td>
<td>2.80</td>
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<tr>
<td>Maize</td>
<td>14.56</td>
<td>4.52</td>
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<td>1.80</td>
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<td>Finger millet</td>
<td>5.20</td>
<td>3.04</td>
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<tr>
<td>Barnyard millet</td>
<td>0.50</td>
<td>0.52</td>
<td>0.08</td>
</tr>
</tbody>
</table>
A total of 10 q quality seeds were produced during the period in targeted vegetable (garden pea, onion, garlic, French bean and tomato).

**TL seed production**

TL seed (approx. 3.0 q) of improved varieties of black soybean VL *Bhat* 201 and soybean VL *Soya* 77 was produced at experimental farm, ICAR-VPKAS, Almora during *kharif* 2017 for the conduction of FLDs during *kharif* 2018.
3. Natural Resource Management for Sustainable Productivity

Research Projects


- Utilization of Plant Growth Promoting Bacteria (PGPB) for Enhancing Crop Productivity in Hill Agriculture [Drs. P.K. Mishra, J.K. Bisht, B.M. Pandey, Tilak Mondal (upto August 2017), V.S. Meena & Mahipal Choudhary]

- Mechanization of Hill Agriculture through Development of Suitable Farm Implements and Machineries [Drs. B.M. Pandey, Sher Singh, Kushagra Joshi & Er. Shyam Nath]

- Fodder Production Management with Special Reference to Utilization of Marginal and Wasteland [Drs. J.K. Bisht, R.P. Yadav, P.K. Mishra, B.M. Pandey & Tilak Mondal (upto August 10, 2017)]

3. Natural Resource Management for Enhancing Productivity

Basic and strategic research programme of farming systems and operational management of inputs for harnessing sustainable production were carried out. These include tillage, water harvesting, intensive cropping, long term fertility management, Integrated Plant Nutrient Supply (IPNS), weed management, forage and grassland management, farm machinery and post-harvest technology, plasticulture engineering and technology in hilly regions.

3.1. Soil Health Management for Enhancing Productivity of Hill Crops

**Productivity evaluation of soybean-wheat crop rotation under long term fertility management**

The analysis of grain yield data after 44 years of experimentation under rainfed soybean (Bragg, VLS 2 before 2009 and VL Soya 63 since 2009) – wheat (Sonalika, VL 421, VL 616 before 2008-09 and VL Gehun 829 since 2008-09) system confirmed that only those plots where FYM applied showed an increase in the wheat equivalent grain yield compared to the first year (1973-74) (Fig. 3.1). The average yield (6,784 kg/ha) with application of 10 t/ha FYM along with the recommended NPK recorded 105% higher wheat equivalent grain yield of the system than recommended NPK, which confirmed that the application of chemical fertilizer only is not sustainable.

![Fig. 3.1. Comparative wheat equivalent yield of rainfed soybean–wheat system](image1)

**Evaluation of application of P-enriched compost and biofertilizer on different crops**

The potential wheat equivalent yield of wheat (VL 804; 4,060 kg/ha), lentil (VL 126; 3,144 kg/ha) and toria (VL 3; 2,735 kg/ha) by application of P-enriched compost (PEC) could be achieved with application of 116, 120 and 111% of recommended P and inoculation of seed with *Pseudomonas fragi* CS11RHI, which were 33, 29 and 35% higher than the recommended P through SSP, respectively (Fig. 3.2). From the quadratic response equation, it was estimated that the PEC requirement rate to achieve the yield level at recommended SSP for wheat (SSP-w), lentil (SSP-l) and toria (SSP-t) were only 24, 57 and 63% of recommended P with inoculation of seed with *Pseudomonas fragi* CS11RHI.

![Fig. 3.2. Response of wheat, lentil and toria to P-enriched compost](image2)

**Comparative influence of organic and chemical amendments on rainfed wheat-soybean cropping system**

Different levels of phosphorus from farmyard manure (FYM) and vermicompost (VC) sources were evaluated against the recommended NPK (60-30-20 kg N-P₂O₅-K₂O/ha) for rainfed wheat (VL Gehun 829)-soybean (VL Soya 47) cropping system. The potential wheat equivalent yield through FYM and VC of 10,248 and 10,622 kg/ha from wheat-soybean cropping system could be achieved with application of 57 and 54 kg
P/ha, which were 56 and 62% higher than the recommended NPK, respectively (Fig. 3.3). From the quadratic response curve, it was estimated that the level of P required from FYM and VC to achieve the same yield level as recommended NPK for wheat-soybean cropping system were only 4.4 and 3.4 kg P/ha, respectively. The level of N required from FYM and VC to achieve the same yield level, as recommended NPK for wheat-soybean cropping system were only 11.9 and 6.9 kg N/ha, respectively.

Validation of nutrient expert in maize
The nutrient application by estimating the level of nutrients through nutrient expert was compared with recommended NPK (150-60-60 kg/ha N-P₂O₅-K₂O) and nutrient omission plots in maize (Vivek Maize Hybrid 45). The nutrient expert treatment provided 24% higher grain yield compared to the recommended NPK (8,093 kg/ha). The N, P and K use efficiency of applied Urea, SSP and MOP estimated with the help of nutrient omission plots was 30, 11 and 9 kg grain per kg of applied nutrients, respectively.

3.2. Yield Enhancement of Major Hill Crops through Diversification and Efficient Resource Utilization

Screening of suitable crops to different dates of sowing under rainfed conditions for contingent crop planning
Six kharif crops, viz., finger millet (VL Mandua 347), buckwheat (VL Ugal 7), soybean (VLS 73), okra (VL Bhindi 2), amaranth (VL Chua 44) and horsegram (VL Gahat 19) were evaluated in 3 dates of sowing (10 July, 20 July and 30 July) under rainfed condition to screen their suitability for delayed monsoon. Though okra is a vegetable crop but, this was taken as a rainfed crop in the experiment to exploit the rainy season. The average yield of finger millet, buckwheat, soybean, okra, amaranth and horsegram were recorded as 3,228, 795, 473, 10,817, 2,636 and 749 kg/ha, respectively. To compare all these different crops, the yields were converted into finger millet equivalent yield on the basis of their prevailing price in the market. The results of five-year experimentation showed that the highest finger millet equivalent yield was recorded by okra (5,312 kg/ha) followed by finger millet (3,228 kg/ha) and amaranth (3,514 kg/ha). The finger millet equivalent yields of different crops in varying sowing dates are depicted in Fig. 3.5.
Most of the farmers of the hill region of Uttarakhand complete the sowing of rabi crops by November 15. But, there is a need of contingency planning for the event of late cessation of southwest monsoon and late winter rains. Therefore, during rabi season, wheat, toria and lentil were evaluated at 4 dates of sowing (15 November, 25 November, 5 December and 15 December) under rainfed condition to evaluate suitability for delayed sowing. Based on five years average, wheat (1,458 kg/ha) gave significantly higher wheat equivalent yield than lentil (1,232 kg/ha) and toria (922 kg/ha) under rainfed condition. Planting of wheat and lentil was observed at par up to November 25 and only wheat was found suitable afterwards (Fig. 3.6).

3.3. Enhancing Crop Productivity with Special Emphasis on Conservation Agriculture

Effect of tillage, mulching and sowing methods on productivity of rainfed finger millet–wheat cropping system

Finger millet–wheat cropping system was evaluated for tillage, mulching and sowing methods under rainfed conditions with short duration variety, VL Mandua 347 of finger millet and rainfed timely sown wheat variety, VL Gehun 907. Among the different sowing methods, transplantation of finger millet resulted into 20.8% higher grain yield than the direct line sowing (1,985 kg/ha) and 48.9% higher than the traditional method of sowing (1,610 kg/ha). In wheat, sowing through seed drill gave 9.0 and 21.2% more yield than manual line sowing (1,460 kg/ha) and traditional method of sowing (1,313 kg/ha), respectively. Mulch application in finger millet increased the grain yield by 9.8% over no mulch. The soil moisture conserved through the mulch followed by hoeing in wheat crop improved the wheat grain yield by 19.2% over no mulch treatment. Although tillage effect was non-significant during both the seasons, conventional tillage in finger millet resulted into 5.1% higher yield than zero-tillage while zero-tillage in wheat proved better and gave 8.2% higher yield than conventional tillage. In finger millet, transplanting with mulch under zero tillage resulted into highest net returns (Rs 25,547/- per ha) with B:C ratio of 1.81 while in wheat sowing...
with seed drill under zero tillage using mulch fetched highest net returns (Rs 14,785/- per ha) with BC ratio of 1.62.

**Effect of thiourea application on performance of wheat under rainfed conditions**

Poor germination due to low soil moisture at the sowing time and adverse effect of terminal heat coupled with soil moisture deficiency during the reproductive stage are the most important constraints of rainfed wheat production. To resolve this problem, seed soaking and spray of 1000 ppm thiourea solution was used in rainfed wheat. Although the effect of thiourea application was non-significant but the highest wheat grain yield (942 kg/ha) was recorded under seed soaking + FYM packing + dew harvesting, and it was closely followed by seed soaking + two sprays at tillering and booting stages with 1000 ppm thiourea (885 kg/ha). The seed soaking + two sprays gave 2.4% higher yield than control (735 kg/ha). Seed soaking alone improved yield by 9.7% over the control, which further increased by 12.8% with two sprays at tillering and booting stages.

3.4. Utilization of Plant Growth Promoting Bacteria (PGPB) for Enhancing Crop Productivity in Hill Agriculture

**Evaluation of cold tolerant PGP Pseudomonad on nutrient uptake, growth and yield of lentil**

Eight cold tolerant plant growth promoting Pseudomonad strains having multiple traits at 4 and 15 °C were evaluated under field conditions on growth, nutrient uptake and yield of lentil (VL Masoor 126). Inoculation with *Pseudomonas fluorescens* PPRs4 recorded maximum FDA enzyme activity (5.66 fluorescein produced μg/g dry weight) at 45 days after sowing (DAS) and *Pseudomonas lurida* NPRs3 (5.80 fluorescein produced μg/g dry weight) at 90 DAS as compared to control (4.92 and 5.18 fluorescein produced μg/g dry weight, respectively) in lentil rhizosphere. Bacterization with *Pseudomonas* sp. NARs9 recorded maximum (311.9 μgNP/g dm/h) total phosphomonoesterase enzyme activity at 90 DAS over the control (215.1 μgNP/g dm/h). All the strains showed enhancement in rhizospheric soil microbial carbon and nitrogen ratio ($C_{mic}:N_{mic}$) ranging from 4.93 to 10.40 and 4.70 to 6.71 at 45 and 90 DAS, respectively. Bacterization with *Pseudomonas fluorescens* NPRp15 recorded highest $C_{mic}:N_{mic}$ ratio (10.41) followed by *Pseudomonas* sp. PGERs17 (10.33) at 45 DAS over uninoculated control (7.77) in lentil rhizosphere. Single inoculation of cold tolerant bacterial strains *Pseudomonas* sp. NARs9, *Pseudomonas putida* PGR4 and *Pseudomonas* sp. PPERs23 enhanced lentil grain yield by 13.9, 12.3 and 8.4%, respectively (average of four years) over uninoculated control (1,060 kg/ha) in field conditions.

**Effect of cold tolerant plant growth promoting bacterial consortia to enhance chilling tolerance, growth and yield of lentil**

Eight cold tolerant plant growth promoting bacterial consortium were evaluated under field conditions on growth, nutrient uptake and yield of lentil (VL Masoor 126). Inoculation with PGP consortium C4 recorded highest rhizospheric soil microbial carbon and nitrogen ratio ($C_{mic}:N_{mic}$) (10.14) followed by C3 (9.98) over uninoculated control (8.18) in lentil rhizosphere at 45 days after sowing (DAS). Consortium C6 recorded maximum (2.268 mg/g tissue) total chlorophyll in comparison to uninoculated control (1.68 mg/g tissue) at 90 DAS. Inoculation with PGP consortium C5 recorded maximum (401.2 μgNP/g dm/h) total phosphomonoesterase enzyme activity followed by C6 (393.23 μgNP/g dm/h) at 90 DAS over the control (267.5 μgNP/g dm/h). Consortia C3 and C8 significantly improved ‘P’ content by 16.9 and 12.9%, respectively over uninoculated control (1.24%) at 90 DAS. Inoculation with PGP bacterial consortium C2, C4 and C8 enhanced lentil grain yield by 11.4, 11.0 and 8.1%, respectively (average of four years) over uninoculated control (1,205 kg/ha) under field conditions.
Effect of cold tolerant ‘P’ solubilizing bacterial consortium to enhance ‘P’ uptake, growth and yield of lentil

Eight psychrotolerant ‘P’ solubilizing bacterial consortium were evaluated under field conditions for enhancement of nutrient uptake and yield of lentil (VL Masoor 126). Consortium C8 recorded maximum (258.17 µgNP/g dm/h) total phosphomonoesterase enzyme activity over the control (166.8 µgNP/g dm/h) at 90 DAS. Consortium C2, C1 and C3 significantly enhanced lentil ‘P’ content by 16.2, 12.6 and 11.7%, respectively over uninoculated control (1.11% P content) at 90 DAS. Average of four years field trials revealed that inoculation with ‘P’ solubilizing bacterial consortium C4 enhanced lentil grain yield by 15.8% followed by C3 (13.9%) and C2 (7.9%) over uninoculated control (1,162 kg/ha) under field conditions.

Effect of cold tolerant phosphate solubilizing bacterial strains to enhance ‘P’ uptake, growth and yield of lentil

Eight psychrotolerant, ‘P’ solubilizing bacterial strains having multiple traits (IAA, siderophore, HCN & ammonia production and phosphate solubilisation) at 4 and 15 ºC were evaluated under field conditions on growth, nutrient uptake and yield of lentil (VL Masoor 126). All the strains showed enhancement in physiological available iron ranging from 3.09 to 2.23 mg/g tissue. *Pseudomonas* sp. CS11RP1 recorded maximum (3.09 mg/g tissue) total chlorophyll in comparison to uninoculated control (1.58 mg/g tissue) at 90 days after sowing (DAS). Inoculation with *Pseudomonas* sp. RT6RP recorded highest (380.55 µgNP/g dm/h) total phosphomonoesterase enzyme activity over the control (253.7 µgNP/g dm/h) at 90 DAS. All the strains showed enhancement in rhizospheric soil microbial carbon and nitrogen ratio (C$_{mic}$:N$_{mic}$) ranging from 5.6 to 9.0 at 90 DAS under field conditions. Bacterization with *Pseudomonas* sp. CS11RP1 recorded highest C$_{mic}$:N$_{mic}$ ratio (9.0) followed by *P. fragi* CS11RH4 (7.8) over uninoculated control (6.7). Single inoculation of cold tolerant bacterial strains *Pseudomonas* sp. RT5RP(2), *P. fragi* CS11RH1 and *Pseudomonas* sp. CS11RP1 enhanced lentil grain yield by 23.0, 21.0 and 19.4%, respectively over uninoculated control (1,153 kg/ha) under field conditions.

3.5. Mechanization of Hill Agriculture through Development of Suitable Farm Implements and Machineries

**Vermicompost straining drum for small farmers**

The institute developed a solar cum manual operated continuous vermicompost strainer (*Channa* drum) which is ready for commercialization. The length of the cylinder of the machine is 90 cm with 50 cm dia. The capacity of the machine is 300–350 kg vermicompost per hour along with zero mortality of earthworm during the process.

**Assessment of already developed small tools and their refinement on the basis of feedback from stake holders**

All developed small tools were assessed at farmers field. The improved VL sickle is very much effective for cutting of standing crops; however, farmers complained difficulty in fodder cutting from green trees. During testing, it was observed that local sickle is giving a sharp cut, whereas the VL sickle is giving a blunt cut.
Therefore, the multipurpose sickle (for harvesting as well as cutting of bushes) is being modified at workshop. After its validation, the same will be commercialized.

**Design and development of smokeless chulha for pine needle briquettes**

A new kind of stove (*Chulah*) was introduced, which is suitable for pine needle briquettes. This stove is light weight (2.5–3.0 kg), good looking and suitable for house hold activities. The briquette is made of pine charcoal and mud in the ratio of 3:1 (technology developed by GB Pant National Institute of Himalayan Environment and Sustainable Development, Almora). Once the dried briquette catches fire, it last up to 45 min to one hour. The burning heat may be used for room heating as well as cooking. After designing of this stove, various groups of farmers were trained for its manufacturing under skill development programme supported by the District Magistrate, Almora. This initiative will lessen forest fire problems in the state.

**Evaluation and demonstrations of VL paddy thresher at farmers field**

The VL Paddy Thresher was demonstrated to 10 farmers of Almora district in 1.0 ha area. The capacity of pedal operated paddy thresher was found 100 kg/ha with the work efficiency of 99%.

**Study and evaluation of various tillage devices for a new metallic plough**

A new metallic plough is under the process of evaluation based on farmers' feedback. During this period, the first major feedback given by farmers was the wear of shear tip. Wear of shear creates a "U" shape structure in the direction of motion, which was a concern of the farmers. To overcome this problem, a new material was selected to make the shear along with a change in the attachment to frog and champer. Also, to make it suitable for irrigated (puddled rice) fields, changes have been made in the mould board assembly. The new plough will be commercialised after further testing. Secondly, the wings of the mould board assembly were modified to use the Vivek (VL) *Syahi hal* in irrigated regions. In the upland conditions, the broad wings help for better inversion of soil, whereas ploughing in puddled rice field, broad wings creates difficulty in operation due to poor soil penetration and more draft requirement.

Three different type of *Danela* (tool for intercultural operation in finger millet or finger millet weeder) was demonstrated at village Suri, Naugaon and Chaunsli. It is made as an attachment of the new metallic plough. Distance between *Dhanau* (soil penetrating tools) was 7, 8 and 9 cm. The *Danela* having 9 cm distance between the tools was appreciated by farmers, however farmers gave feedback for its further refinement and modification and the tool will be given for demonstration in 2018.
Evaluation of weed wiper in finger millet for weed management

A light weight manual weed wiper (1.85 kg) was developed for weed control in between crop rows by using non-selective herbicides i.e. glyphosate (Roundup®) on the targets (weeds) by direct contact with an impregnated absorbent surface without damaging the crops. It is based on the principle of wiping (or brushing) a non-selective herbicide directly on to unwanted plants. The herbicide solution is supplied to an absorbent surface i.e. spongy roller (81.18 mm dia.) in weed wiper. A transparent pipe is used as the reservoir for the herbicide. Flow is regulated with a throttling valve that controls the amount and rate of air that gets inside the pipe, thus regulating the amount and rate of solution that can leave the pipe. A length of 15 cm plastic pipe (16 mm dia.) with small holes in the bottom is mounted above the spongy roller. The herbicide solution is continuously supplied from main pipe to this pipe and then over to the spongy roller at a controlled rate. The chemical is then applied to the weeds as the unit wipes over them. An experiment was laid out to study the response of various weed control measures in finger millet variety VL Mandua 352 [T1: Weedy check (Control), T2: Weed free, T3: Manual weeding at 35 DAS, T4: Two manual weeding at 25 & 45 DAS, T5: One weed wiping at 35 DAS, T6: Two weed wiping at 25 & 45 DAS, T7: Isoproturon 0.75 kg a.i./ha (pre emergence) + one manual weeding at 30 DAS, T8: Isoproturon 0.75 kg a.i./ha (pre emergence) + one weed wiping at 30 DAS]. A 0.05% solution of non-selective herbicide, glyphosate was used though weed wiper using 400L of water/ha. The highest grain yield of finger millet was recorded with two manual weeding (T4) (3,322 kg/ha) which is at par with weed free (T2) (3,217 kg/ha). The highest net return was recorded with T7 (Rs. 20,721) followed by T3 (Rs. 20,049) and T4 (19,355) however the highest B:C ratio was recorded with T7 (1.75) followed by T3 (1.74) and T8 (1.64).

3.6. Fodder Production Management with Special Reference to Utilization of Marginal and Wasteland

Adaptability and Evaluation

Evaluation of grasses under wasteland conditions

Setaria: Out of six entries of Setaria grass, entry VTGS 15-4 produced significantly higher green (43,458 kg/ha) and dry fodder (5,366 kg/ha) than the remaining entries except for VTGS 15-1.

Bajra Napier hybrid: Out of five entries of Bajra Napier hybrid grass, entry VTBN 15-7 produced significantly higher green (61,244 kg/ha) and dry fodder (14,708 kg/ha) than the remaining entries.

Rye Grass: Rye grass entry IVTRG-3 produced the highest green biomass (10,900 kg/ha) followed by IVTRG-1 (10,600 kg/ha). However, in case of dry matter production, IVTRG-2 (2,140 kg/ha) produced significantly higher dry matter than the rest of entries.

White Clover: In white clover initial varietal trial, entry VTWC-5 produced significantly higher green fodder (7,580 kg/ha) than rest of the entries except VTWG-2 (7,040 kg/ha).

Red Clover: In red clover, VTRC-5 produced significantly higher biomass (4,020 kg/ha) than VTRC-3 and VTRC-1.

Evaluation of cultivated fodder

Oat: Entry IVTO MC-1-10 produced significantly higher green fodder (11,170 kg/ha) than rest of the entries except IVTO MC-1-5 (10,540 kg/ha) in
multi-cut oat in IVT entries. However, in case of dry matter, IVTO MC-1-5 produced significantly higher dry matter (2,740 kg/ha) than rest of the entries except IVTO MC-1-10 (2,680 kg/ha).

Maize: In initial varietal trial of maize entries, AVTM-12 produced significantly higher green fodder (46,019 kg/ha) than rest of the cultivars except AVTM-11. In case of dry matter production, AVTM-12 (8,868 kg/ha) was better than AVTM-13.

Cowpea: In cowpea advance varietal trial, entry AVT2C-2 produced significantly higher green fodder (22,099 kg/ha) than rest of the cultivars except AVT2C-8, AVT2C-4, AVT2C-7 and AVT2C-5 (15,988–20,494 kg/ha). However, in case of dry matter production, AVT2C-2 was the best (3,271 kg/ha).

Dual Purpose Wheat

Bacterial and chemical fertilization on the dual-purpose wheat

To have maximum yield from dual purpose wheat after green forage cut, proper fertilization is essential to overcome the stress of crop after cut. Due to the higher prices of nitrogenous fertilizer some other alternative sources are required. Application of PGPR can be a good option for it. Wheat variety, VL Gehun 829 was grown in N fertilization with Azotobacter and Pseudomonas seed treatment and compared with cutting for fodder and without cutting for fodder. The grain yield was not found to get affected by green forage cutting. However, seed treatment with Azotobacter and Pseudomonas sp. produced 13% higher green forage than control (4,730 kg/ha) in forage cut treatments. Grain yield was 11% higher in uncut with normal N dose than seed treatment of bacteria and its combination (4,666 kg/ha) (Fig. 3.7).

Fodder Production Potential of Trees

Grassland management

In silvipastoral system, fodder trees i.e., Quercus leucotrichophora, Grewia optiva, Morus alba, Bauhinia retusa and Melia azedarach were tested along with four cutting management viz., coppicing, pollarding at 1 m height, pollarding at 2 m height and pollarding at 3 m height with Setaria kazungula grass under these trees. Oak (Q. lecotrichophora) stored significantly high carbon (24.85 t/ha) as compared to other trees (Fig. 3.8). Among cutting management, pollarding at 3 m height stored highest carbon (14.87 t/ha), which was significantly higher than other cutting management. In case of biomass production, S. kazungula under Q. lecotrichophora yielded the highest green biomass (7,000 kg/ha).

Cutting management of trees

The effect of eight lopping methods on the fodder yield of Kachnar (Bauhinia retusa) grown along the side of path at the ICAR-VPKAS Experimental Farm, Hawalbag was studied. Different lopping treatments applied were (C1) pollarding (cut to the trunk) at 1 m height, (C2) pollarding at 1 m height but leaving the main shoot intact, (C3) pollarding at 2 m height, (C4) local practice (removal of leaves and tender twigs at random just above the bifurcation of the branches), (C5)
lopping of leaves and tender twigs once in a year (December), (C6) lopping of leaves and tender twigs twice (July and December) in a year, (C7) lopping of lower 2/3 part of tree keeping top 1/3 undisturbed and (C8) lopping of lower 1/2 part of tree keeping top ½ undisturbed. The green forage yield (mean of 3 years) showed that lopping of leaves and tender twigs twice in a year, produced the highest green forage (5.49 kg/tree) followed by pollarding at 1 m height leaving main shoot intact (5.16 kg/tree) (Fig. 3.9). In B. retusa terrace and way plantation, carbon stock was recorded @ 3.17±0.9 t/1000m length with lopping of lower ½ part and keeping top ½ parts undisturbed and 2.60±0.3 t/1000m length with lopping of lower 2/3 part and keeping top 1/3 undisturbed.

**Agro-forestry**

**Agri-horti system**

In pecannut based agri-horti system, grain yield of wheat, lentil, soybean and ragi did not vary significantly with that of sole cropping (without pecannut). In fruit based agri-horti system, soybean in *kharif* and dual-purpose wheat during *rabi* season were grown with four fruit trees i.e. hill lemon, pear, plum and apricot. It was observed that green fodder and grain yield of wheat did not vary significantly in *rabi* season, but, during *kharif* season, grain yield of soybean was affected significantly when grown under fruit trees. Green forage yield of wheat ranged between 4,390 and 5,238 kg/ha in different treatments.

In pecannut based agroforestry system, average litter fall of 3.6 t/ha was recorded. Litter fall from pear (*Pyrus pommunis*) was highest (2.56 t/ha) followed by plum (*Prunus domestica*) 1.04 t/ha and apricot (*Prunus armeniaca*) 0.43 t/ha in fruit-based agroforestry system. Oak high-density plantation (1 x 1 m) accumulated a maximum biomass C (526.5±28.2 Mg/ha) and minimum in hill lemon (6 x 6 m) of agrihorti system (3.8±0.4 Mg/ha).

In peach based agri-horti system, the grain and straw yield of four different varieties of *ragi* such as VL Mandua 149, VL Mandua 324, VL Mandua 315 and VL Mandua 347 were significantly influenced in the presence of peach tree. The grain and straw yield ranged from 8.2 to 17.4 q/ha and 29.5 to 62.3 q/ha under peach and from 16.0 to 21.9 q/ha and 56.6 to 77.8 q/ha in open (without peach), respectively (Fig. 3.10). Irrespective of varieties, mean grain yield was reduced by 26.8% (13.1 q/ha) in peach-based system compared to open (without peach).

**Silvi-horti system**

The yield of turmeric grown under oak (with different cutting managements) did not significantly differ with the yield of sole crop. The turmeric yield ranged from 77.1 to 137.7 q/ha and 62.5 to 120.0 q/ha for Pant pithab and
Swarna variety, respectively. The significantly high green forage yield (267.2 q/ha) and girth (55.80 cm/tree) was recorded with pollarding at 3 m height than the rest of cutting treatments. Among different fodder trees, maximum girth was recorded in C. australis (66.0 cm/tree), which was significantly high and followed the order: Q. leucotrichophora (45.2 cm /tree) > B. retusa (24.8 cm /tree) > G. optiva (8.8 cm /tree).

3.7. Integrated Water and Soil Management for Enhancing Production and Input Use Efficiency

Irrigation requirement of rice–wheat rotations in relation to tillage alterations

In the studies on tillage and irrigation management in direct seeded rice–wheat rotation, significant higher wheat yield and applied water productivity (29.6 q/ha and 2.5 kg/m³) was obtained under zero tillage in comparison to conventional tillage (25.1 q/ha and 2.3 kg/m³). Increasing levels of irrigation increased the yield. The highest wheat and rice yields (36.0 q/ha and 18.6 q/ha, respectively) was obtained with four irrigations scheduled at pre-sowing irrigation (PSI) (I₁), irrigation at PSI + active tillering (AT)/ crown root initiation (CRI) (I₂), irrigation at PSI + AT/CRI + panicle initiation (PI)/flowering (FL) (I₃), and irrigation at PSI + AT/ CRI + PI/ FL + grain filling (GF) (I₄).

Cumulative CO₂-C significantly (p <0.05) varied under different tillage system from 638 to 730 mg CO₂-C mg/kg and 440 to 522 mg CO₂-C/kg soil in 0–15 and 15–30 cm soil layers, respectively after 28 days of incubation (Fig. 3.11). Plots under ZT evolved significantly (p <0.05) ~15 and 18% higher cumulative CO₂-C than CT (638 and 440 mg CO₂-C/kg) in 0–15

![Diagram](image1.png)

**Fig. 3.11.** Cumulative CO₂-C of soil under different tillage and irrigation levels in 0-15 (a and b) and 15-30 cm (c and d) of RWCS. Symbol * denotes significant differences between the treatments at p ≤ 0.05 according to Duncan Multiple Range Test for separation of means; NS indicates not significant (for treatment details refer to Table 1).
and 15–30 cm soil layers, respectively. Irrigation had significant impact on CO₂ evolution. Plots under I₄ and I₃ evolved nearly 35 and 23% greater cumulative CO₂ than I₁ (586 mg CO₂-C/kg) in the 0–15 cm soil layer. In the 15–30 cm soil layer, I₄ and I₃ evolved about 38 and 22% greater CO₂ than I₁ (408 mg CO₂-C/kg).

Tillage and irrigation both had significant (p <0.05) impact on carbon sequestration (CS). Plots under ZT had significantly ~9 and 6% higher carbon sequestered as compared to CT (22.78 and 20.50 Mg/ha) in the 0–15 and 15–30 cm soil layer respectively (Table 3.1). The CS found significantly higher under I₄ plots (24.7 and 22.9 kg C/ha/year) and lowest under I₁ (22.0 and 20.2 kg C/ha/year) in the 0–15 and 15–30 cm soil layer, respectively. Data showed that the CSR significantly (p <0.05) affected by tillage and irrigation under long-term rice–wheat cropping system. The carbon sequestration rate was higher under ZT (459 and 333 kg C/ha/year) as compared to CT plots (339 and 259 kg C/ha/year) in the 0–15 and 15–30 cm soil layers, respectively. The CSR significantly varied under different irrigation levels from 297 to 464 kg C/ha/year in the 0–15 cm layer and 237 to 408 kg C/ha/year in the 15–30 cm soil layer. Apart from treatments, depth wise distribution of CS and CSR was higher in the 0–15 cm layer as compared to 15–30 cm soil layer. No tillage and irrigation interaction were observed on CS and CSR in both soil layers.

**Soil moisture and nutrient dynamics in wheat–soybean rotation under irrigated conditions**

Profile moisture balance studies involving soybean-wheat rotation under different fertilizer and manure treatments revealed that the continuous application of either FYM or FYM in combination with NPK improved profile moisture capacity of soil, increased organic carbon content. Maximum yield of wheat (5093

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**Table 3.1. Carbon sequestration (CS) and carbon sequestration rate (CSR) under different soil layers as influenced by 16-year tillage practices and different irrigation levels**

<table>
<thead>
<tr>
<th>Treatments†</th>
<th>CS (Mg/ha)</th>
<th>CSR (kg C/ha/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0–15 cm</td>
<td>15–30 cm</td>
</tr>
<tr>
<td></td>
<td>0–15 cm</td>
<td>15–30 cm</td>
</tr>
<tr>
<td><strong>Tillage</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT</td>
<td>22.7</td>
<td>20.5</td>
</tr>
<tr>
<td>ZT</td>
<td>24.6</td>
<td>21.7</td>
</tr>
<tr>
<td>LSD</td>
<td>1.3</td>
<td>1.0</td>
</tr>
<tr>
<td>P value</td>
<td>0.004</td>
<td>0.027</td>
</tr>
<tr>
<td><strong>Irrigation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I₁</td>
<td>22.0</td>
<td>20.2</td>
</tr>
<tr>
<td>I₂</td>
<td>23.3</td>
<td>20.5</td>
</tr>
<tr>
<td>I₃</td>
<td>24.6</td>
<td>20.9</td>
</tr>
<tr>
<td>I₄</td>
<td>24.7</td>
<td>22.9</td>
</tr>
<tr>
<td>LSD</td>
<td>1.8</td>
<td>1.5</td>
</tr>
<tr>
<td>P value</td>
<td>0.014</td>
<td>0.003</td>
</tr>
<tr>
<td>T ×I</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>P value</td>
<td>0.22</td>
<td>0.85</td>
</tr>
</tbody>
</table>

NS – non-significance; LSD – least significant difference (p ≤0.05).

†Treatments CT: conventional tillage, ZT: zero tillage, I₁: pre-sowing irrigation (PSI), I₂: PSI + irrigation at active tillering (AT)/crown root initiation (CRI), I₃: PSI + irrigation at AT/CRI + panicle initiation (PI)/flowering (FL), and I₄: PSI + irrigation at AT/CRI + PI/FL + grain filling (GF).
kg/ha) and soybean (174.74 kg/ha) was obtained in NPK+FYM treatments, which was followed by N+FYM. The yield of soybean grown on residual fertility showed an increasing trend in balanced fertilized plots and decreasing trend in control plots and plots that received only nitrogen. Wheat was grown under fertilized condition and soybean was grown on the residual fertility, barring one treatment where it was grown with recommended NPK. The results showed that 21-year chemical and organic fertilization (NPK + FYM) significantly (p < 0.05) increased soil reaction (5.96, 6.41 and 6.56) as compared to CK. However, it was 0.24, 0.11 and 0.12 unit lower than FYM in 0-15, 15-30 and 30-45 cm soil depths, respectively. Plot with the application of NPK + FYM significantly (p < 0.05) reduced bulk density and increased total porosity as compared to untreated plot (Fig. 3.12).

Plot that received NPK + FYM showed ~ 54, 51 and 52% significantly higher total organic carbon (TOC) and ~46, 56 and 55% higher total nitrogen (TN) as compared to control plot at 0–15, 15–30 and 30–45 cm soil depths, respectively. The average TOC and TN with different plots were 9.89, 9.23 and 8.57 g/kg and 0.80, 0.74 and 0.68 g/kg under 0–15, 15–30 and 30–45 cm soil depths, respectively. Higher carbon (~ 22, 20 and 19 Mg C/ha) and nitrogen (1.79, 1.67 and 1.53 Mg N/ha) storage was recorded in plots that received NPK + FYM as compared to control at 0–15, 15–30 and 30–45 cm soil depths, respectively (Fig. 3.13).

**Effect of irrigation schedule on onion and garlic**

The mean onion (238.3 q/ha) and garlic (118.3 q/ha) yield under drip irrigation was higher in comparison to check basin irrigation (153.4 & 73.7 q/ha, respectively) in 2016. The highest onion yield (271.1 q/ha) was obtained under drip irrigation scheduled at 1.2 IW: CPE followed by drip irrigation scheduled at 1.0 IW: CPE. The onion yield was higher in 2017 compared to the yield during 2016 but trend was the same. The highest yield of garlic was obtained under drip irrigation scheduled at 1.0 IW: CPE followed by drip irrigation scheduled at 0.8 IW: CPE. The lowest yield (111.2 and
62.5 q/ha, respectively) was recorded under check basin irrigation scheduled at 0.8 IW: CPE in onion and garlic respectively. No significant difference was noticed in 2016 and 2017 garlic yields (Fig. 3.14).

**Artificial-recharging techniques for hill springs**

The roof water as well as surface water harvested in trenches to increase ground water level. Recharging of spring increased annual water yield by 156.3% during 2017 in comparison to data recorded before imposing the treatments i.e., during 2000.

Fig. 3.14. Effect of irrigation on onion and garlic yields

Recharging of spring
4. Integrated Pest Management

Research Projects


- Integrated Management of Chewing Pests in Major Hill Crops [Drs. A.R.N.S. Subbanna & J. Stanley]

4. Integrated Management of Diseases and Pests of Hill Crops

Crop protection measures play vital role in reducing the crop yield losses by disease and insect-pests management. Integrated methods of management are environmentally safe and important in hill ecosystem. Thus, emphasis have been given on use of varietal resistance, biological control options, organic amendments, and safer pesticides including survey and identification of important diseases and insect pests of hill crops.

4.1. Survey and Surveillance

A survey was conducted in the hilly region of Uttarakhand during *Rabi* 2016-17. At Baralgaon, Ganai (N 29°52'49", E 79°22'14", amsl 974 m), Almora, around 70% area was planted with VL *Gehun* 907. In these fields, yellow rust symptoms upto 10S-15S were observed. Out of nineteen samples of yellow rust collected from different locations of Uttarakhand and analysed at IIWBR regional station, Flowerdale, the frequency of pathotype 46S119 (virulent to Yr2, Yr3, Yr4, Yr6, Yr7, Yr8, Yr9, Yr17, Yr18, Yr19, Yr21, Yr22, Yr23, Yr25 and YrA) was maximum (08) followed by 110S119 (05). Pathotype 238S119 was identified in three samples and remaining two samples showed the presence of 46S103 and 6S0 each. From the analysis of barley yellow rust (*Puccinia striiformis hordei*) samples, pathotype 1S0 (M) was identified. Analyses of 34 samples of wheat brown rust showed twenty-four pathotypes belonging to 4 major groups i.e., 12, 77, 104 and 162. There was an increase in the proportion of pathotype 77-9, which was identified in about 16 samples analysed. On the contrary, pathotype 77-5, the most predominant for several years, was identified in only 3 samples. In addition, a new pathotype designated as 162-4 was also observed in two samples.

Rice leaf and neck blast disease was moderate to severe (>40% score 6-8). In maize, Turcicum leaf blight was moderate to severe while Maydis leaf blight severity was low to medium and the incidence of banded leaf and sheath blight was moderate in all the field trials. The severity of leaf blast of finger millet was high but neck and finger blast severity was medium. Very low incidence of foot rot of finger millet was also noticed. In barnyard millet, grain smut disease was high. Field monitoring of *Pyricularia oryzae* was carried out under Uniform Blast Nursery (UBN) system with 25 blast differentials and Raminad STR-3, *Oryza minuta* and Tetep were found highly resistant (3 score on 0-9 scale). At experimental farm, Hawalbagh moderate rust (15-25%) and angular leaf spot (25-30%) disease was recorded in french bean. In garden pea, 10-15% root rot was recorded.

Medium infestation of cabbage aphids and butterfly was found in cabbage and cauliflower during April. Medium infestation of fruit flies in summer squash was noticed during May-June months. Medium infestation of grasshoppers and stem borers as noticed in rice during July-Sept. High infestation of webber, *Hymenia recurvalis* was found in amaranth during August. Medium infestation of sucking bug, *Chauliops choprai* and high incidence of soybean beetle, *Platypria hystrix* was noticed in soybean during July to September.
In polyhouses, low infestation of whiteflies in tomato during April-May and high incidence during June was noticed. High infestation of thrips was noticed in French bean during August month.

4.2. Race Profiling, Variability and Management of Major Plant Pathogens of Hill Crops

Race profiling of *Magnaporthe oryzae* isolates on monogenic blast differentials of rice

Infected rice leaf and neck blast samples collected from farmers’ field and experimental farm, Hawalbagh of Uttarakhand (Table 4.1) were kept at –20°C until isolations were made. Isolation of pathogen was carried out using spore drop method. Twenty-one days old rice seedlings were inoculated, and disease severity was scored 7 days after inoculation using standard 0–5 disease scoring scale (Bonman et al. 1986).

Table 4.1. Rice blast samples collected from the different locations of Uttarakhand

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Place of collection</th>
<th>Plant part infected</th>
<th>Variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>LB-VLD-209</td>
<td>Mallahata, Almora</td>
<td>Leaf</td>
<td>VL Dhan 209</td>
</tr>
<tr>
<td>LB-VLD-206</td>
<td>Mallahata, Almora</td>
<td>Leaf</td>
<td>VL Dhan 206</td>
</tr>
<tr>
<td>LB-VLK-39</td>
<td>Hawalbagh, Almora</td>
<td>Leaf</td>
<td>VLK 39</td>
</tr>
<tr>
<td>LB2-HWG</td>
<td>Hawalbagh, Almora</td>
<td>Leaf</td>
<td>Bala</td>
</tr>
<tr>
<td>LB1 Chinyalisaur</td>
<td>Chinyalisaur, Uttarkashi</td>
<td>Leaf</td>
<td>Local cultivar</td>
</tr>
<tr>
<td>LB Khuwali</td>
<td>Khuwali, Almora</td>
<td>Leaf</td>
<td>Local cultivar</td>
</tr>
</tbody>
</table>

Virulence analysis of *M. oryzae* isolate

Six isolates were characterized on monogenic blast differentials under artificial epiphytotic conditions. The virulence percent ranged from 27 to 61 with minimum in LB-VLD 206 and maximum in LB2-HWG isolate (Fig. 4.1).

Resistance spectrum of *R* genes

Among twenty-four *R* genes, complete resistance was shown by *Pi9* and *Piz5* genes to all tested isolates followed by *Pita2, Piz, Pizt, Pia, Pib, Piks* and *Pii* and complete susceptibility was shown by *Pish* gene followed by *Pi1* (Table 4.2).

Artificial screening of maize inbred lines for banded leaf & sheath blight (BLSB) resistance

Sixty-seven maize inbred lines were screened with an isolate from Hawalbagh for identifying resistant source to BLSB disease under artificial epiphytotic conditions. The pathogen (*Rhizoctonia solani*) was inoculated on 45 days seedling stage. Identified tolerant sources include V351, V402, V431, V 440, VSL-27 and CM 141.
Identification of resistance source to neck and finger blast disease from finger millet hill germplasm collections

A total 225 hill collections of finger millet germplasm were evaluated against leaf, neck and finger blast disease under natural field conditions. Based on scoring pattern, it was observed that none of the germplasm was highly resistant to leaf blast disease. Neck blast incidence ranged from 0 to 86 per cent and finger blast incidence from 0 to 40 per cent. Entries VHC-3796, VHC-4085, VRB-MF-1217, VL 324, VR-MF-1516 and VL Ragi 149 were highly resistant to both neck and finger blast while moderately resistant to leaf blast. Entries VHC-3899, VHC-4168, VHC-3603, VHC-3637, VHC-4149, VHC-4167, VHC-4006, VHC-3641, VRS-MF-859, VRB-MF-1214, VHC-4134, VHC-4136, VHC-4087, VHC-3975, VRB-MF-1817, VRB-MF-1819 and VHC-3583 were highly resistant to neck blast and moderately resistant to leaf and finger blast. Germplasms VHC-3899, VHC-4103, VHC-3658, VHC-3757, VHC-3993, VHC-4074, VHC-

### Table 4.2. Reaction of monogenic blast differentials against M. oryzae isolates

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>IRBL1-CL</td>
<td>Pi1</td>
<td>R</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>IRBL11-ZH</td>
<td>Pi11</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>S</td>
<td>R</td>
</tr>
<tr>
<td>IRBL12-M</td>
<td>Pi12</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>S</td>
<td>R</td>
</tr>
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<td>IRBL19-A</td>
<td>Pi19</td>
<td>S</td>
<td>S</td>
<td>R</td>
<td>S</td>
<td>R</td>
<td>S</td>
</tr>
<tr>
<td>IRBL20-IR24</td>
<td>Pi20</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>R</td>
<td>R</td>
<td>S</td>
</tr>
<tr>
<td>IRBL3-CP4</td>
<td>Pi3</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>S</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>IRBL5-M</td>
<td>Pi-5(t)</td>
<td>S</td>
<td>R</td>
<td>S</td>
<td>S</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>IRBL7-M</td>
<td>Pi7</td>
<td>S</td>
<td>R</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>IRBL9-W</td>
<td>Pi-9</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>IRBLA-a</td>
<td>Pia</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>IRBLA-b</td>
<td>Pi-b</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>IRBLI-F5</td>
<td>Pi</td>
<td>R</td>
<td>S</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>IRBLK-KA</td>
<td>Pik</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>IRBLKH-K3</td>
<td>Pikh</td>
<td>S</td>
<td>R</td>
<td>S</td>
<td>R</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>IRBLKMTS</td>
<td>Pikm</td>
<td>S</td>
<td>S</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>IRBLKP-K60</td>
<td>Pikp</td>
<td>S</td>
<td>S</td>
<td>R</td>
<td>S</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>IRBLKS-F5</td>
<td>Piks</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>IRBLSH-S</td>
<td>Pish</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>IRBLT-K59</td>
<td>Pit</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>R</td>
</tr>
<tr>
<td>IRBLTA-K1</td>
<td>Pita</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>S</td>
<td>R</td>
</tr>
<tr>
<td>IRBLTA2-PI</td>
<td>Pita2</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>IRBLZ-FU</td>
<td>Piz</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>IRBLZ5-CA</td>
<td>Piz5</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>IRBLZT-T</td>
<td>PizT</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>LTH</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Tetep</td>
<td></td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>No. of R genes knocked down</td>
<td>8</td>
<td>7</td>
<td>12</td>
<td>16</td>
<td>10</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Percent virulence</td>
<td>30.76</td>
<td>26.92</td>
<td>46.15</td>
<td>61.53</td>
<td>38.46</td>
<td>30.76</td>
<td></td>
</tr>
</tbody>
</table>
3640, VHC-3900, VHC-4127, VHC-4200, VRB-MF1218 and VR-MF2233 were highly resistant to finger blast disease.

**Effective R genes for blast resistance under field conditions**

Twenty-four monogenic blast differentials were evaluated for both leaf and neck blast resistance under natural field conditions. Among R genes tested, none of the gene was highly resistant to leaf blast disease but R genes showed varied reaction to neck blast disease. Some differentials like Pi11, Pi20, Pi5, Pia, Pikh, Pikm, Piz, Piz5 and Pizt were highly resistant to neck blast (Table 4.3).

**Table 4.3. Blast reaction of monogenic blast differentials under field conditions**

<table>
<thead>
<tr>
<th>Monogenic line</th>
<th>R-gene</th>
<th>Leaf blast</th>
<th>Neck blast</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRBL1-CL</td>
<td>Pi1</td>
<td>6.3</td>
<td>9</td>
</tr>
<tr>
<td>IRBL11-ZH</td>
<td>Pi11</td>
<td>7.7</td>
<td>1.7</td>
</tr>
<tr>
<td>IRBL12-M</td>
<td>Pi12</td>
<td>5.0</td>
<td>3</td>
</tr>
<tr>
<td>IRBL19-A</td>
<td>Pi19</td>
<td>6.3</td>
<td>7</td>
</tr>
<tr>
<td>IRBL20-IR24</td>
<td>Pi20</td>
<td>5.3</td>
<td>1</td>
</tr>
<tr>
<td>IRBL3-CP4</td>
<td>Pi3</td>
<td>8.3</td>
<td>3.7</td>
</tr>
<tr>
<td>IRBL5-M</td>
<td>Pi-5 (t)</td>
<td>5.0</td>
<td>3</td>
</tr>
<tr>
<td>IRBL7-M</td>
<td>Pi7</td>
<td>5.7</td>
<td>6.3</td>
</tr>
<tr>
<td>IRBL9-W</td>
<td>Pi-9</td>
<td>5.0</td>
<td>1.7</td>
</tr>
<tr>
<td>IRBLA-a</td>
<td>Pia</td>
<td>7.0</td>
<td>3</td>
</tr>
<tr>
<td>IRBLA-b</td>
<td>Pi-b</td>
<td>6.3</td>
<td>7</td>
</tr>
<tr>
<td>IRBL1-F5</td>
<td>Pii</td>
<td>8.3</td>
<td>4.3</td>
</tr>
<tr>
<td>IRBLK-KA</td>
<td>Pik</td>
<td>6.3</td>
<td>7</td>
</tr>
<tr>
<td>IRBLKH-K3</td>
<td>Pikh</td>
<td>8.3</td>
<td>3</td>
</tr>
<tr>
<td>IRBLKMKS</td>
<td>Pikm</td>
<td>7.7</td>
<td>3</td>
</tr>
<tr>
<td>IRBLKP-K60</td>
<td>Pikp</td>
<td>7.7</td>
<td>8.3</td>
</tr>
<tr>
<td>IRBLKS-F5</td>
<td>Piks</td>
<td>6.3</td>
<td>1</td>
</tr>
<tr>
<td>IRBLSH-S</td>
<td>Pish</td>
<td>9.0</td>
<td>7</td>
</tr>
<tr>
<td>IRBLT-K59</td>
<td>Pit</td>
<td>6.3</td>
<td>1.7</td>
</tr>
<tr>
<td>IRBLTA-K1</td>
<td>Pita</td>
<td>8.0</td>
<td>7</td>
</tr>
<tr>
<td>IRBLTA2-P1</td>
<td>Pita2</td>
<td>5.0</td>
<td>5</td>
</tr>
<tr>
<td>IRBLZ-FU</td>
<td>Piz</td>
<td>5.7</td>
<td>3</td>
</tr>
<tr>
<td>IRBLZ5-CA</td>
<td>Piz5</td>
<td>5.0</td>
<td>1.7</td>
</tr>
<tr>
<td>IRBLZT-T</td>
<td>Pizt</td>
<td>5.0</td>
<td>3</td>
</tr>
<tr>
<td>LTH</td>
<td>-</td>
<td>8.3</td>
<td>6.3</td>
</tr>
<tr>
<td>Tetep</td>
<td>-</td>
<td>3.0</td>
<td>1</td>
</tr>
</tbody>
</table>

**4.3. Development of Cost Effective Management of Diseases and Pests under Protected Cultivation**

**Effect of soil amendments on tomato diseases and nematode under polyhouse and open conditions**

Out of different treatments evaluated against tomato diseases under polyhouse conditions, soil amendment of mustard cake + *Parthenium* (1:1) @ 10t/ha (T8) resulted in minimum late blight severity (1.7%) and root rot incidence (2.3%) (Fig. 4.2). Same result was obtained in open conditions also, where soil amendment of mustard cake + *Parthenium* (1:1) @ 10t/ha (T5) resulted in minimum late blight severity (3%) and root rot incidence (4%) (Fig. 4.2).

![Fig. 4.2. Effect of soil amendments on tomato diseases and nematode under polyhouse conditions](image)

Out of ten soil amendments tested under polyhouse condition against total soil nematode population, spent mushroom compost @ 10 t/ha (T4) and mustard cake+ neem cake (1:1) @ 20 t/ha (T7) were found effective in comparison to control (T10). In open field condition, soil amendment with spent mushroom compost @ 10 t/ha (T2) and oxalis leaf @ 10 t/ha (T6) significantly reduced the soil nematode population as compared to control (T10) (Fig. 4.3).
4.4. Integrated Management of Chewing Pests in Major Hill Crops

Light trap catches of different species of whitegrubs

A total of 5,200 beetles were trapped in 10 light traps installed at the experimental farm, Hawalbagh during June to October 2017. A maximum of 65.6% of total catches were recorded during June-July months. The total number of beetles caught during 2017 is the lowest among the last five-year catches i.e only 27.9% of 2016 and 9.6% of 2015. Diversity of the beetles comprised of 30 species, of which 16.4% was the predominant species, Anomala dimidiata. The catches of A. dimidiata are showing a decreasing trend from 2016. Other species viz., Aphodius sp., Anomala sp. and Hemiserica nasuta were 13.9, 12.1 and 9.0% of the total catch, respectively whereas the scarabaeinae accounted for 18.0%. The species composition of light trap catches is given in the Fig. 4.4.

4.5. Bio-intensive Management of Major Polyphagous Pests of Uttarakhand Hills

Field evaluation of pesticides against pests of soybean

Field evaluation of different pesticides against pests of soybean revealed cartap hydrochloride (T3) was most effective in decreasing the population of Chauliops to a tune of 96.8% after 2 days of treatment followed by deltamethrin (T5) and profenophos (T6) to a tune of 92.4%. Imidacloprid (T4) and indoxacarb (T2) were also found to be effective and decreased the chauliops population to around 43.4%. The effective treatments i.e., cartap hydrochloride, deltamethrin and profenophos treated plots showed no significant builtup of Chauliops population up to 8 days after treatment. The chitinolytic isolate, UKCH83 treatment was found to reduce the pest population with time along with minimal levels of aphid infestation as that of cartap hydrochloride, deltamethrin and profenophos. Indoxacarb was found to be ineffective against aphids by showing at par infestation as that of control (Fig. 4.5).
Multiphase characterization of chitinolytic Bacillus spp.

Eighty-three chitinolytic Bacillus isolates native to Uttarakhand Himalayas were studied for cell strength, supernatant protein content, enzyme activity, thermal stability from 3 days old fermented cultures in half strength nutrient broth infused with 1% colloidal chitin. The protein content of culture supernatants was at its peak in UKCH73 and UKCH80 with 0.94 and 0.9 mg/mL, respectively. Most of the isolates showed less enzyme activity at pH 7 compared to pH 5. Peak enzyme activity of 217 U/mL was observed in UKCH23 and UKCH62 at pH 5. However, at pH 7 highest activity was observed in UKCH38 (247 U/mL). About 10 isolates viz., UKCH19, UKCH20, UKCH31, UKCH32, UKCH34, UKCH39, UKCH51, UKCH73, UKCH74 and UKCH78 showed comparable activity at both the pH. The thermal stability study of enzymes after a temperature stress at 50 ºC for 1 h showed 23 isolates as thermally stable by retaining their percent activity. However, psychrotolerance was observed in only nominal isolates despite of existing annual low temperatures. Cold tolerance study revealed a significant low-temperature tolerance by UKCH6, UKCH32 and UKCH47, which was manifested by 4 mm halo after 7 days of incubation at 5ºC in chitinase detection agar medium.

Diversity of chitinase genes from chitinolytic Bacillus spp.

A sample of 15 isolates out of 83 was studied for chitinase gene characteristics by PCR amplification followed by direct sequencing of amplicon. Sequence homology study using entire GenBank database by BLASTN search revealed 10 isolates as 78 to 80% identical to chiA gene from Paenibacillus sp. FPU7 (Accession no. AB683959). Two isolates (UKCH17 and UKCH77) showed 99% identity to a variety of B. licheniformis chitinases and with variable identity (88 to 95%) to other Bacillus species (B. paralicheniformis, B. circulans, B. pumilus, B. subtilis etc) chitinases. Interestingly, three isolates (UKCH19, UKCH20 and UKCH44) showed 89 to 90% similarity with B. circulans chitinase (Table 4.4). Multiple sequence alignment of obtained nucleotide sequences showed 40 and 16 single nucleotide polymorphisms (SNPs) in paenibacillus (UKCH19, UKCH20 and UKCH44) and circulans

<table>
<thead>
<tr>
<th>Isolate</th>
<th>NCBI accession number</th>
<th>BLAST similarity</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Identity (%)</td>
<td>Accession No</td>
</tr>
<tr>
<td>UKCH17</td>
<td>KX235873</td>
<td>99</td>
<td>CP014781</td>
</tr>
<tr>
<td>UKCH19</td>
<td>KX446921</td>
<td>90</td>
<td>M57601</td>
</tr>
<tr>
<td>UKCH20</td>
<td>KX446922</td>
<td>89</td>
<td>M57601</td>
</tr>
<tr>
<td>UKCH21</td>
<td>KX446923</td>
<td>79</td>
<td>AB683959</td>
</tr>
<tr>
<td>UKCH39</td>
<td>KX446924</td>
<td>79</td>
<td>AB683959</td>
</tr>
<tr>
<td>UKCH42</td>
<td>KX446925</td>
<td>79</td>
<td>AB683959</td>
</tr>
<tr>
<td>UKCH44</td>
<td>KX446926</td>
<td>90</td>
<td>M57601</td>
</tr>
<tr>
<td>UKCH47</td>
<td>KX446927</td>
<td>80</td>
<td>AB683959</td>
</tr>
<tr>
<td>UKCH56</td>
<td>KX446928</td>
<td>80</td>
<td>AB683959</td>
</tr>
<tr>
<td>UKCH59</td>
<td>KX446929</td>
<td>79</td>
<td>AB683959</td>
</tr>
<tr>
<td>UKCH60</td>
<td>KX446930</td>
<td>79</td>
<td>AB683959</td>
</tr>
<tr>
<td>UKCH66</td>
<td>KX446931</td>
<td>78</td>
<td>AB683959</td>
</tr>
<tr>
<td>UKCH68</td>
<td>KX446932</td>
<td>80</td>
<td>AB683959</td>
</tr>
<tr>
<td>UKCH77</td>
<td>KX446933</td>
<td>99</td>
<td>CP014781</td>
</tr>
</tbody>
</table>

Table 4.4. Details of chitinase gene fragments sequenced from chitinolytic Bacillus of Uttarakhand Himalayas
(Annexure 5) grouped chitinases, respectively. The *licheniformis* sequences (UKCH17 and UKCH77) were identical. Multiple sequence alignment of deduced primary structure (approximately 120 amino acids) showed 8 conserved, 19 semiconserved, 22 non-conserved amino acids substitutions (Fig. 4.6) between all 15 sequences covering the three groups. The *circulans* group reported only one semi-conserved amino acid substitution (A to S) despite of observed 16 SNPs, whereas, the *Paenibacillus* group reported 2 conserved (especially in UKCH68), 8 semiconserved and one non-conserved substitution.

UKCH77 and UKCH17 were *licheniformis* group; UKCH19, UKCH20, UKCH44 were *circulans* group; remaining sequences were *Paenibacillus* group. The amino acid substitutions in each group were highlighted.

*: and indicates conserved, semi conserved and unconserved amino acid residues, respectively.

**Fig. 4.6.** Multiple sequence alignment of deduced amino acid sequences of partial chi gene from chitinolytic *Bacillus* of Uttarakhand Himalayas

### Bioactivity of chitinolytic *Bacillus* against *Plutella xylostella*

A preliminary bioassay screening of all the chitinolytic *Bacillus* against *P. xylostella* led to identification of eight bioactive isolates based on mortality and growth reduction of the test insect. Further bioefficacy testing of these identified isolates against *H. armigera* revealed poor mortality except at higher concentrations. Despite this poor mortality, a significant growth reduction was observed when evaluated at three different concentrations. Among the eight studied isolates, only three isolates (UKCH27, UKCH29 and UKCH77) showed a sizeable reduction in weight of larvae even at the lowest concentration (10^2 cfu/mL) tested (Table 4.5). However, the effect was not much dependent on dosage although a nominal variation was observed.

**Table 4.5. Mortality and growth reduction of *H. armigera* by selected chitinolytic *Bacillus* of Uttarakhand Himalayas**

<table>
<thead>
<tr>
<th>Isolate</th>
<th>Mortality (%)</th>
<th>Percent growth reduction at different dilution (cfu/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10^8</td>
<td>10^6</td>
</tr>
<tr>
<td>UKCH3</td>
<td>71.3</td>
<td>82.5bc</td>
</tr>
<tr>
<td>UKCH11</td>
<td>82.3</td>
<td>72.3^d</td>
</tr>
<tr>
<td>UKCH27</td>
<td>92.5</td>
<td>84.6^c</td>
</tr>
<tr>
<td>UKCH29</td>
<td>91.2</td>
<td>90.2^a</td>
</tr>
<tr>
<td>UKCH58</td>
<td>61.3</td>
<td>78.7^cd</td>
</tr>
<tr>
<td>UKCH77</td>
<td>88.2</td>
<td>82.9^bc</td>
</tr>
<tr>
<td>UKCH80</td>
<td>75.5</td>
<td>63.3^e</td>
</tr>
<tr>
<td>UKCH83</td>
<td>45.3</td>
<td>72.6^d</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>ND</td>
<td>4.53</td>
</tr>
</tbody>
</table>

Three potent isolates were selected to test the synergistic potential with Cry toxins of *B. thuringiensis* strain HD-1. An initial bioefficacy of HD1 Cry toxins against *H. armigera* and *P. brassicae* revealed LC<sub>30</sub> of 0.15 and 0.6 µg/mL, respectively. These LC<sub>30</sub> values were tested in combination with the selected isolates at two different concentrations. The results showed a soaring increase in mortality of both the test insects. Especially, *P. xylostella* was found to be highly susceptible to the mixtures of chitinolytic bacteria and Cry toxins with cent percent mortality even at the lowest concentration combinations. *Helicoverpa armigera* was also found to be highly susceptible to the mixture as indicated by elevated mortality range of 85 to 97% (Table 4.6).
Table 4.6. Synergistic potential of potent chitinolytic *Bacillus* with *B. thuringiensis* strain HD-1

<table>
<thead>
<tr>
<th>Combination</th>
<th>Mortality (%)</th>
<th>Pod borer, <em>Helicoverpa armigera</em></th>
<th>Diamondback moth, <em>Plutella xylostella</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>UKCH27</td>
<td>UKCH29</td>
</tr>
<tr>
<td>$LC_{30}+10^2$</td>
<td></td>
<td>85.4</td>
<td>88.8</td>
</tr>
<tr>
<td>$LC_{30}+10^3$</td>
<td></td>
<td>92</td>
<td>97</td>
</tr>
</tbody>
</table>
5. Socio-Economic Studies, Transfer of Technology and Information Technology

**Research Projects**

- Study of Socio-Economic Aspects of Hill Farming and Extension Methods [*Drs. Nirmal Chandra, Renu Jethi and Kushagra Joshi*]

- Assessment of Drudgery Prone Activities and Nutritional Status of Hill Farm Women [*Drs. Renu Jethi, Nirmal Chandra and Kushagra Joshi*]
5. Socio-Economic Studies, Transfer of Technology and Information Technology

Socio-economic survey and analysis is an important aspect of any developmental activity. Analysis of socio-economic conditions is not only the basis of successful transfer of technologies but also provides inputs for refinement of research activities to develop economically viable and farmer friendly agrotechnologies.

5.1. Socio-Economic Issues of Hill Farming and Extension Methods

Outmigration from hilly regions of Uttarakhand

Migration has been the major problem in the hilly regions of Uttarakhand. According to the census of 2011, out of 16,793 villages of Uttarakhand, about 1,053 (6.27%) have no inhabitants. The pattern of migration was studied by collecting data from 200 farmers representing ten blocks of Almora district of Uttarakhand (ten household per block) through a pre-structured interview schedule. Three types of migrants were considered in the study i.e, short term migrants, the long-term migrants and permanent migrants. Persons migrating for less than nine months during the last one-year are considered as short-term migrants. Persons migrating for a total of nine months and more during the last one-year have been considered as long-term migrant. Permanent migrants are those persons who have earlier been member/ members of a village household but have permanently settled elsewhere along with their family. Out of the ten blocks, highest migration was observed in Chaukhutiya followed by Dwarahat (Fig. 5.1).

Trends of permanent migration and short-term migration were in opposite direction with respect to the land size (Fig. 5.2). People with high land holdings tend to migrate for long term whereas small holding farmers migrate for short period.

The study also revealed that almost half of the surveyed households in the ten blocks migrated due to the lack of local employment opportunity (Fig. 5.3), which was followed by lack of proper medical facility. A total of 16% migrations are due to job transfers or getting different jobs. The attraction to cities due to hardships of village life in hills such as poor road connectivity, lack
of water, inadequate medical facilities, poor educational facilities and inaccessible markets further accelerated the process of migration, especially of the youth.

**Value chain analysis of vegetables**

Ramgarh block of Nainital district have its unique existence for high production of fruit and vegetable crops. But lot of bottle necks across the supply chain led to poor price realization of growers on one hand and exorbitant prices paid by consumers on the other. The major chunk of consumer price goes to market intermediaries who exploit the farmers due to poor market linkages, virtually non-existence of cold chain infrastructure and processing facilities. A study was carried out to analyze the vegetable value chains in Ramgarh Block. The existing supply chain (Fig. 5.4) showing the movement of vegetables is depicted below.

![Fig. 5.4. Existing vegetable supply chain in Ramgarh Block](image)

The activities involved in the value chain process are divided into three categories viz., value added activities, non-value added activities and necessary non-value added activities. Value added activities are those activities for which customers are willing to pay. Necessary but non-value-added activities are those which are necessary for supply chain but do not add value to the product. Table 5.1 shows different activities identified in the existing vegetable value chain in the study area. Out of total 18 major activities observed in the vegetable value chain, harvesting of vegetables and cleaning were the only two value adding activities and there were five necessaries non-value adding activities and eleven non-value adding activities, which could be avoided.

**Table 5.1. Various value adding, non-value adding and necessary non-value adding activities of vegetable value chain**

| Activities between farmer and local wholesaler | Value adding activity: 2 | 1. Collecting vegetable  
2. Cleaning |
| Non-value adding activity: 3 | 1. Holding  
2. Packaging  
3. Loading/unloading |
| Necessary non-value adding activity: 1 | 1. Transportation to local market |
| Activities between local traders to traders at mandi | Non-value adding activity: 3 | 1. Loading  
2. Unloading  
3. Holding |
| Necessary non-value adding activity: 1 | 1. Transportation |
| Activities between wholesaler to retailer | Non-value adding activity: 3 | 1. Loading  
2. Unloading  
3. Intermediate holding |
| Necessary non-value adding activity: 1 | 1. Transportation |
| Activities between Retailers to customer | Non-value adding activity: 2 | 1. Holding at Retailer  
2. Unloading |
| Necessary non-value adding activity: 2 | 1. Transportation  
2. Cleaning |

**Motivating factors for growing vegetable crops:** To know the preference of farmers for various motivating factor at the grass root level, questions were included as opinion survey in the questionnaire. It was found that the good price followed by favourable climatic conditions were the most important motivational factors for vegetable growing (Fig. 5.5). On the other hand, low cultivation cost and easy availability
of seeds were the factors which influence the least. In a nutshell, profitability of the crop (good price) is the most important factor for motivating farmers in crop production. This is possible by creating marketing facilities and reducing the not necessary and non-value adding activities in the supply chain.

Application of ICT in blast disease management of rice

The impact of ICT enabled extension services to improve rice productivity was studied by addressing the most important disease of rice i.e., rice blast using mobile services. A total of 100 farmers were selected from Binta and Basulisera group of villages. Advisories were sent to farmers as and when needed through mKisan SMS portal. Disease was reported by the farmers through mobile calls (32 calls) and WhatsApp (6 picture messages) messages and management measures were sent back through the same channel. Trainings were conducted to create awareness and demonstrations made for disease management.

Production data collected from the farmers of these two villages showed that the productivity of three main rice varieties grown in the area had increased by 10, 7.2 and 6.4%, respectively (Table 5.2) due to the ICT based extension activities.

### Table 5.2. Increase in production and productivity of rice after ICT intervention.

<table>
<thead>
<tr>
<th>Rice variety</th>
<th>Average yield before intervention (2016) (q/ ha)</th>
<th>Average yield after intervention (2017) (q/ ha)</th>
<th>Increase in productivity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lal Dhan (local)</td>
<td>22</td>
<td>24.2</td>
<td>10</td>
</tr>
<tr>
<td>Vivek Dhan 85</td>
<td>25</td>
<td>27.5</td>
<td>7.2</td>
</tr>
<tr>
<td>Vivek Dhan 62</td>
<td>27.5</td>
<td>30.25</td>
<td>6.4</td>
</tr>
</tbody>
</table>

5.2. Assessment of drudgery prone activities and nutritional status of hill farm women

Assessment of occupational health hazards in vegetable cultivation

Occupational health hazards refer to the potential risks to the health and safety of those who work in agriculture sector. Hazards due to agricultural work could be the direct cause of a disease, a contributing cause, or an aggravating factor in the onset of chronic diseases. Agriculture,
being an unorganized sector, such incidences often remains unreported and lack appropriate medical surveillance. A study was carried out as an attempt to assess the prevalence of occupational health hazards experienced by hill farmwomen. Perceived occupational health hazards in carrying out different activities in vegetable cultivation were examined for 120 hill farm women. To explore the extent of occurrence of health hazards, opinion of the respondents regarding their occurrence in different agricultural operations in vegetable cultivation has been taken in the form of frequently, sometimes and rarely. Based on self-reported responses, hazard score was calculated for identifying the most hazard prone activity using following formula:

\[
\text{Score attained by respondents} \times 100 \frac{\text{Hazard score}}{\text{Maximum attainable score}}
\]

Knowledge level of farm women on nutritional security

To understand the knowledge level of farm women on nutritional security, a total of 65 farm women from three blocks (Kafligair, Jageshwar and Lamgara) were surveyed with a structured questionnaire. It was found that 69% of the women had medium level of knowledge on food security. They had medium level of knowledge on preservation of nutrients (MPS 53), nutritional deficiencies (MPS 51) and source of nutrients (MPS 47).

Consumption of carbohydrates and protein rich food by hill farm women

Consumption of carbohydrates and protein rich food by hill farm women in winters was studied using structured interview schedule and focused group discussions (FGD). It was found that majority of women were receiving carbohydrate and protein from daily diet that consists of cereals and pulses. Pulses are major source of protein but majority of women (64.6%) consumed pulses only twice or thrice a week (Table 5.3) whereas as per RDA given by ICMR, 2010, daily requirement of pulses by women is 60 g/day. Animal protein is consumed by a few farm women.
Table 5.3. Consumption of carbohydrates and protein rich food by farm women

<table>
<thead>
<tr>
<th>Food Groups</th>
<th>Respondents (%)</th>
<th>Daily</th>
<th>Twice/Thrice a week</th>
<th>Once in a week</th>
<th>Rarely</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td></td>
<td>58.1</td>
<td>16.9</td>
<td>0.0</td>
<td>5.4</td>
<td>19.6</td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
<td>100.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Rice</td>
<td></td>
<td>87.7</td>
<td>12.3</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Finger millet</td>
<td></td>
<td>44.6</td>
<td>55.4</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Maize</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Pulses</td>
<td></td>
<td>35.4</td>
<td>64.6</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Meat/Fish</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td>1.5</td>
<td>26.2</td>
<td>72.3</td>
</tr>
<tr>
<td>Eggs</td>
<td></td>
<td>0.0</td>
<td>1.5</td>
<td>6.2</td>
<td>15.4</td>
<td>76.9</td>
</tr>
</tbody>
</table>

Consumption of micro nutrients rich food by hill farm women

Food groups like vegetables, milk and milk products are the major source of micro nutrients for farm women. But majority of the women (86%) consume milk and milk products in the form of tea (Table 5.4). About 83% of women are consuming roots and tubers, which are also good source of carbohydrates and micro nutrients. Food groups like meat products and eggs, which are rich source of micro-nutrients are consumed by only 1.5 and 6.2% farm women, respectively on once in a week basis.

Table 5.4. Consumption of micro nutrient rich food by hill farm women

<table>
<thead>
<tr>
<th>Food Groups</th>
<th>Respondents (%)</th>
<th>Daily</th>
<th>Twice/thrice a week</th>
<th>Once in a week</th>
<th>Rarely</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetables</td>
<td></td>
<td>27.7</td>
<td>34.0</td>
<td>31</td>
<td>7.3</td>
<td>0.0</td>
</tr>
<tr>
<td>Roots &amp; Tubers</td>
<td></td>
<td>83.1</td>
<td>16.9</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Green leafy vegetables</td>
<td></td>
<td>0.0</td>
<td>43.1</td>
<td>35.4</td>
<td>21.5</td>
<td>0.0</td>
</tr>
<tr>
<td>Other vegetables</td>
<td></td>
<td>0.0</td>
<td>41.5</td>
<td>58.5</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Fruits</td>
<td></td>
<td>0.0</td>
<td>15.4</td>
<td>46.2</td>
<td>38.4</td>
<td>0.0</td>
</tr>
<tr>
<td>Meat/Fish</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td>1.5</td>
<td>26.2</td>
<td>72.3</td>
</tr>
<tr>
<td>Eggs</td>
<td></td>
<td>0.0</td>
<td>1.5</td>
<td>6.2</td>
<td>15.4</td>
<td>76.9</td>
</tr>
<tr>
<td>Milk &amp; Milk products</td>
<td></td>
<td>58.1</td>
<td>17.0</td>
<td>0.0</td>
<td>5.4</td>
<td>19.6</td>
</tr>
<tr>
<td>Milk</td>
<td></td>
<td>18.5</td>
<td>13.8</td>
<td>9.2</td>
<td>40</td>
<td>18.5</td>
</tr>
<tr>
<td>Tea</td>
<td></td>
<td>86.1</td>
<td>0.0</td>
<td>0.0</td>
<td>6.2</td>
<td>7.7</td>
</tr>
</tbody>
</table>

Gender difference in knowledge on vegetable cultivation practices

A study was conducted to investigate gender difference in knowledge level on vegetable cultivation practices. Total 51 farmers and 29
farm women engaged in vegetable production from adopted villages were selected and studied. A significant gender difference was observed in knowledge level on vegetable cultivation practices (Table 5.5). Farm women had lowest knowledge in practices like pest management (MPS: 11.72) and application of fertilizers/manure (MPS: 18.9). This study inferred that the highest training need is required in pest management practices followed by application of manures and fertilizers.

**Gender differences in the level of participation in vegetable farming**

It was found that application of pesticides and marketing of produce is male dominated activities in vegetable cultivation. Weeding and application of manure/fertilizer are jointly performed but female dominated activities. Application of pesticides and marketing of produce are mainly a male dominated activity (Fig. 5.8).

<table>
<thead>
<tr>
<th>Vegetable Cultivation Practices</th>
<th>Farmers</th>
<th>Farm women</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursery raising</td>
<td>72.5</td>
<td>53.4</td>
<td>3.094**</td>
</tr>
<tr>
<td>Improved varieties</td>
<td>94.1</td>
<td>27.6</td>
<td>8.607**</td>
</tr>
<tr>
<td>Application of manures and fertilizers</td>
<td>59.8</td>
<td>18.9</td>
<td>5.583**</td>
</tr>
<tr>
<td>Seed rate</td>
<td>86.2</td>
<td>25.9</td>
<td>7.939**</td>
</tr>
<tr>
<td>Agronomic practices</td>
<td>82.3</td>
<td>43.1</td>
<td>3.651**</td>
</tr>
<tr>
<td>Pest management</td>
<td>69.4</td>
<td>11.72</td>
<td>12.266**</td>
</tr>
<tr>
<td>Irrigation</td>
<td>43.1</td>
<td>44.8</td>
<td>0.145 NS</td>
</tr>
</tbody>
</table>

MPS: Mean Percent Score; P< 0.01; NS – Non-Significant

Fig. 5.8. Participation of men and women farmers in vegetable cultivation
6. Other Research Projects

6.1. ICAR-NAIF funded Project
- Genetic transformation and development of elite transgenic maize (*Zea mays* L.) for biotic and abiotic stresses tolerance (*Mr. Rakesh Bhowmick up to Jan. 2018, Drs. A. Pattanayak and J. Stanley*)

6.2. Consortium Research Platform (CRP) Projects
- ICAR-CRP on Biofortification in Selected Crops for Nutritional Security (*Drs. R.K. Khulbe, R.S. Pal & Mr. Rakesh Bhowmick up to Jan. 2018*)
- ICAR-CRP on Molecular Breeding in Maize (*Drs. R.K. Khulbe, R.S. Pal, Rajasekara H. & Mr. Rakesh Bhowmick up to Jan. 2018*)
- CRP on agrobiodiversity, PGR management, Component II – Wheat (*Dr. Raghu B.R. up to June 2017*)
- CRP on Molecular Breeding Wheat (*Drs. Lakshmi Kant, K.K. Mishra, Raghu B.R. up to June 2017 and Mr. Rakesh Bhowmick up to Jan. 2018*)

6.3. DUS Project
- DUS/GOT trials in kidney bean (*Dr. Anuradha Bhartiya*)

6.4. AICRP/Network projects
- Post Harvest Technology for Value Addition and Marketing of Agricultural Produce (*Drs. Sher Singh, Er. Shyam Nath, Jitendra Kumar (w.e.f., April 15, 2017) and Kushagra Joshi*)
- Use of Plastics in Agriculture Particularly in Protected Cultivation, Water Harvesting and Packaging (*Drs. Sher Singh, Er. Shyam Nath and Jitendra Kumar (w.e.f., April 15, 2017),*)
- All India Network Project on Soil Arthropod Pests (*Drs. J. Stanley and A.R.N.S. Subbanna*)

6.5. AMAAS Projects
- Bioprospecting for Microbial Products that Effects Cold Alleviation and Growth (*Dr. Pankaj K. Mishra*)

6.6. ICAR-FCI Sponsored Project
- Study on Determining Storage Losses of Food Grains in FCI and CWC Warehouses and to Recommend Norms for Storage Losses in Efficient Warehouse Management (*Dr. Sher Singh*)
6.7. NMHS Project
- Identification, Assessment and Enhancement of Soil Carbon and Nitrogen Sequestration Potential of Different Ecosystems in the Central Himalayan through a Community Participatory Approach (Drs. V.S. Meena, B.M. Pandey, A. Mukherjee, T. Mondal (upto August 2017), R.P. Yadav, N.K. Singh, H.C. Joshi, P. Nautiyal and G. Papnai)

6.8. NMSHE Project

6.9. DST Funded SERB Young Scientist Project
- Habitat Management for Non-Apis Bee Pollinator Conservation (Dr. J. Stanley)

6.10. NABARD Funded Project
- Formation and Promotion of Farmers’ Producer Organization (Dr. Renu Jethi)

6.11. DAC Funded Project through ICAR-NCIPM
- Efficacy of phosphine fumigant against storage pests of pulses, wheat, rice and coffee beans; and residue analysis for quarantine and long-term storage purpose (Dr. J. Stanley)

- Production of quality seed and planting materials for long day onion and garlic for large scale demonstration at farmer field on cluster basis (Drs. N.K. Hedau & G.V. Choudhari)
- Production of quality seed (Planting material) of improved varieties of potato (Drs. G.V. Choudhari & N.K. Hedau)

6.13. HATS, Mukteshwar
- High Altitude Testing Site, Mukteshwar (Drs. N.K. Hedau & Sher Singh)
6.1. NAIF Funded Project

6.1.1. Transformation of Maize for Herbicide Tolerance and Insect Resistance

Approximately 1500 callus have been transformed with codon optimized Cry1Ac gene construct by biolistic method. After 15 days, a total of 1500 bombarded calli were transferred to regeneration medium to obtain complete seedlings. Three hundred regenerated seedlings were transferred to greenhouse for hardening and then transferred to large pot (25cm dia.). Out of 300 plants, 56 were found positive in PCR by gene specific primer. However, no plant was found to produce protein in Cry1Ac specific strip test. To overcome problem of expression, modified Cry1Ac construct (pCAMB1AC) was used to transform 2000 callus by Agrobacterium-mediated method. It was found that transformed calli were able to produce Cry1Ac proteins. For herbicide resistance, 300 calli were bombarded with gene editing construct of CRISPR/Cas9 along with EPSPS sgRNA. Sixty-seven plants have been regenerated but failed to find any positive plant for cas9 gene.

6.2. Consortium Research Platform (CRP) Projects

6.2.1. ICAR-CRP on Biofortification in Selected Crops for Nutritional Security

The F1 populations of five crosses between elite QPM lines (VQL 1, VQL 2, VQL 17, VQL 373 and SA-12-1) and low phytate donor (LPA 2) were raised at Almora during kharif 2017. Foreground selection and biochemical evaluation for high tryptophan and low phytate was carried out using trait-specific markers and agronomically superior individuals (high vigour, good cob size, tolerance/resistance to turcicum leaf blight) carrying the desired trait combination [high tryptophan (>0.6%) + low phytate (<8 mg/g)] were selected for further advancement. The number of plants selected for advancement is as given in Table 6.1.

<table>
<thead>
<tr>
<th>Cross</th>
<th>Target trait</th>
<th>Homozygous</th>
<th>Heterozygous</th>
</tr>
</thead>
<tbody>
<tr>
<td>V 407/VQL 373</td>
<td>High tryptophan</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>V 390/CML 173</td>
<td>High tryptophan</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>V 412/CIMMYT 13</td>
<td>High provitamin A</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>V 400/CIMMYT 4</td>
<td>High provitamin A</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>V 409/LPA 2</td>
<td>Low phytate</td>
<td>11</td>
<td>Nil</td>
</tr>
</tbody>
</table>

In case of V 407/LPA 2, individual plants with recurrent parent phenotype were biochemically screened for phytate content and 16 plants with phytic acid content of <8 mg/g were selected for further advancement.

Sixty-seven maize inbred lines were artificially screened with an isolate from Ranchi for identifying resistant source to banded leaf and sheath blight disease. The pathogen (Rhizoctonia solani) was inoculated to 30 days old seedlings with help of mycelium and sclerotia, and proper
humidity was maintained by spraying water at regular intervals. Symptom development was observed and disease scoring was done based on 0-5 disease rating scale. Based on two replication data, tolerant lines viz., V 351, V 402, V 431, V 440, VSL 27 and CM 141 were identified.

6.2.3. CRP on Agrobiodiversity, PGR Management, Component II – Wheat

Altogether, 551 wheat accessions were inoculated for loose smut during 2015-16 and sown in expression nursery. Out of these 551 accessions, 120 lines were found free (0.0% infection) and 47 found resistant (0.1 to 5.0% infection) to loose smut. Powdery mildew was also recorded in these accessions and 259 were found resistant to powdery mildew (Avg score 0-3). Another set of 700 new accessions were inoculated during rabi 2016-17.

6.2.4. CRP on Molecular Breeding Wheat

Two popular wheat varieties viz., VL Gehun 907 (timely sown conditions) and VL Gehun 892 (late sown condition) had started showing susceptibility to the new races of yellow rust pathogen and were selected to pyramid durable rust resistance genes viz., Yr10 and Lr 24. During rabi 2016-17, BC2F1s [(VL Gehun 892/ Yr10/5*Datatine // VL Gehun 892) (204 plants), (VL Gehun 892/ FLW1 // VL Gehun 892) (228 plants), (VL Gehun 907/ Yr10/5*Datatine // VL Gehun 907) (536 plants) and (VL Gehun 907/ FLW 1 // VL Gehun 907) (580 plants)] were planted. The foreground markers XPSP 3000 and SR24#12 linked to the yellow rust resistance genes Yr10 and leaf rust resistance gene Lr24, respectively were used for foreground selection. After foreground selection, background selection was done with around 90 markers. The foreground positive plants with more than 90% background recovery and agronomic suitability were selected in BC3F1 generation for attempting backcrosses with recurrent parents to generate BC2F1s (around 1000 seeds).

During off-season of 2017, BC2F1s (VL Gehun 892/ Yr10/5*Datatine // VL Gehun 892 - 122 plants), (VL Gehun 892 / FLW1 // VL Gehun 892 - 144 plants), (VL Gehun 907 / Yr10/5*Datatine // VL Gehun 907 - 298 plants) and (VL Gehun 907/ FLW1 // VL Gehun 907 - 160 plants) were planted at Dalang Maidan, Lahaul Spiti, Himachal Pradesh. Leaf samples were collected, DNA extraction was done, and foreground selection was carried out with the
above-mentioned markers. Background selection was carried out with 90 markers. The foreground positive plants with more than 90% background recovery and agronomic suitability were selected in BC\textsubscript{2}F\textsubscript{1} generation for attempting backcrosses with recurrent parents to generate BC\textsubscript{3}F\textsubscript{2} and around 750 to 3000 seeds were produced. These were planted during rabi 2017-18 for intercrossing for pyramiding of \textit{Yr}10 and \textit{Lr}24 genes.

### 6.3. DUS/GOT Trials in Kidney Bean

Six farmers’ varieties \textit{viz}., Reg/2016/1717, Reg/2013/2010, Reg/2016/907, Reg/2016/906, Reg/2016/985 & Reg/2016/905 along with three reference varieties \textit{viz}., IPR-98-5, IPR 98-3-1 & IPR 96-4 were raised for grow out test and characterized for 22 DUS traits as per national guidelines to conduct the test for DUS on kidney bean.

### 6.4. All India Coordinated Research Projects (AICRP)/ Network Projects

#### 6.4.1. Post Harvest Technology for Value Addition and Marketing of Agricultural Produce (AICRP on PHET)

**Design, development and evaluation of pedal operated chaff cutter suitable for hilly areas**

Keeping in view of the acute shortage of quality green fodder during winter months, wastage of fodder and straw resulting from direct feeding and cost of electric operated cutter, a pedal operated chaff cutter suitable for hills has been developed. In this machine, it is easy to feed the straw/fodder in the hopper by the same person who is running the machine, while in conventional
chaff cutter two persons are required. The output capacity of the machine is about 170 kg/hr for green fodder and 29.4 kg/hr for dry fodder. The machine has 39.2% higher RPM than conventional manual hand operated chaff cutter with 18.1% higher output capacity. However, in pedal operated chaff cutter the heart rate was slightly higher (9.1%) than the conventional manual hand operated, which was mainly because, the test subjects were not habitual cycle riders.

6.4.2. Use of Plastics in Agriculture Particularly in Protected Cultivation, Water Harvesting and Packaging

Enhancing energy use efficiency of vegetable-based cropping system under protected condition

In vegetable-based cropping system, yield of capsicum, green onion and tomato crop under polyhouse conditions were 218, 36 and 192% higher respectively than open field conditions (196, 229 and 83 kg/100 m², respectively). Polyhouse conditions provided 1.4 to 7.2 and 1.2 to 2.7 times better net energy return and energy productivity than open conditions, respectively. However, open conditions recorded 1.2 to 3.0 times better specific energy than polyhouse conditions in all the three crops.
Development and evaluation of polyhouse covered polytank for fish rearing in high hills of Uttarakhand

The growth trend of advanced fingerlings of exotic carp and minor carp stocked in polytanks showed better growth of grass carp and improved strain of common carp in all ponds. The average growth was observed in the range of 270 to 600 g with highest growth in polytank without any covering material on the polyfilm but having bottom sand bed of 75-100 mm and the whole polytank covered with polyhouse. Species wise maximum growth was recorded in grass carp and improved common carp. Growth of the minor carp was also encouraging with the advantage of cleaning of the excess periphyton. Comparatively better growth and survival was recorded in polythene covered polytanks due to the advantage of increase in temperature. The water temperature during different months in the polytanks covered with polyhouse was about 1.59 to 4.70 °C higher than open polytanks at 0712 hrs (morning) while it was 0.88 to 4.37°C higher at 1412 hrs (Afternoon). After snowfall, there was an icy layer in open polytanks while there was no icy layer in polytanks covered with polyhouse.

Development of plastic mulch laying roller and laying techniques suitable for hills

To overcome the problem of movement of 8 hp prime mover mounted mulch laying roller from one terrace/field to the other terrace, a manual light weight mulch roller was fabricated and tested. Only two labours (draft of 32.2 kg) were required for operating the machine and the machine performed multiple operations in a single run. The effective area of standard width (1.2 m) plastic mulch after laying varied from 0.90 to 0.95 m. Plastic mulch of less than 1.2 m width can also be laid with the adjustable nature of frame as per the need of farmer. It also marks (puch) small holes on the laid plastic mulch and the marking can be done as per spacing (row to row and plant to plant) required for a crop. Facility of laying inline drip pipe/tape beneath the plastic mulch has also been provided in the machine. The theoretical field capacity of the machine is 0.29 ha/h. Actual field capacity of the machine is 0.059 ha/h which is almost 10 times faster than manual laying. Therefore, the field efficiency is 20.3 percent.

6.4.3. All India Network Project on Soil Arthropod Pests

Population monitoring of scarabs in host trees

The whitegrub beetles, *Brahmina* sp. was found more in *Bauhinia* sp. whereas the *Holotrichia longipennis* in *Sapium sebiferum* and *Sophrops* sp. in *Carya illinoensis*. *Anomala bengalensis* is found to get congregated only on *Ligustrum nepalensis*.

*Bacillus thuringiensis* on white grubs

Out of six native cry8 positive *Bacillus thuringiensis* isolates at the concentration of 1 µg/10 g soil evaluated for toxicity of 1st and 2nd instar *Anomala dimidiata* grubs, VLS 64-3 and VLS 64-6 were found promising.
**Phylogenetic studies of different species of genus Anomala**

Partial gene sequences of two mitochondrial genes viz., cytochrome oxidase I (COI) and cytochrome b were done. The COI sequence of *A. dimidiata* was compared with 12 different species of genus Anomala. *Anomala dimidiata* is found evolutionarily associated with *A. xanthoptera*.

**Production of entomopathogen, Bacillus cereus WGPSB2**

The white grub entomopathogen, *B. cereus* WGPSB2 is produced upto 66 kg in talc formulation (@ 10¹⁰ spores/g of talc) and about 124 kg was used for demonstrations on white grub management.

**Population mapping of white grubs in Uttarakhand hills**

Population mapping of white grub species in Uttarakhand hills was done and 55 species of white grubs were recorded in Almora district. Uttarkashi, Tehri Garhwal, Chamoli and Bageshwar districts recorded 36, 10, 27 and 8 species respectively. *Anomala lineatopennis*, *H. longipennis*, *Brahmina* sp., *Xylotrupes* sp. and *Copris* sp. are common in all the 5 districts studied. *Dichelomorpha alsiosia* is found only in Tehri Garhwal.

### 6.4.4. Network Project on Organic Farming (NPOF)

**Evaluation of farm waste recycling techniques for organic farming**

**Table 6.2. Properties of composts from farm waste**

<table>
<thead>
<tr>
<th>Treatment details</th>
<th>Weight of waste before composting (kg)</th>
<th>Compost yield (kg)</th>
<th>C (%)</th>
<th>N (%)</th>
<th>P (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (CR:CDS*) = 4:1</td>
<td>30</td>
<td>52.3</td>
<td>28.2</td>
<td>1.05</td>
<td>0.30</td>
</tr>
<tr>
<td>Vermicompost (CR:CDS = 4:1)</td>
<td>30</td>
<td>54.9</td>
<td>29.9</td>
<td>1.70</td>
<td>0.35</td>
</tr>
<tr>
<td>Vermicompost (CR:CDS:LR = 3:1:1)</td>
<td>30</td>
<td>53.2</td>
<td>30.2</td>
<td>2.15</td>
<td>0.39</td>
</tr>
<tr>
<td>CR:CDS = 4:1 + <em>Pleurotos sajorcaju</em> + <em>Trichoderma harzianum</em></td>
<td>30</td>
<td>52.0</td>
<td>30.7</td>
<td>2.08</td>
<td>0.37</td>
</tr>
<tr>
<td>CR:CDS:LR = 3:1:1 + <em>P. sajorcaju</em> + <em>T. harzianum</em></td>
<td>30</td>
<td>48.7</td>
<td>31.7</td>
<td>2.34</td>
<td>0.41</td>
</tr>
<tr>
<td>CR:CDS = 4:1 + <em>P. sajorcaju</em> + <em>T. harzianum</em> + <em>Biomineralizer + Aspergillus niger + Azotobacter spp.</em></td>
<td>30</td>
<td>49.3</td>
<td>31.5</td>
<td>2.31</td>
<td>0.39</td>
</tr>
<tr>
<td>CR:CDS:LR = 3:1:1 + <em>P. sajorcaju</em> + <em>T. harzianum</em> + <em>Biomineralizer + Aspergillus niger + Azotobacter spp.</em></td>
<td>30</td>
<td>48.0</td>
<td>32.3</td>
<td>2.46</td>
<td>0.44</td>
</tr>
</tbody>
</table>

*CR - Cereal residue; CDS - Cattle dung slurry; LR - Legume residue; *Biomineralizer = Microbial consortia of P & Zn solubilizer and PGPR
Farm wastes were composted with different proportion of raw materials and inoculation of different microbes and earthworm. The compost yield was more than the weight of waste materials in all treatments. But, vermicomposting provided the highest compost yield. The composting with *Pleurotus sajor-caju*, *Trichoderma harzianum*, *Aspergillus niger*, biomineralizer of P and Zn, *Azotobacter* and PGPR enhanced 11, 32 and 119% C, N and P compared to control, respectively. Vermicomposting enhanced 6, 19 and 61% C, N and P compared to control, respectively. Addition of legume residue enhanced the nutrient composition of composts from farm waste with different technologies (Table 6.2).

**Evaluation of organic, inorganic and integrated production systems**

Different nutrient sources were evaluated for finger millet + black soybean (2:1 ratio – substitution of row)-wheat + *toria* (2:1 ratio) and grain amaranth-wheat + lentil (2:1 ratio) under rainfed system. Among crop management systems, application of 100% N requirement of crop through organic manure and 50% N requirement of crop through organic manure + 50% N requirement through inorganic produced highest wheat equivalent grain yield of 3160 and 5509 kg/ha for finger millet + black soybean-wheat + *toria* and grain amaranth-wheat + lentil, respectively (Fig. 6.1). The highest yielding treatment recorded 122 and 67% higher wheat equivalent grain yield of finger millet + black soybean-wheat + *toria* and grain amaranth-wheat + lentil, respectively than 100% inorganic package.

**Field evaluation of botanicals and bioagents against *toria* aphids**

A field evaluation of botanicals and bio-agents was carried out during *rabi* 2016-17. Spray of botanicals and bio-agents were made at the time of peak incidence of aphids, which coincided with late flowering of the crop. The aphid infestation in panicles before the application of treatment ranged from 50 to 63% in different plots. None of the bio-agents or botanicals was found effective against *toria* aphids except *Metarrhizium anisopliae*, which gave 24% reduction in aphid infestation. Nimbicidine 3 mL/L registered a reduction of 13% and pine leaf 5% extract gave 12% reduction in aphid infestation. However, insecticide acetamiprid was found effective in managing the aphids by causing a reduction of 93% (Table 6.3).

**Table 6.3. Field testing of botanicals and bio-agents on *toria* aphids**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Percent infestation Before treatment</th>
<th>Percent infestation After treatment</th>
<th>Percent reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melia extract 5%</td>
<td>60.33</td>
<td>53.33</td>
<td>11.65 (19.35)</td>
</tr>
<tr>
<td>Artemisia leaf extract 5%</td>
<td>63.00</td>
<td>56.67</td>
<td>10.05 (18.23)</td>
</tr>
<tr>
<td>Pine leaf extract 5%</td>
<td>53.33</td>
<td>46.67</td>
<td>12.49 (20.27)</td>
</tr>
<tr>
<td>Nimbicidine 3 mL/L</td>
<td>50.00</td>
<td>43.33</td>
<td>13.34 (21.23)</td>
</tr>
<tr>
<td>Metarhizium 3 g/L</td>
<td>56.67</td>
<td>43.33</td>
<td>23.54 (28.62)</td>
</tr>
<tr>
<td>Beauveria 3 g/L</td>
<td>60.33</td>
<td>56.67</td>
<td>6.07 (14.34)</td>
</tr>
<tr>
<td>Acetamiprid 0.25 g/l</td>
<td>56.67</td>
<td>3.75</td>
<td>93.38 (74.16)</td>
</tr>
<tr>
<td>Control</td>
<td>60.00</td>
<td>63.33</td>
<td>-5.55 (13.02)</td>
</tr>
</tbody>
</table>

*Mean of 2, 4, 6 and 8 days after treatment

*Figures in the parentheses are arc sign transformed values

†Means in the same column with different letters are significantly (*P* < 0.05) different

![Fig. 6.1. Wheat equivalent grain yield of finger millet + black soybean-wheat + *toria* and grain amaranth-wheat + lentil in different crop management system (IP = Innovative practices – 3% *Panchagavya* and vermiwash)](image)
**Laboratory experiments on predatory potential of coccinellids on toria aphids**

A laboratory experiment was conducted to find out the predatory potential of different coccinellid adults i.e. *Coccinella septempunctata* and *Harmonia dimidiata*. The coccinellids fed on aphids voraciously and a single *H. dimidiata* and *C. septempunctata* fed as many as 53 and 34 aphids per day, respectively.

**Pest incidence and disease in organic production system**

During *rabi* season of 2016-17, in the organic and inorganic production system experiment, *toria* was found to be infested with aphids to a tune of 10-22%, which was found to increase up to 22-38% during the second fortnight of February. After spray with acetamiprid @ 0.3 g/L the aphid infestation reduced to 3.6 and 3.0% in 100% inorganic and 50% inorganic plots, respectively. The incidence of coccinellids was 0.6 to 1.8 per 10 panicles of *toria* irrespective of treatments, whereas the incidence of syrphid grubs was low (0.3 to 1.0 per 10 panicles). In general disease severity was low in all the crops (Table 6.4).

![Fig. 6.2. Ice nucleation activity of psychrophilic bacterial isolates](image)

### Table 6.4. Disease index in different crops under organic and inorganic production system during *rabi* 2016-17

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Wheat + toria intercropping</th>
<th>Wheat + lentil intercropping</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wheat</td>
<td>Toria</td>
</tr>
<tr>
<td></td>
<td>Yellow rust</td>
<td>Brown rust</td>
</tr>
<tr>
<td>100% Organic</td>
<td>TS</td>
<td>0</td>
</tr>
<tr>
<td>75% Organic + 3% Panchagavya + Vermiwash</td>
<td>TS</td>
<td>TS</td>
</tr>
<tr>
<td>50% Organic + 50% inorganic</td>
<td>5S</td>
<td>5S</td>
</tr>
<tr>
<td>100% Inorganic</td>
<td>10S</td>
<td>5S</td>
</tr>
</tbody>
</table>

* Scale for yellow rust and brown rust of wheat = 0-100S scale
* Scale for alternaria leaf spot and white rust of toria and wilt of lentil = 0-100%
*TS-Traces

### 6.5. Application of Microorganisms in Agriculture and Allied Sectors (AMAAS) Project

#### 6.5.1. Bioprospecting for Microbial Products that Effects Cold Alleviation and Growth

Psychrophilic bacterial isolates possessed type III ice nucleation activity (Fig. 6.2). Maximum ice nucleation activity was shown by bacterial isolates (LS11Rp1, LS17Rs12, LS18Rp3 & LS18Rs5). Out of twenty psychrophilic bacterial isolates, four isolates (LS18Rs5, F15, N2M4 and LS18Rp3) showed 97.1, 95.4, 95.1 and 90.3% freeze tolerance, respectively after 94h of
incubation at -20°C. Four psychrophilic bacterial isolates (LS18Rs5, F15, N2M4 and LS18Rp3) revealed presence to major cold shock protein (csp).

6.6. ICAR-FCI Sponsored Project

6.6.1. Study on Determining Storage Losses of Food Grains in FCI and CWC Warehouses and to Recommend Norms for Storage Losses in Efficient Warehouse Management

Samples were taken fortnightly from 4 wheat and 12 rice stacks at Food Corporation of India, Food Storage Depot, Rudrapur. The samples were analyzed for quality parameters, moisture content and 1000-grain weight. The data on temperature and relative humidity were also recorded inside and outside the chamber. Liquidation of four wheat and eight rice stacks was completed. In wheat, loss of 0.08 to 0.01% during 33 to 36 months of storage while in rice loss of 0.98 to 1.49% during 27 to 36 months of storage was recorded.

6.7. National Mission on Himalayan Studies (NMHS)

6.7.1. Identification, Assessment and Enhancement of Soil Carbon and Nitrogen Sequestration Potential of Different Ecosystems in the Central Himalayan through a Community Participatory Approach

The baseline surveys for all the three sites in low mid and high hills were completed. A total 1230 composite soil samples from three soil layers (0-15, 15-30 and 30-45 cm) has been collected from Balta, Shama and Badethi cluster along with the GPS coordinates. Baseline soil and data collection survey was conducted for the 320 farmer families. Meanwhile, 2 ha lentil crop (VL Masoor 126) and 1 ha wheat (VL 832, VL Gehun 907 and VL Gehun 963) were demonstrated. For pilot studies on long-term monitoring and soil quality, demonstration of land management practices was done at four field experimental set ups with various nutrient management practices as per approved plan (two each for wheat and lentil crop). Three awareness programmes (300 hill farm household) were conducted one each at selected site, to sensitize the soil health management.


For implementation of the project, ICAR-VPKAS, Almora selected Jur Kafun village of Hawalbagh block of Almora, where average size of land holdings is 0.32 ha and most of the farmers are either marginal (96%) or small (4%). Various climate resilient technologies were demonstrated at farmers’ field, i.e. improved varieties of different hill crops, low tunnel polyhouse for nursery raising and leafy vegetable and construction of water harvesting/conservation structures.

Two polythene lined tanks of capacity 48.49 m³, which can irrigate about 970 m² area through flood in one filling were constructed. The discharge measured in 2017 varied from 1.5 to 6.6 L/min. from the sources tapped for tank filling. The discharges of springs, which are not tapped, and flow freely were also measured. It ranged from 2 to 12 L/min. Fourteen light traps were installed and entomopathogen, Bacillus cereus WGPSB2 was used for white grub management. Besides, annual flowering plants have been introduced at the site along with flowering trees like Privet, Ligustrum sp. Four colonies of Asian honey bee, Apis cerana were introduced to demonstrate planned honey bee pollination in different crops.

In every visit, farmers were sensitized about the improved farm practices to minimize the adverse affects of climate change. Through Kisan Mela, farmers were exposed to the technologies related to effective crop production system. Two hundred eighty-nine-kilogram seed of ten crops were distributed in two seasons. The main objective was to identify climate resilient crop variety and convince farmers that by using improved seed and other input like irrigation, productivity can be increased and sustained.
**Crops and their varietal performance**

It was observed that crops like wheat, barley and lentil sown under rainfed condition, generally did not produce grain except some biomass, which was used as fodder for cattle by the farmers. Those farmers having irrigation facility irrigated their field either through tank or gul. The data revealed that wheat yield of different varieties was 10 to 35 percent lower than the potential rainfed yield and 45 to 48 percent lower than potential irrigated yield of experimental farm. The barley yield was 46 percent lower than experimental farm. In *kharif* crops, finger millet yield was lower by 12 to 36% and amaranth by 10%. The maize and rice yields were also lower by 41 to 71% and 58 to 61%, respectively than the experimental yield but soybean yield was 3 to 126 percent higher and barnyard millet yield was 26.0% higher than experimental plot yield. This suggests that there is a wide yield gap-I that needs to be bridged.

A total of 26 different species of non-Apis bees, which comprise of Megachila, Andrena, Bombus, Ceratina, Nomia, Xylocopa, Lasioglossum were identified from the region.

**Sand Bees (Andrena sp.)**

Bioecology of sand bees, *Andrena* sp was studied. They make their nest on the ground near the foraging area in the sandy soil. The nests are of few celled, single occupant and gregarious with a mean of 8.0 ± 0.9 nests in one m² area. The bees were found hovering over their nests (@ 12.2 ± 1.1 bees/m²/min.) in the early morning hours (supposed to be guarding). The foraging behavior of sand bees were studied *i.e.*, they spent about 5.4±0.6 sec in a single flower and forages 6.4 flowers in one minute. Sand bees were found to collect provisions for nest and visit nests with a time frequency of 40.9±3.8 min. They took 10.3±0.8 min. inside the nest to keep the provisions in. However, some bees took much time even more than one hour but involved in some other activities like digging/nest making and nest maintenance.

**Small Carpenter Bees (Ceratina sp.)**

Among the three Ceratina bees studied, *C. smaragdula* was found to make long nests with more number of cells (upto 13) but found to occupy the alternate cells only. The orientation of larva, pupa and preadults of *C. smaragdula* was downward towards the base of the nesting stem with the mother bee guarding at the entrance. The total nest length was estimated to be 32 cm with 10.5 and 18.2 mm cell length of occupied and vacant cells, respectively. The adults and pupa weighed about 17.5 and 19.1 mg, respectively.

6.9. DST Funded Projects

6.9.1. Habitat Management for Non-Apis Bee Pollinator Conservation (SERB YSS 00861/ 2015)
Unlike *C. smaragdula*, *Ceratina* sp. occupied all the cells and left no cells vacant in between. The average number of cells in a colony was about 6.5 cells with a cell length of 9.3 mm. The adult and pupa weighed around 13.2 and 18.3 mg, respectively. The mean weight of provision/bee bread was 31.6 mg.

**Impact of honeybee introduction on native non-Apis bees**

Honey bees (*Apis cerana* and *A. mellifera*) were introduced in toria and radish fields and impact if any, on the non-Apis bee foraging was studied. Non-Apis bee pollinators like sand bees and sweat bees were found slightly more in the non-introduced fields than in the introduced fields. The average presence of non-Apis bee was slightly more in the non-introduced fields of toria (1.06 bees/m²/min) than in the bee introduced fields (0.98 bees/m²/min). In case of radish, no difference was seen in the leaf cutter bee population in the introduced and non-introduced fields, whereas significant difference was observed in the population of sand bees. Honey bee introduced, and non-introduced radish harboured an average of 0.23 and 0.73 sand bees/m²/min., respectively. The average density of non-Apis bees in honeybee introduced and non-introduced radish fields were 0.42 and 0.92/m²/min., which reveals a competition between the native sand bees (*Andrena* sp.) and the introduced honeybees.

**Managing flora and providing nesting sites**

Floral calendar of cultivated crops, natural vegetation and trees and ornamental plants was made for throughout the year foraging of different non-Apis bees. Nesting sites with sticks of *Morus alba*, *Grewia optiva*, *Jacaranda mimosifolia*, *Lantana camara* etc of pith size of 2.8-3.8 mm were provided for nesting of three different *Ceratina* bees. Logs with holes were provided for *Megachila* bees and nest boxes for Bumble bees.

6.10. NABARD Funded Project

6.10.1. Formation and Promotion of Farmers’ Producer Organisation

Farmers’ Producer Organisation (FPO) “*Vivekananda Krishi Utapadan Swayatt Sahakari*” started collective marketing of vegetables in local markets. Membership of the FPO has reached to 96 farmers. Two *krishak gosthis* were organized for mobilizing farmers towards importance of FPO and collective marketing. One market exposure visit of farmers was organized to Haldwani mandi and Rudrapur for purchase of seeds, fertilizer and pesticides through FPO.
During the year 2017-18, FPO has earned more than seven lakh rupees (₹ 7,00,000.00) from marketing of vegetables like tomato, cabbage, cauliflower, radish, onion, brinjal, potato, ginger and cucumber. Four members of FPO have undergone training on accounting, bookkeeping and promotion of FPO. Ten quintals of potato seed (Kufri Himalini) was purchased for farmers through FPO from the institute. About 86% farmers perceived it better than the local variety and major constraints perceived by farmers for lower productivity of potato was animal damage and termite infestation.

6.11. Department of Agriculture & Cooperation (DAC) Funded through ICAR-NCIPM

6.11.1. Efficacy of Phosphine Fumigant against Storage Pests of Wheat and Residue Analysis for Quarantine and Long-Term Storage Purpose

*Sitophilus oryzae*, *Rhyzopertha dominica* and *Tribolium castaneum* were mass cultured in the laboratory. Two different parasitoids *viz.*, *Theocolax elegans* and an unidentified pteromalid parasitoid were found in the *Sitophilus* cultures. An experiment was carried out in completely randomized design with 10 treatments and three replications to study the efficacy of both the formulations of aluminium phosphide (77.5% granule and 55% tablets) at different concentrations against storage pests in the godown. Each experimental stack was of 5 MT wheat stacked in gunny bags. The stacks were sealed, and phosphine is generated through QuickPhlo® phosphine generator for the granular treatments. Test insects (*S. oryzae*, *R. dominica* and *T. castaneum*) were kept in test containers @ 10 insects per container and 12 boxes of each insect per stack, kept at top, middle and bottom layers. After the treatment, leakages if any were checked using Phosphine Alert® and the concentration was monitored by FumiSense Pro® at regular intervals. The average concentration of phosphine in 1 and 1.5g of 77.5% granule treatment was 1437.0 and 1099.5 ppm on the first day and it was reduced to 450.5 and 350.0 ppm, respectively on the seventh day. The average concentration of phosphine in the 55% tablet treatments were maximum on the third day of the treatment i.e., 1590 and 1078 ppm for 9 and 6g treatments, respectively. It was reduced to 924 and 612 ppm, respectively on the seventh day of treatment. A 100% mortality of all the insects (adults of *S. oryzae*, *R. dominica* and adults and grubs of *T. castaneum*) kept in insect test containers was recorded in all the treatments except control. No insect was found alive in any of the treatments after one month of incubation. Thus, both the formulations of phosphine are found effective in controlling storage pests in wheat.

6.12.1. Production of quality seed and planting materials of long day onion and garlic for large scale demonstration at Farmer field on cluster basis

As per the target in the project, onion bulbs were planted in 300 m² at Experimental farm, Hawalbagh and 20 kg breeder seed of VL Piaz 3, was produced. Ten kg onion seed was also distributed to farmers at Mulya village, Devprayag for production of quality seed-lings. Bulbs of the VL Piaz 3 were also planted at Mulya village as a demonstration of seed production. Bulbs of VL Lahsun 2 are also planted at HATS, Mukteshwar to get 5 q quality planting materials.

6.12.2. Production of quality seed (Planting material) of improved varieties of potato

As per the target in the project, 350 kg breeder seed of each kufri Girdhari & K. Himalini were planted in HATS, Mukteshwar in 4000 m². In the month of Sept. 2017, 25 q potato seed (Truthful levelled) have been produced of each variety. Ten q (K. Himalini) seed were used for large scale demonstration.
6.13. High Altitude Testing Site (HATS), Mukteshwar

Yield evaluation trials

**French bean**: Nineteen new genotypes (advance lines) were evaluated for their suitability to high altitude during *kharif* 2017. VLFB 1613 (122.9 q/ha) & VLFB 1615 (115.6 q/ha) were found promising during off-season cultivation in high altitude.

**Garden pea**: Fourteen new genotypes of garden pea (advance lines) were evaluated for their suitability to high altitude during off-season during *kharif* 2017. VP 1423 and VP 1511 produced 102 and 98 q/ha green pod, respectively.

Breeder seed production

**Garlic**: Breeder seed crop of VL *Lahsun* 2 (long day garlic) was sown in 1100 m² area and 5.5 q breeder seed was produced and supplied to the Institute. Five kg bulbils of VL *Lahsun* 2 were also produced from breeder seed crop.

Truthfully labelled seed

Truth full levelled seed and planting materials of following vegetable crops were also multiplied at HATS, Mukteshwar during 2017-18.

<table>
<thead>
<tr>
<th>Crop (Variety)</th>
<th>Production (q)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potato (<em>Kufri Girdhari</em>)</td>
<td>25</td>
</tr>
<tr>
<td>Potato (<em>Kufri Himalini</em>)</td>
<td>25</td>
</tr>
<tr>
<td>French bean (<em>VL Bean 2</em>)</td>
<td>0.15</td>
</tr>
<tr>
<td>Garden pea (<em>VM 12</em>)</td>
<td>0.25</td>
</tr>
</tbody>
</table>

On-going Infrastructure Development

Stepped pathway with drainage channel, brick road with drainage system inside the farm from main gate to tin shed and RCC retaining wall of water harvesting pond worth ₹ 59,99,000.00 were constructed at the farm.
DDG (Animal Science) visiting the Mukteshwar Farm

Stepped pathway with drainage channel

Brick road with drainage system

RCC retaining wall of water harvesting pond
7. Technology Assessment and Transfer
7. Technology Assessment and Transfer

The institute has one KVK at Uttarkashi and another at Bageshwar district for wider dissemination of developed technologies to the farmers of the region. Vocational training programmes are organized by KVKs for farmers and extension workers. These KVKs also serve as active link between research-extension and farmers and provide critical feedback to the ICAR-SAU Research System on one hand and extension system on the other. Front Line Demonstrations (FLDs) are conducted to demonstrate latest technology on farmers' fields & field days and training programmes are organized to acquaint farmers with the advances in the field of hill agriculture, provide answers to farmers queries and to suggest ways to enhance their income and living standards.

7.1. KVK Chinyalisaur

7.1.1. Trainings

Krishi Vigyan Kendra, Chinyalisaur, Uttarkashi conducted 61 training for 1501 participants (practicing farmers, farmwomen, and rural youths - 610 male and 891 female) (Table 7.1) on various topics like horticulture, home science, agricultural extension etc. with an objective to uplift the socio-economic status of underprivileged farmers through improvement in agriculture production and allied enterprises.

7.1. Discipline wise training programme conducted

<table>
<thead>
<tr>
<th>Discipline</th>
<th>No. of trainings</th>
<th>No. of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Horticulture</td>
<td>21</td>
<td>292</td>
</tr>
<tr>
<td>Home Science</td>
<td>22</td>
<td>101</td>
</tr>
<tr>
<td>Agricultural Extension</td>
<td>15</td>
<td>190</td>
</tr>
<tr>
<td>Sponsored Training Programme</td>
<td>4</td>
<td>27</td>
</tr>
<tr>
<td>Total</td>
<td>61</td>
<td>610</td>
</tr>
</tbody>
</table>

7.1.2. On Farm Trials

Six on farm trials (OFTs) on the management of red mite in apple, fruit fly in tomato, stemphylium blight in onion, effect of zinc sulphate on yield and quality of potato, nutritional practices for correcting malnutrition and nutritional kitchen gardening were conducted (Table 7.2).

Table 7.2. On farm trails conducted

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Title of OFTs</th>
<th>Crop (Variety)</th>
<th>Area (ha)</th>
<th>No. of farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Management of red mite in apple</td>
<td>Apple (Royal Delicious)</td>
<td>0.2</td>
<td>5</td>
</tr>
<tr>
<td>2.</td>
<td>Management of fruit fly in tomato</td>
<td>Tomato (VLT-4)</td>
<td>0.1</td>
<td>5</td>
</tr>
<tr>
<td>3.</td>
<td>Effect of zinc sulphate on yield and quality of potato</td>
<td>Potato (Kufri Jyoti)</td>
<td>0.1</td>
<td>5</td>
</tr>
<tr>
<td>4.</td>
<td>Management of Stemphylium blight in onion during seed production</td>
<td>Onion (VL Pyaz-3)</td>
<td>0.1</td>
<td>5</td>
</tr>
<tr>
<td>5.</td>
<td>Assessment of effectiveness of nutritional practices for correcting malnutrition</td>
<td>Protein, calcium &amp; iron rich food products (soybean, sugar, ragi, barnyard millet and moong dal)</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>6.</td>
<td>Nutritional kitchen gardening</td>
<td>Seeds and saplings of seasonal vegetables</td>
<td>-</td>
<td>10</td>
</tr>
</tbody>
</table>

7.1.3. Front Line Demonstrations

Front line demonstration on oilseed, pulses, other crops were conducted at the farmers’ field in an area of 41.5 ha under KVK, Chinyalisaur during kharif 2017 and rabi 2017-18. Total 673 farmers were benefited.
7.1.4. Seed Production
A total of 10.45 q seed and 1,10,610 seedlings were produced at KVK Chinyalisaur farm.

7.1.5. Other Extension Activities
- **Swachhata Pakhwada**: KVK, Chinyalisaur, Uttarkashi organised Swachhata Pakhwada during May 16 to 31, 2017.
- **Field Day**: The KVK organized four field days on wheat, maize, bean and pigeon pea. A total of 291 participants (156 male and 135 Female) attended the programme.
- **Breast feeding week**: The KVK organized Breast-Feeding week during August 01 to 07, 2017. A total of 21 participants attended the programme.
- **Parthenium awareness week**: The KVK organized Parthenium week during August 16 to 22, 2017. A total of 50 participants attended the programme.
- **New India Manthan- Sankalp se Siddhi Programme and Exhibition**: The KVK organized Sankalp se Siddhi Programme on August 29, 2017. A total of 464 participants attended the programme.
- **National Nutrition week**: The KVK organized National Nutrition week on September 01 to 07, 2017. Total 60 participants attended the programme.
- **Field Day**: A field day on maize crop was organised on September 16, 2017. Total 25 participants attended the programme.
- **Hindi Chetna Mass**: The KVK celebrated Hindi Chetna Mass programme from 14th September to October 13, 2017.
- **Swacchta hi Sewa**: The KVK celebrated Swacchta hi Sewa during September 15th to September 20, 2017.
- **Exposure visit to Farmers’ fair**: The KVK organized farmers’ exposure visit to Farmers’ fair held at ICAR-VPKAS, Almora on October 7, 2017 under NICRA Project. Total 20 farmers of tribal area were benefited.
- **Krishak Mahotsav**: The experts of KVK attended Rabi Krishak Mahotsav-2017 and farmers goshthi at block and village level organized by the state government during October 7 - 12, 2017.
- **Arhar Diwas**: The KVK had organized ‘Arhar Diwas’ (Field day on Pigeon pea) programme at Bharkot village on October 25, 2017.
A total of 215 participants (111 male and 104 Female) attended the programme.

World Soil Day: The KVK organized Pre rabi Sammelan and World Soil Day on December 05, 2017 at Barethi Village. On this occasion 110 soil health cards were distributed to the farmers of five villages. More than 200 farmers participated in the event.
7.2. KVK Bageshwar

7.2.1. Trainings
The KVK organised 49 training programmes, with 1392 total beneficiaries (675 males, 709 females) for farm women, rural youth, extension functionaries and sponsored trainings programmes on various topics (Table 7.3) including six sponsored training programmes.

Table 7.3. Training Programmes conducted during 2017-18

<table>
<thead>
<tr>
<th>Discipline</th>
<th>No. of trainings</th>
<th>No. of Trainees</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Animal Science</td>
<td>14</td>
<td>161</td>
<td>186</td>
<td>347</td>
<td></td>
</tr>
<tr>
<td>Plant Protection</td>
<td>13</td>
<td>227</td>
<td>152</td>
<td>379</td>
<td></td>
</tr>
<tr>
<td>Horticulture</td>
<td>03</td>
<td>64</td>
<td>36</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Home Science</td>
<td>11</td>
<td>34</td>
<td>230</td>
<td>272</td>
<td></td>
</tr>
<tr>
<td>Agricultural Extension</td>
<td>02</td>
<td>41</td>
<td>09</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Sponsored training</td>
<td>06</td>
<td>148</td>
<td>96</td>
<td>244</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>49</strong></td>
<td><strong>675</strong></td>
<td><strong>709</strong></td>
<td><strong>1392</strong></td>
<td></td>
</tr>
</tbody>
</table>

7.2.2. Front Line Demonstrations
Front Line Demonstrations (FLD’s) on various crops in kharif (2017) & rabi (2017-18) crops were conducted on 50.4 ha (29.3 ha in kharif and 21.1 ha in rabi) benefitting 1783 (Table 7.4). Under poultry farming, six hundred chicks were distributed to 30 farmers under FLD on Backyard Poultry farming. FLDs were also conducted for fodder production. The FLDs resulted in increasing average yield from 10.0 to 47.8 per cent in various hill crops.

7.2.3. On Farm Trials
The following trials were conducted at farmers’ fields:

**Efficacy of chemical and bioagents in management of anthracnose disease in chilly:** Chemically (Thiram @ 2 g/kg seed for seed treatment and Mancozeb @ 2.5 g/L for three foliar spray) treated plot yielded 108.6 q/ha while Bioagent (Trichoderma harzianum @ 5 g/kg seed for seed treatment and Pseudomonas fluorescens @ 10 g/L for three foliar spray) treated plot yielded 101.92 q/ha while, farmers practice yielded 84 q/ha.

Table 7.4. Details of Frontline demonstrations on crops and other aspects

<table>
<thead>
<tr>
<th>Season</th>
<th>Crop</th>
<th>Variety</th>
<th>Area (ha.)</th>
<th>No. of beneficiaries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oil seeds</td>
<td>VL Soya 47</td>
<td>3.0</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td>Pulses</td>
<td>VL Arhar 1 &amp; VL Gahat 10</td>
<td>12.0</td>
<td>379</td>
</tr>
<tr>
<td></td>
<td>Vegetables</td>
<td>Okra (VL Bhindi 2)</td>
<td>0.2</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Okra (S-9)</td>
<td>0.2</td>
<td>134</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VL Bean 2</td>
<td>0.4</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>Fodder</td>
<td>Maize (African Tall)</td>
<td>0.5</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td><strong>Sub-total</strong></td>
<td><strong>29.3</strong></td>
<td><strong>1187</strong></td>
<td></td>
</tr>
<tr>
<td>rabi 2017-18</td>
<td>Cereals &amp; Millets</td>
<td>Wheat (VL Gehun-829, 832, 892, 907 &amp; 953)</td>
<td>10.9</td>
<td>121</td>
</tr>
<tr>
<td></td>
<td>Oil seed</td>
<td>Barley (VL Barley118 &amp;130)</td>
<td>0.81</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>Pulses</td>
<td>Toria (VL Toria-3)</td>
<td>0.5</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mustard (Pant Pili Sarson)</td>
<td>0.5</td>
<td>08</td>
</tr>
<tr>
<td></td>
<td>Vegetables &amp; Spices</td>
<td>Veg. Pea (Arkil)</td>
<td>0.35</td>
<td>124</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coriander (Pant haritima)</td>
<td>1.4</td>
<td>22</td>
</tr>
</tbody>
</table>
Efficacy of chemical and bioagents in management of wilt disease and nematode pest in pigeon pea (VL Arhar 1): Chemical treatment (Thiram @ 2 g/kg seed for seed treatment and Carbendazim @ 1 g/L water for drenching and Nemagone @ 2 mL/L soil drenching) yielded 11.5 q/ha while bioagent treatment (Trichoderma harzianum @ 5 g/kg seed for seed treatment and soil application of Trichoderma harzianum @ 250 g/q FYM at the time of sowing + soil application of Neem cake @ 5 q/ha) yielded 9.5 q/ha in comparison to farmers practice yielded 8.5 q/ha.

Effect of potassium permangenate and mastilap ointment in control of mastitis in cows: Use of 0.001 percent KMnO₄ as teat dip solution can reduce 50 percent incidence of Mastitis in cow while topical application of Mastilap ointment after use of KMnO₄ as teat dip solution can reduce 80 percent incidence of Mastitis in cow. Hence, application of Mastilap ointment along with 0.001 percent KMnO₄ as teat dip solution is suitable non-clinical method for control of Mastitis in cow.

Effect of Anthelmentics, specific mineral mixture and Janova (herbal heat inducer) in the correction of post-calving anoestrus condition in cows: Use of Fenbendazole (Fendikind bolus 3 g) and area specific mineral mixture (Lykamin powder @ 50 g twice daily for 45 days) can reduce 40% incidence of post-calving anoestrus condition in cows while the application of Janova capsule (herbal heat inducer) along with use of Fenbendazole and area specific mineral mixture can reduce 80% incidence of post-calving anoestrus condition in cows. Hence, correction of post-calving anoestrus condition in cows, use of Fenbendazole, area specific mineral mixture and Janova capsule is found suitable package of practice.

7.2.4. Production of Seed and Bio-products
During 2017-18 a total of 54.2 q quality seed, 1,34,249 numbers of vegetable seedlings, 145 q vermicompost and 8,404 L milk were produced and a total revenue of Rs 6.47 lakhs was generated by KVK, Kafligair.

7.2.5. Other Extension Activities
- Farmers field days: KVK, Kafligair organized 5 field days on Paddy (VL Dhan 65), Pigeonpea (VL Arhar 1), Horsegram (VL Gahat 10) and Wheat (VL Gehun 953) crops benefitting 235 farmers (138 Male and 97 Female).
- New India Manthan-Sankalp se Siddhi programme: KVK organized New India Manthan-Sankalp se Siddhi programme on August 28, 2017 under the chairmanship of Dr A. Pattanayak, Director, ICAR-VPKAS, Almora and Central Minister of State, Ministry of Textile and Jute Hon’ble Shri Ajay Tamta. During the occasion, Bageshwar
MLA Hon'ble Shri Chandan Ram Das, Zila Panchayat chairman Shri Harish Chandra Aithani, DM Bageshwar Smt Ranjna Rajguru and other dignitaries along with 400 farmers also participated.

- **Krishak gosthi and farmers feedback programme:** During the visit of Dr. M.R. Prasad, Director, NILERD, NITI AYOG and Dr. A. Pattanayak, Director ICAR-VPKAS, Almora at KVK Campus Kafligair a Krishak Gosthi and Farmers feedback programme was organized. On this occasion Dr. M.R. Prasad declared that KVK (ICAR-VPKAS)-Bageshwar is ranked in “A” category.

- **Pre-rabi kisan sammelan and krishak gosthi 2016 and world soil day:** KVK Kafligair, Bageshwar organized Pre-Rabi Kisan Sammelan and Krishak Gosthi 2017 and World Soil Day at KVK campus on December 5, 2017 and 300 soil health cards were distributed to 300 farmers in the presence of Hon'ble Zila Panchayat Chairman, Bageshwar Shri Harish Chandra Aithani and Honorable Zila Panchayat Sadashya Shri Rabi Karayat.

- **National nutrition week programme:** KVK celebrated National Nutrition Week programme from September 1-7, 2017 and 124 farmers and students were benefited.

- Parthenium awareness week (August 16-22, 2017), World Honey bee day (August 19, 2017), Breast feeding week (August 1-7, 2017) and Mahila Kisan Diwas (October 15, 2017). Programmes were organized at KVK, Kafligair.

- **Agriculture education awareness programme:** KVK Kafligair organized 10 agriculture education awareness programmes during 2017-18 for creating awareness about carrier opportunities in agricultural science among school students.

- **Scientific Advisory Committee Meeting (SAC):** KVK Kafligair organized 11th SAC meeting on March 13, 2018. On this occasion Dr. Ramakrishanan, ICAR-IVRI, Mukteshwar was the chief guest, Dr. Raj Narayan, ICAR-CITH, Mukteshwar campus as a special guest and Dr. A. Pattanayak, Director, ICAR-VPKAS, Almora was chairman of the programme. Altogether 25 members of different line departments, nearby ICAR institutes, GBPUSA&T, Pantnagar, Farmers and media representatives were present.

- **Live telecast of speech of Honorable Prime Minister during krishi unnati mela 2018 at New Delhi:** KVK, Bageshwar organized an awareness programme and Krishak Gosthi for spreading the message of Honorable Prime Minister for doubling the farmers’ income till 2022 during Krishi Unnati Mela on March 17, 2018 at New Delhi.
KVK, Bageshwar participated with exhibition stall in “National Workshop on Farmers Rights and Agro-biodiversity Exhibition” and in Kisan Mela for Northern Region on February 23-25, 2018 at ICAR-IIVR, Varanasi.

Table 7.5. Trainings organized for farmers at the Institute

<table>
<thead>
<tr>
<th>Topic</th>
<th>Duration</th>
<th>Coordinators</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>State level training programme on Sookshm sinchai prabandhan evam krishi takniki</td>
<td>April 6-7, 2017 (2 Days)</td>
<td>Drs. Sher Singh and Mahipal Choudhary</td>
<td>24</td>
</tr>
<tr>
<td>Training Program on Kharif fasalon ki unнат utpadan takniki</td>
<td>July 5-8, 2017 (4 Days)</td>
<td>Drs. Anuradha Bhartiya, Rajashekara H. and V.S. Meena</td>
<td>27</td>
</tr>
<tr>
<td>Training programme to improve the kharif crop production, sponsored by ATMA, Directorate of Agriculture, Dehradun</td>
<td>July 24-26, 2017 (3 Days)</td>
<td>Drs. Subbanna A.R.N.S. and Tilak Mondal</td>
<td>21</td>
</tr>
<tr>
<td>Training programme to improve the kharif crop production, sponsored by ATMA, Directorate of Agriculture, Dehradun</td>
<td>July 27-29, 2017 (3 Days)</td>
<td>Dr. J.P. Aditya and Er. Syam Nath</td>
<td>24</td>
</tr>
<tr>
<td>Training programme on Parvatiya kshetron hetu rabi fasalotpadan ki unnat takniki</td>
<td>October 4-7, 2017 (4 Days)</td>
<td>Drs. R.P. Yadav and Anuradha Bhartiya</td>
<td>26</td>
</tr>
<tr>
<td>Training Programme on Unnat krishi utpadan takniki dwara aay mein vridhi</td>
<td>October 5-7, 2017 (3 Days)</td>
<td>Dr. R.K Khulbe and Dr. B.M. Pandey</td>
<td>30</td>
</tr>
<tr>
<td>Training Programme on Unnat krishi utpadan takniki dwara aay mein vridhi</td>
<td>October 7-9, 2017 (3 Days)</td>
<td>Dr. B.M. Pandey and Dr. R.K Khulbe</td>
<td>24</td>
</tr>
<tr>
<td>Training Programme on Rabi fasalon ki utpadan takniki sponsored by Himmothan</td>
<td>October 10-13, 2017 (4 Days)</td>
<td>Drs. R.S. Pal and C. Ganesh Vasudeo</td>
<td>28</td>
</tr>
<tr>
<td>Training Programme on Sabji utpadan taknneckey sponsored by BIAF, Dehradun</td>
<td>December 15-17, 2017 (3 Days)</td>
<td>Drs. N.K. Hedau and C. Ganesh Vasudeo</td>
<td>30</td>
</tr>
<tr>
<td>Topic</td>
<td>Duration</td>
<td>Coordinators</td>
<td>Number of Participants</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>---------------------------</td>
<td>---------------------------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Training Programme on Parvatiya krishi hetu faslotpadan takniki sponsored by Department of Agriculture, Bageshwar</td>
<td>January 10-12, 2018 (3 Days)</td>
<td>Drs. R.S. Pal, D.C. Joshi and V.S. Meena</td>
<td>24</td>
</tr>
<tr>
<td>Training Programme on Parvatiya krishi hetu faslotpadan takniki sponsored by Department of Agriculture, Bageshwar</td>
<td>January 15-17, 2018 (3 Days)</td>
<td>Drs. D.C. Joshi, R.S. Pal and V.S. Meena</td>
<td>24</td>
</tr>
<tr>
<td>Training programme on Mahila krishakon ka beej utpadan mein kaushal vikas under ICAR-Seed project</td>
<td>March 5-7, 2018 (3 Days)</td>
<td>Drs. C. Ganesh Vasudeo and Hanuman Ram</td>
<td>27</td>
</tr>
<tr>
<td>Training programme on Parwatiya faslon ka beejotpadan evam krishigatt udhyam under Tribal Sub Plan</td>
<td>March 8-12, 2018 (5 Days)</td>
<td>Drs. Renu Jethi and C. Ganesh Vasudeo</td>
<td>29</td>
</tr>
<tr>
<td>Training programme on Kharif fasalon ki unmat utpadan takniki sponsored by ATMA</td>
<td>March 13-15, 2018 (3 Days)</td>
<td>Drs. R.P. Yadav and Mahipal Choudhary</td>
<td>31</td>
</tr>
<tr>
<td>State level Training-cum-Exposure visit programme sponsored by ATMA, Dehradun</td>
<td>March 16-18, 2018 (3 Days)</td>
<td>Dr. J.P. Aditya</td>
<td>41</td>
</tr>
<tr>
<td>Training program on Janjatiya krishakon ka beej utpadan mein kaushal vikas under ICAR-Seed project</td>
<td>March 21-23, 2018 (3 Days)</td>
<td>Drs. C. Ganesh Vasudeo, Renu Jethi and Anuradha Bhartiya</td>
<td>28</td>
</tr>
<tr>
<td>Training program on Paudh kism evam krishak adhikar samraksan pradhikaran</td>
<td>March 22, 2018 (1 Day)</td>
<td>Dr. Anuradha Bhartiya</td>
<td>100</td>
</tr>
<tr>
<td>Training Programme on Unnat krishi utpadan takniki dwara aay mein vridhi</td>
<td>March 23-25, 2018 (3 Days)</td>
<td>Dr. Kushagra Joshi</td>
<td>43</td>
</tr>
<tr>
<td>Training programme on Sabji fasalon ki utpadan takniken under Uttarakhand Van Sansadahan Prabandhan Pariyojna</td>
<td>March 27-28, 2018 (2 Days)</td>
<td>Drs. C. Ganesh Vasudeo and Hanuman Ram</td>
<td>30</td>
</tr>
<tr>
<td>Training program on Vegetables and other crops</td>
<td>March 30-31, 2018 (2 Days)</td>
<td>Dr. Nirmal Chandra</td>
<td>23</td>
</tr>
</tbody>
</table>

**Exposure Visits**

- Exposure visit of MC member WUA in other states under capacity development of farmers' group to Uttarakhand | April 21, 2017 | Dr. R.P. Yadav | 24 |
- Exposure visit of the farmers from district Kurukshetra, Haryana sponsored by ATMA | April 26, 2017 | Dr. Tilak Mandal | 21 |
- One day training program and exposure visit under H.M.N.W.H. Project | May 2, 2017 | Dr. Tilak Mondal | 14 |
- Exposure visit of the Students of M.Sc. Animal Sciences from B.B. Ambedkar University, Lucknow | May 11, 2017 | Dr. Nirmal Chandra | 27 |
- One day training program for farmers from Ludhiana | June 15, 2017 | Dr. R.P. Yadav | 20 |
- Exposure visit of farmers from Kapkot, Bageshwar | June 17, 2017 | Dr. Nirmal Chandra | 9 |
- One day training program on Sankar Makka Beejotpadan funded by Himothan for the farmers from Almora, Nainital, Pithoragarh districts | June 21, 2017 | Dr. R.K. Khulbe | 9 |
- Exposer visit of Judges (Trainees) Judicial and legal academy, Bhowali, Nainital | August 09, 2017 | Dr. Nirmal Chandra | 18 |
- Farmers exposure visit of farmers sponsored by Department of Agriculture, Thalisain (Pauri Garhwal) | August 18, 2017 | Dr. Kushagra Joshi | 31 |
<table>
<thead>
<tr>
<th>Topic</th>
<th>Duration</th>
<th>Coordinators</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure visit of the farmers from Raipur, Dehradun</td>
<td>September 22, 2017</td>
<td>Drs. Nirmal Chandra and Kushagra Joshi</td>
<td>26</td>
</tr>
<tr>
<td>One day exposure visit of trainees of GBPUA&amp;T, Pantnagar, U.S. Nagar</td>
<td>September 22, 2017</td>
<td>Dr. Nirmal Chandra</td>
<td>16</td>
</tr>
<tr>
<td>Exposure visit of farmers from Gairsain</td>
<td>October 28, 2017</td>
<td>Dr. R.S. Pal</td>
<td>9</td>
</tr>
<tr>
<td>Exposure visit of farmers from Syaldeh, Almora</td>
<td>October 30, 2017</td>
<td>Dr. Kushagra Joshi</td>
<td>20</td>
</tr>
<tr>
<td>Exposure visit of farmers from Gairsain</td>
<td>October 28, 2017</td>
<td>Dr. R.S. Pal</td>
<td>9</td>
</tr>
<tr>
<td>Exposure visit of farmers from Syaldeh, Almora</td>
<td>October 30, 2017</td>
<td>Dr. Kushagra Joshi</td>
<td>20</td>
</tr>
<tr>
<td>Exposure visit of farmers from district Bareilly, organized by Agriculture Department of Agriculture-Uttar Pradesh</td>
<td>November 17, 2017</td>
<td>Dr. Nirmal Chandra</td>
<td>15</td>
</tr>
<tr>
<td>Exposure visit of trainees sponsored by Department of Plant Pathology, GBPUA&amp;T Pantnagar</td>
<td>December 01, 2017</td>
<td>Dr. Nirmal Chandra</td>
<td>15</td>
</tr>
<tr>
<td>Exposure visit of the Farmers from Himalai Gram Vikas Samiti (Pithoragarh farmers)</td>
<td>December 23, 2017</td>
<td>Dr. J.P. Aditya</td>
<td>18</td>
</tr>
<tr>
<td>Exposure visit of women from ‘Shri Bhuvireshwari Mahila Asram-the Hans Foundation Anjanisain” Tihari Garwal</td>
<td>January 31, 2018</td>
<td>Dr. Nirmal Chandra</td>
<td>12</td>
</tr>
<tr>
<td>Exposure visit of farmers Under Pradhan Mantri Sinchai Yojna, organized by Department of Agriculture, district-Thalisain, Pauri Garwal</td>
<td>February 07, 2018</td>
<td>Dr. Nirmal Chandra</td>
<td>20</td>
</tr>
<tr>
<td>Exposure visit of farmers organized by “Sanjeevani Vikas Avam Jan Kalyan Samiti” Ranikhet</td>
<td>February 07, 2018</td>
<td>Dr. Nirmal Chandra</td>
<td>20</td>
</tr>
<tr>
<td>Training program on “Parwatiya Krishakon ka beej utpadan mein kaushal vikas” for the farmers of district Almora</td>
<td>March 20, 2018</td>
<td>Dr. Nirmal Chandra</td>
<td>10</td>
</tr>
</tbody>
</table>

7.3.2. Front Line Demonstrations

**Soybean/ black soybean**

Improved varieties of soybean and black soybean were popularized among farmers through FLDs during *kharif* 2017 involving 84 farmers in 2.4 ha area at village *Raun-Dal* of Almora district. VL Soya 47, VL Soya 63 of soybean and black soybean (VL Soya 65) provided yield superiority of 33.4, 40.7 and 56.8% respectively, than local
traditional cultivars. Results exhibited more technology gap (Yield gap I) for soybean (7.87 q/ha) as compared to black soybean (1.58 q/ha). A field day of soybean was organised at Raun-Dal village on October 09, 2017, and which benefitted 34 farmers.

**Finger Millet**

Front line demonstrations of two improved varieties of finger millet (VL Mandua 324 and VL Mandua 352) and one variety of barnyard millet (VL Madira 172) were conducted in 8.8 and 2.5 ha, respectively in two districts (Almora and Nainital) of Uttarakhand. Results of high yielding cultivars under FLDs during kharif 2017 are presented in Table 7.6.

**Wheat**

During rabi 2016-17, wheat FLDs were conducted in 8 ha area involving 90 farmers from five villages.

**Table 7.6. Economics of finger millet FLDs**

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Grain yield (q/ha)</th>
<th>Fodder yield (q/ha)</th>
<th>Cost of cultivation (Rs./ha)</th>
<th>Gross return (Rs./ha)</th>
<th>Net return (Rs./ha)</th>
<th>B:C ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finger millet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VL Mandua 352</td>
<td>19.83</td>
<td>42.33</td>
<td>34,705</td>
<td>63,282</td>
<td>28,577</td>
<td>0.82</td>
</tr>
<tr>
<td>VL Mandua 324</td>
<td>17.25</td>
<td>44.50</td>
<td>34,705</td>
<td>62,106</td>
<td>27,401</td>
<td>0.79</td>
</tr>
<tr>
<td>Mean</td>
<td>18.54</td>
<td>43.50</td>
<td>34,705</td>
<td>63,694</td>
<td>27,989</td>
<td>0.80</td>
</tr>
<tr>
<td>Farmer practice</td>
<td>15.63</td>
<td>40.55</td>
<td>35,486</td>
<td>53,340</td>
<td>17,854</td>
<td>0.50</td>
</tr>
<tr>
<td>Barnyard millet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VL Madira 172</td>
<td>16.39</td>
<td>32.23</td>
<td>32,956</td>
<td>54,717</td>
<td>21,761</td>
<td>0.66</td>
</tr>
<tr>
<td>Farmer practice</td>
<td>14.53</td>
<td>37.87</td>
<td>33,902</td>
<td>47,377</td>
<td>13,475</td>
<td>0.40</td>
</tr>
</tbody>
</table>
(Karala, Khaulseer, Sainj, Bedibagad, Masskhet) of Bageshwar District and two villages (Melaut and Majhgaon) of Dehradun District. High yielding varieties namely VL Gehun 907 and VL Gehun 953 were used. The improved varieties VL Gehun 953 and VL Gehun 907 yielded 3,359 and 3,460 kg/ha, which were 35.0 and 34.7% higher than the local check, respectively. A field day was organized on April 19, 2017 at Khaulseer village and the farmers were briefed about the details of the cultivation of VL Gehun 953 and VL Gehun 907. The farmers were very happy with the performance of these varieties and confirmed that they will be using the seed of these varieties in coming years.

7.3.3. **Mera Gaon Mera Gaurav**

*Mera Gaon Mera Gaurav* (MGMG) programme is operational at ICAR-VPKAS Almora, in which scientists regularly visit the assigned village and take latest technologies to the doorstep of the farming community. Under this program 31 villages in six clusters from 5 blocks in Almora district are selected. Six teams of 5 multi-disciplinary scientists have been constituted to work in each cluster of 5 villages. National priorities such as soil and water conservation, secondary agriculture, mechanization and distribution of soil health cards to farmers are also taken care of.

Under MGMG, ICAR-VPKAS distributed seeds of improved varieties on demand basis along with suitable package of practices. Regular visits were made to provide technical inputs on improved cultivation practices, water harvesting, soil conservation and IPM. Soil health cards were distributed in Jageshwar cluster by Dr. H S Gupta, Ex-DG BISA, New Delhi. Scientists undergone surveillance program of yellow rust in wheat. ICAR-VPKAS released varieties possess field resistance to yellow rust, whereas local varieties were affected by yellow rust. Farmers were advised to spray Propiconazole @ 1mL/L for the management of yellow rust. Farmers Producer Group were formed to establish market linkages and sale of farm produce. Credit linkages through banks were established for farmer producer groups. A 3-days (March 5-7, 2018) training
Distribution of Soil health cards

DD Kisan recording at Bhagartola

Demonstration of fodder tree cutting management at Bimola

Participatory crop monitoring at Amsyari

Training and skill development programme on Seed Production for MGMG hill farmwomen at Hawalbagh

Surveillance of yellow rust in wheat

Exposure visit to Krishi Unnati Mela

Farmers at ICAR-VPKAS stall at Krishi Unnati Mela

Farmers at ICAR pavallian at Krishi Unnati Mela
and skill development programme on seed production was organized for hill farmwomen at Hawalbagh.

Institute organized an exposure visit of 27 farmers from MGMG villages to Krishi Unnati Mela held at IARI, Pusa, New Delhi during March 16-18, 2018

Summary of activities organized under MGMG by Institute/SAU

<table>
<thead>
<tr>
<th>Name of activity</th>
<th>No. of activities conducted</th>
<th>No. of farmers participated/benefitted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visit to village by teams</td>
<td>40</td>
<td>369</td>
</tr>
<tr>
<td>Interface meeting/ Goshthis</td>
<td>18</td>
<td>237</td>
</tr>
<tr>
<td>Trainings conducted</td>
<td>7</td>
<td>111</td>
</tr>
<tr>
<td>Mobile based advisories</td>
<td>972</td>
<td>400</td>
</tr>
<tr>
<td>Literature support provided</td>
<td>160</td>
<td>228</td>
</tr>
<tr>
<td>Awareness created</td>
<td>11</td>
<td>334</td>
</tr>
<tr>
<td>Linkages developed with other agencies</td>
<td>4</td>
<td>183</td>
</tr>
</tbody>
</table>

7.3.4. Krishi Samridhi Programme

This institute sponsored Krishi Samridhi programme is being broadcasted as a means for information empowerment of farmers since 2009, in which the experts from the institute record radio talks on various aspects of hill agriculture beneficial to farmers at AIR, Almora. The programme is broadcasted every Sunday at 6 pm, from All India Radio, Almora, Uttarakhand. In the year 2017-18, fifty two talks were recorded and broadcasted covering information pertaining to crop production and natural resource management (38.5%), crop improvement including information on improved varieties of cereals and vegetables (23.1%), crop protection including insect pest and disease management in crops and on-farm income generating activities like mushroom cultivation and apiary (19.2%), animal husbandry (5.8%) and social science aspects including agricultural health and safety and schemes for farmers (13.5%).

7.3.5. Krishak Helpline

It offers a toll-free telephone (1800 180 2311) service to the farmers by providing answers to the queries raised by them on working days during 10 am to 5 pm. Content analysis of advisories provided to farmers shows that majority of the advisories were related to plant protection (17.1%), seed availability (11.5%) and vegetable cultivation (10.2%) (Fig. 7.1).

Fig. 7.1. Advisories provided through farmers’ helpline service

7.4. Swachhata Pakhwara

Swachhta Pakhwara was organized at ICAR- VPKAS, Almora and its KVKs during May 16-31, 2017. All the staff of the institute at Almora and Hawalbag Campus and KVK, Chinyalisaur and KVK, Kafligair took the pledge for cleanliness on May 16, 2017. The opening of Swachhata Pakhwada was done by sweeping and cleaning of office corridors, premises, rooms and surrounding areas by the staff members.

A committee comprising Drs. J.K. Bisht, N.K. Hedau and Renu Jethi examined the cleanliness and upkeep of laboratories at the Almora campus. The laboratories were evaluated on various swachhta parameters and their ranks were decided in terms of cleanliness. Staff of KVK, Kafligair participated in cleaning programme in front of Farmers’ guest house by uprooting weeds and grasses to make guest house areas clean. At KVK, Chinyalisaur various cleanliness related programme were organized in KVK premises including farmer hostel and dairy unit.
A team comprising Dr. J. Stanley and Dr. G. Vasudeo Chaudhari organized a Swachhta awareness program for the students of Government Inter College, Hawalbag at ICAR-VPKAS, Hawalbagh. Forty-one students along with their teacher participated in the programme. A short video film was shown to the students on Cleanliness – to be initiated from our self to realize them that each and every citizen of India is responsible for making India clean. The video emphasized how to reduce waste, recycle them and utilize the waste into useful matter. Dr. Ganesh explained them the importance of cleanliness and how to feel the difference of a tidy place with that of dirty one.

Swachhta gosti was organized on May 26, 2017 which was chaired by Dr A. Pattanayak, Director, ICAR-VPKAS. Under Swachhta Pakhwara programme, 41 students of Kendriya Vidhyalaya, Almora with their teachers participated in Swachhata awareness programme. The programme was co-ordinated by Mr. Tilak Mondal and Dr. Anuradha Bhartiya. During the programme, students were made aware about importance of cleanliness, personal hygiene and effects of pollution on health and environment. Dr. B.M. Pandey motivated the students for inculcating the habit of keeping their home, workplace and public places neat and clean. Water storage facilities and choked water pipes were cleaned in the Hawalbagh campus. Dr. Sher Singh along with Er. Shyam Nath and Er. D.C. Mishra coordinated the work.

7.5. Tribal Sub Plan (TSP)

7.5.1. TSP

Village clusters in four districts of Uttarakhand viz., Pithoragarh, Bageshwar, Chamoli, and Dehradun were adopted by the institute under Tribal Sub Plan with the objective of socio-economic development of the tribal communities of Uttarakhand. During the reporting period, several programmes were organized at the institute as well as at farmers' fields. A brief description of these programmes is as follows:

Farmer trainings and exposure visits

Three training programmes of three days each on “Increase in farmer's income through improved agricultural production technologies” were organized at Headquarter w.e.f. October 5-7, 2017 October 7-9, 2017 and March 23-25, 2018, respectively for farmers of tribal region of district Chamoli, Dehradun and Pithoragarh. A total of 97 farmers participated in the
programme. The farmers were imparted training on improved varieties of hill crops, improved crop production technologies, disease and insect-pest management, seed production, small tools and farm machinery, mushroom production, and seed processing. They were also sensitized on ‘Swachh Bharat Abhiyaan’. A live demonstration of preparation of soymilk and tofu was also given, which was much appreciated by the farmers.

During the Kisan Mela organized at Experimental Farm Hawalbagh, ICAR-VPKAS, Almora on October 7, 2017 and March 23, 2018, exposure visits of 74 tribal farmers were conducted. The farmers were exposed to progressive agricultural technology including crops/seed production, water conservation technology, post harvest processing technology, and other technologies developed at the institute. An exposure visit to farm of a progressive entrepreneur, at Gewapani, Daulaghat was also organised for practical exposure of farmers to integrated farming system.

Exposure visit of tribal farmers to a progressive entrepreneur

Off-campus training and demonstration

Like elsewhere in the hills, trees are an important source of fodder in Dhanpau-Lakhwad cluster also, particularly during the winter months when green grassy fodder is scarce. Among different fodder trees, Bhimal (Grewia optiva) is valued most on account of the volume and quality of fodder it yields. Besides, the popular belief that milch animals fed on bhimal leaves produce more and thicker/fattier milk further increases its importance. However, the traditional method of fodder collection from the tree results in lower yield, retarded growth and shortened life of the tree. In a training programme and demonstration on ‘Vaigyanik Vidhi se Vrikshon mein Chara Prabandhan’ organized in the cluster, the scientific method of pruning/lopping and fodder collection from the trees were demonstrated to the farmers.

Exposure visit of tribal farmers at ICAR-VPKAS

Tree fodder management training and demonstration at Dhanpau-Lakhwad cluster

The scientific method involves coppicing of the tree after 10 years of growth and pollarding at 2 m height leaving the main shoot intact. With proper management, up to 1.5 times higher fodder yield can be obtained from the same tree as compared to the traditional method.

Livestock management camp

All households in Dhanpau-Lakhwad cluster invariably have livestock comprising cows, buffaloes, oxen and goats. Inadequate knowledge of livestock management keeps the farmers from exploiting full potential of the animals and often animals lives are lost due to lack of
A livestock management camp was, therefore, organized in the cluster to enhance awareness about livestock management among the farmers by imparting information on shed, feed, health and production management. The farmers were also provided tips on home remedies to prevent/manage common/minor problems and diseases of livestock. Extension leaflets on ‘Pashudhan Prabandhan ki Vaigyanik Vidhi’ were distributed to the farmers for ready reference. Farmers’ problems relating to livestock were also addressed and feed supplements, liver tonic, anthelmintics and ectoparasiticides were also provided to the farmers.

**Krishak gosthi and farmer-scientist interactions**

A Krishak Goshti was held at Majhgaon in Kwanu cluster of Jaunsar tribal area of district Dehradun on August 14, 2017. During the goshti, the farmers were imparted information on scientific methods of cultivation of important kharif crops and agriculture-related problems faced by them were addressed. Feedback of the farmers on the performance of institute's varieties was also obtained. During field visits, on-spot solutions for management of diseases and insects were provided. Based on inputs obtained and interest shown by the farmers, additional interventions for introduction in the cluster were identified. A total of 72 farmers participated in the programme.

An on-farm training-cum-demonstration on ‘Sabji Fasalon mein Nursery Prabandhan’ was organized at Mailot in Kwanu cluster of Jaunsar tribal area of district Dehradun on February 22, 2018. In the training, the farmers were given demonstration on scientific method of vegetable nursery bed preparation. Information on nutrient and disease management in the nursery was also shared with the farmers. To acquaint farmers with the modern nursery techniques, the farmers were given demonstration and hands-on training on use of plug-trays for nursery raising.
Seed of tomato and capsicum hybrids, plug-trays, cocopeat and fungicides were also distributed to the farmers. A total of 14 leading vegetable growing farmers of the cluster participated in the programme.

A visit was undertaken to Dhanpau-Lakhwad village cluster on August 15, 2017, for monitoring of ongoing FLDs of Vivek Maize Hybrid 45. On this occasion, a Krishak gosthi was held during which problems faced by the farmers in their kharif crops were addressed. Agriculture-related problems faced by the farmers were also addressed. During the field visits, feedback of the farmers on the performance of institute’s varieties was also obtained. Based on inputs provided by the farmers, additional interventions for introduction in these areas were also identified. A total of 69 farmers and farm women participated in the programme.

Farmers-scientists interaction meet
Two visits were undertaken to adopted villages of Niti clusters during 19-24 September and 15-17 October 2017 for monitoring of demonstrations and holding interactions with the farmers. During the visit, monitoring of demonstrations of French bean variety VL Bean 2, rajmash varieties VL Rajmash 63 and VL Rajmash 125, potato variety Kufri Himalini was conducted and farmer-scientist interactions were held at village Merag, Malari, and Gamshali. A total of 175 farmers participated in farmer-scientist interaction programmes. During the interactions, feedback of the farmers on the performance of the varieties was obtained and the work plan for next crop season was discussed.

Technology dissemination and adoption
Frontline demonstrations of Vivek Maize Hybrid 45 were conducted at Dhanpau-Lakhwad village cluster of Jaunsar tribal area of district Dehradun in about 15 ha during kharif 2017. Like previous year, performance of the VMH 45 (50.05 q/ha) was superior to the local cultivar (31.03 q/ha). Apart from a yield advantage of 61.30 per cent over the local cultivar, the hybrids offered
advantage in terms of fodder quality (owing to their stay green trait), lower bird damage and higher tolerance to lodging.

Maize field day was organized at village Dhanpau in Dhanpau-Lakhwad cluster of Jaunsar tribal region of district Dehradun on September 7, 2017. A Krishak Gosthi was also held on the occasion. A total of 73 farmers from the adopted village cluster and neighbouring villages participated in the programme. The programme was also attended by state agricultural department officials. During the programme, the farmers were briefed about institute activities in the tribal cluster. Feedback of farmers on the performance of VMH 45 was also obtained. The farmers were also sensitized about the Sankalp Se Siddhi mission and were administered pledge to double agricultural income by 2022.

Establishment of farmer participatory seed production system

As part of the institute’s work plan to establish a farmer-participatory seed production system at local level, seed production of Kufri Himalini variety of potato and VL Bean 2 of Frenchbean was initiated in village Merag and Malari, respectively. A total of 4.5 quintals Breeder seed of Potato variety Kufri Himalini was procured from CPRI in 2016 and multiplied in Merag village for seed. During 2017, 37.5 quintals seed of the variety was made available to 29 tribal farmers of Merag village for further seed production. Monitoring and diagnostic visits were made to the village by the scientists for agricultural advisory services during the crop season. Apart from this, Malari and Gamshali villages of Joshimath block of Chamoli district were found suitable for seed production of bean, rajmash and pea. A total of 40 kg seed of VL Bean 2 was procured from village Malari, which will be multiplied further in 2018. For varietal demonstration of onion, garlic and garden pea in the region, more than 2 lakh seedlings of VL Piaz 3, 1.0 q seed of VL Lahsun 2 and 0.5 q seed each of VL Matar 10 and VL Matar 11 were distributed among farmers in Merag, Parsari and Badgaon tribal villages of Chamoli district. The feasibility of onion and garlic seed production in the area will also be studied.

7.5.2. Tribal Sub Plan (IISS Main Scheme) - Seed Production

A five days training programme on “Parvatiy fasalon ka beejotpadan evam krishigat udyam par kaushal evam udyamita vikas prashikshan” was organized during March 8-12, 2018 at ICAR-VPKAS experimental farm Hawalbagh for 29
farmers from 20 different villages of Lahaul Spiti district of the Himachal Pradesh. In the training programme farmers were imparted information on quality seed production of hill crops and emphasis was laid on entrepreneurship development in agriculture. Field and exposure visits were also organized for sharing practical experiences.

Three more farmers’ trainings were conducted during year 2017-18, on Gehun beejotpadan fasal mein kharpatriya niyantran dated November 11, 2017 attended by 34 famers; Gehun va masoor beejotpadan fasal mein keet evam rog niyantran on dated January 01, 2018 attended by 30 farmers and Gehun ki unnat utpadan takniki evam beejotpadan” was organized on March 16, 2018 which was attended by 35 farmers. All these three trainings were organized in the village Jhankat (Sitarganj block, Udham Singh Nagar district).

A krishak gosthi on ‘Gehun evam masoor ki unnat utpadan takniki va beejotpadan” was organized at village Jhankat (Sitarganj) on October 31, 2017 and seed of wheat varieties VL 804, VL Gehun 829, VL Gehun 907, VL Gehun 953 and lentil variety VL Masoor 126 along with fertilizers was distributed to fermers. In the gosthi, farmers were imparted information on scientific cultivation of wheat and lentil crop covering weed, nutrition and disease management.

The farmers were also informed about the practices to be adopted in quality seed production. Total 27 farmers and farm women took part in the programme. During the year wheat and lentil varieties were demonstrated in 13.0 and 0.5 ha, respectively, under seed production. Regular visits were made for monitoring of rouging operation in wheat and lentil seed production plots and distribution of propiconazole.
8. Success Stories

8.1. Eco-friendly White grub Management

The Challenge
White grubs are polyphagous insect pests of agriculture, forest, and pasture lands. It causes severe economic loss in upland paddy, finger millet, barnyard millet, maize, potato and many other vegetables, fruits, and fodder crops in the hills of North-Western Himalayan Region. The grubs feed on the roots and the adults feed on the leaves especially during night time. The damage caused by white grubs in terms of production loss in the North West Himalayan states is estimated to be around 0.34 million tonnes resulting in an estimated economic loss of Rs. 1.8 billion per annum. To contain this menace, farmers have been relying generally on application of broad spectrum insecticides, which are expensive, leave their residue and pollute the environment.

The Solution
To overcome this problem, ICAR-VPKAS, Almora has developed a two-pronged strategy i.e., VL white grub beetle trap-1 (Patented: IN290170) and entomopathogen, Bacillus cereus WGPSB2 for the management of adult beetles and white grubs, respectively.

The light trap attracts the adult beetles, which subsequently get hit and trapped in the collection pot. Continuous trapping of adult beetles reduces the egg laying and thus manage the pest. The biocontrol agent, B. cereus WGPSB2 was isolated from a diseased grub and found effective in causing mortality to the grubs. The bacteria formulated in a talc base are applied in the infested crop fields through farmyard manure. The bacteria are found biologically safe as tested by IITR, Lucknow and was found not to have any adverse effect on any soil microbes in the field. The technology of insect trap and entomopathogen, B. cereus is found effective in the laboratory and demonstrated in farmer fields in six adopted villages.

The Application
Light traps were installed in strategic locations @ 1-2 traps per ha and talc formulation of B. cereus @ 10 kg per ha was put in FYM pits and subsequently in the fields and found effective. Field application of B. cereus was made during May months on FYM pits and the FYM with the biocontrol agent was applied on the fields during June, targeting the first instar white grubs in the field. Light traps were lit from May to October months and during 7 PM to 10.30 PM targeting the adult beetles which emerge after the first monsoon showers.

The Impact
The light trap catches were found reducing drastically due to continuous capture of beetles.
The mean number of beetles trapped per light trap was 10,263 in first year which was reduced to 5,190 in second year and even to 812 in the sixth year of experimentation in different adopted villages. White grubs were found to be in the range of 0.20 per ft² during 2007 in different villages which was reduced to 0.05 per ft² during 2012 registering an average reduction of about 75% in 5 years of experimentation.

Avoided to get more yields. The increase in income to a farmer due to this technology is estimated to be a minimum of Rs. 4,500 per ha. Further, the beetles caught in the traps can also be used as poultry feed.

8.2. Enhancing Water Use through Low Cost Poly Lined Water Harvesting Tanks

The Challenge
Though number of rivers originates from the hills, majority of the cultivated area in hills are rainfed as lift water irrigation facilities are meagre. There occur number of perennial water springs in various hilly areas, but they also cannot be used for irrigation purpose due to very low discharge. One of the effective ways to utilize this water as well as rain water for crop cultivation and other uses is to harvest this water in storage tanks. The tanks made of concrete also do not serve the purpose as invariably they develop cracks due to frequent tremors experienced in hilly areas resulting in seepage losses.

The Solution
Keeping these facts in view the institute has developed a very low-cost technology to harvest the water through poly lined tanks which tolerates tremors and reduce seepage losses. These tanks have a long life when poly lining is pitched by river boulders or low-cost blocks. The stored water can be utilized for irrigation and fish cultivation. Tanks of 20 to 500 m³ size and of trapezoidal shape having slope of 1:1 with 1 to 1.5-meter depth were made as per the farmer’s need. The tanks are lined with LDPE 200 to 400 micron (800 -1000 gauge) /200 to 250 GSM multilayered cross laminated silpaulin film. The pitching material is made of locally made cement blocks (local sand+ cement+ small stone/gravels) or river boulders.

The Application
The technology is disseminated in more than 25 villages through 341 demonstrations on
325 beneficiary’s fields in different districts of Uttarakhand by ICAR-VPKAS, Almora through various projects. This is widely adopted technology by hill farmers. One-liter water storage cost comes Rs. 1.20/- of 25 m³ tank and Rs. 0.7/- of 500 m³ tank lined with silpaulin and pitched with blocks, which is very economical in comparison to cement tank cost Rs. 5/- and ferro cement Rs. 15/- per liter of water.

**The Impact**

The multiple water use model which include 100 m³ water tank for fish farming, irrigation, poultry farming, cattle rearing, fruit (kiwi), vegetable and azolla cultivation. The estimated gross returns of Rs. 6.0 lakh from 4000 m² land by adopting above package. Farmers earned (gross income) around Rs. 1 to 1.5 lakh through fish, vegetable and kiwi cultivation by constructing tanks. The livelihood security can be insured by constructing tank and by adopting multiple water use model.

### 8.3. Save the Forest by Iron Plough: Replacement of Wooden Plough with Iron

**The Challenge**

In hills the crop is cultivated in small size of terraces of irregular shape and sizes, which are undulating and generally far away from road making the mechanization very difficult. Owing to this reason, the tractors are seldom used for land preparation and in majority of the area ploughing is done by bullock drawn traditional plough. The traditional plough is entirely made up of wood and almost three green trees are cut for manufacturing of one wooden plough. This is a great threat to the forest as the wood used in preparing the plough is of the tress like Quercus sp., Anlus nepalensis etc., which conserve the soil moisture.

**The Solution**

The institute therefore took initiative, has designed, and developed a completely iron plough named as “VL Syahi Hal”. The plough is environment friendly as every component is metallic, saves trees, efficient in ploughing and ergonomically better for the bullocks. It has adjustments for positioning as per the working height of farmer and controlling the depth of ploughing.

**The Application**

The large-scale adoption of “VL Syahi hal” accrued many benefits to the farmers/stakeholders. It has helped in preserving oak trees in hilly terrain, which play an important role in preserving water resources, fodder for livestock and organic diversity. The major visible achievements are that it is more durable due to all metallic components as there is frequent breakdown of the wooden ploughs, thereby interrupting the operation and more time wastage in repair. The fuse bolt with wing nut is provided to overcome any damage due to obstruction while ploughing. If any stone or roots come while ploughing, it gets bent or
breaks down without damaging the body of the plough. The additional advantage is that it is two-in-one type, in which both ploughing as well as planking work can be done. Depth of operation can also be controlled by beam angle adjustment and rake angle adjustment. It can also take a seed metering unit as an attachment thereby reducing wastage of seed and at the same time maintaining proper density of crops.

**The Impact**

Yield of wheat was recorded highest when sown with VL Syahi hal (48.5 q/ha) followed by seed-cum-ferti drill (46.1 q/ha) and row maker (42.5 q/ha) as compared to broadcasting (32.5 q/ha) at farmers field. The draft observed was 10-20% higher in local hal than “VL Syahi hal”. Working efficiency is higher (150%) in comparison the traditionally used wooden hal. The operator also feels comfortable (HR: 68-72 beats/ min) as compared to local hal (72-76 beats/ min) after one hour of operation and bullocks also showed less fatigue with VL Syahi hal as compared to local hal because of its less weight (11-13 kg). A total of 200 demonstrations were made in 60 villages with more than 3500 beneficiaries. Because its eco-friendly nature, export avenues exist in neighboring countries (Nepal and Bhutan) having similar hill terrain. Also, there is scope to earn C credit as it discourages the deforestation. Its acceptance in Uttarakhand is evident from the fact that more than 3500 VL Syahi hal have been sold till now by different license firms.

8.4. Doubling Farmers Income by Agricultural Diversification

**The Challenge**

Hill farmers mostly engage in rain fed crop cultivation with low crop productivity. They usually grow cereal crops and do sustenance farming. The major hurdle for farming in Uttarakhand hills is the non-availability of water and other inputs like improved seeds, fertilizers and technical guidance.

**The Solution**

To make the farming system lucrative, ICAR-VPKAS, Almora has adopted a village, Bhagartola which is 50 km away from Almora. All the crop production and protection technologies are put in the village for its wholistic development. Water is made available by construction of poly tanks and off-season vegetable cultivation is promoted by polyhouses.

**The Application**

With the initiative of the institute to disseminate improved vegetable production technologies, now in these villages there are more than hundred poly-houses and poly-tanks formed with active participation of farmers. Each polyhouse connected with the polytank for providing irrigation facility for seasonal and off-seasonal vegetable production (tomato, cabbage, cucumber, capsicum, squash, cauliflower and pea).

Due to favourable climatic conditions in the village for vegetable production, the institute
succeeded to convince farmers for commercial vegetable production from traditional and subsistence farming. Protected cultivation of vegetables has offered distinct advantage of quality, productivity and favorable market price to the growers. Besides these, fruits like kiwi, peach, plum etc. were also being produced. Some of the poly tanks are also being used for fish rearing.

Farmers were motivated to form two farmers club and two Self Help Groups. Due to these achievements, local banks are interested in providing loans for the members of these clubs and SHGs. These SHGs are providing banking access to poor and marginal farmers who have not been benefited by any other government schemes. They are saving some amount regularly on monthly basis. The corpus fund thus created is being used for financing among themselves. Total saving of Farmes’ clubs and SHGs is
more than Rs. 3,00,000 in banks. They have made very strong credit linkages with banks, motivates villagers for proper use of credit and timely repayment of bank credit. In order to ensure credit flow to the neediest poor farmers, farmers’ clubs were instrumental in formation of Joint Liability Groups (JLGs) with NABARD assistance. Through these Joint Liability Groups farmers were able to get financial assistance from Gramin Kshetriya Banks for agricultural related activities. These farmers’ clubs are regularly coordinating with banks to ensure credit flow among its members and forge better bank borrower relationship. These club members are collectively getting training and support on improved technologies from the institute and other agencies like state departments and banks.

The Impact
Due to these interventions of the institute, the entire village has shifted from sustenance farming to commercial agriculture.

Various farmers groups under NGOs and state government visit these areas for getting exposure in the field of improved agriculture technology in hills. Some farmers have been recognized by ICAR, State government and the Institute for adopting improved agricultural production technology in hill farming and their contribution in efficient transfer of technology to other farmers.

With the objective of linking the farmers to markets, institute in collaboration with NABARD formed Farmers Producer Organisation “Vivekananda Krishi Utapadan Swayatt Sahkarita” Jageshwar. In this FPO, farmers from nearby villages were also included in order to promote them for enhanced livelihood security. With the formation of FPO, members are undertaking collective purchase of seeds, fertilizers, insecticides and marketing of agriculture produce.

Transportation charges are reduced as vegetables and other agriculture produce are collectively transported to the local market. ICAR-VPKAS, Almora by extending the improved horticultural technologies at the farmers field, enhanced the livelihood of the farmers in the region which in-turn reduced the migration of farmers from hills. With all these efforts carried out by the institute and farmers of the village, Bhagartola has become a model village.
9. Farmers’ Feedback

Farmers Feedback on Various Programmes of ICAR-VPKAS

Two interventions made by the institute (maize hybrid VMH 45 and small maize sheller) have brought about a significant change in maize cultivation in my village. VMH 45 gave higher grain yield and green fodder yield, which saved much of our time otherwise spent on fodder collection. The maize sheller has reduced shelling time by 8-10-fold compared to traditional drudgery prone manual shelling.

Smt. Meena Devi Tomar
Village - Dhanpur - Lakhwad

I left my taxi driver job and became a full-time farmer after coming in contact with the institute. Today I have 12 poly-houses, poly-tanks and cultivating vegetables to earn much profit for better livelihood. After adopting institute technologies, I received innovative farmer award from state government and also from many other institutions.

Mr. Harish Chandra Pandey
Village - Bhagartola

I cultivated wheat varieties like VL Gehun 907 and VL 804 and got a good crop with very high yield than any of the wheat varieties I used to grow earlier. We were encouraged to produce quality seeds as profitable venture. With the help of the institute we formed a club, ‘Rana Kisan Club’ for participatory seed production. Kisan Club also provided platform for marketing our traditional handicraft items.

Mrs Parveen Devi
Village - Jhanakat

I used to grow millets for a long time. The institute’s varieties of finger millet (VL Mandua 352 and VL Mandua 324) and barnyard millet (VL Madira 172) gave about 20% more yield than any of the local cultivars. Seeing good crop in my field, many of my fellow farmers asked for improved variety seeds and got benefitted. Now this whole cluster of Tunakot and Tipola is growing ICAR-VPKAS varieties and getting high yield and inturn good income.

Mr. Bheem Singh
Village - Tipola

I am happy now because I am earning more money by adapting integrated farming. It gave me higher production of grain, vegetable, fodder and honey. Besides, I can stay with my family and give them fresh and nutritious food. The change in my village after the start of NMSHE programme would compel other migrated villagers to give a second thought.

Mr. Har Singh
Village - Jur-Kafun
10. Trainings & Capacity Building

Training of Institute Staff at other Institutes

The following institute personnel were deputed for different HRD programmes as per Annual Training Plan (ATP) during 2017-18.

Table 10.1. Details of trainings undergone by institute staff

<table>
<thead>
<tr>
<th>Duration</th>
<th>Participant</th>
<th>Topic</th>
<th>Venue</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 15 - May 14, 2017</td>
<td>Dr. Jitendra Kumar</td>
<td>Institute Orientation Training</td>
<td>ICAR-VPKAS, Almora</td>
</tr>
<tr>
<td>May 15 - August 14, 2017</td>
<td>Dr. Jitendra Kumar</td>
<td>Professional Attachment Training</td>
<td>ICAR-IISWC, Dehradun</td>
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<tr>
<td>July 03-07, 2017</td>
<td>Dr. Jitendra Kumar</td>
<td>Water conservation practices through adaptation of appropriate management and technological interventions: a practitioner's approach</td>
<td>NIH- Roorkee</td>
</tr>
<tr>
<td>July 05 - October 04, 2017</td>
<td>Mr. Manoj Parihar</td>
<td>Foundation Course for Agricultural Research Service</td>
<td>ICAR-NAARM, Hyderabad</td>
</tr>
<tr>
<td>July 5 - October 4, 2017</td>
<td>Dr. Hanuman Ram</td>
<td>Foundation Course for Agricultural Research Service</td>
<td>ICAR-NAARM, Hyderabad</td>
</tr>
<tr>
<td>July 6-26, 2017</td>
<td>Dr. R.S Pal</td>
<td>ICAR sponsored summer school on Analytical, instrumental and imaging techniques relevant to food safety management</td>
<td>ICAR-CIAE, Bhopal</td>
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<tr>
<td>July 25-26, 2017</td>
<td>Dr. Dibakar Mahanta</td>
<td>Training on Stability/combined analysis methodology for NPOF experimental data</td>
<td>ICAR-IIFSR, Modipuram</td>
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<tr>
<td>September 4-7, 2017</td>
<td>Dr. Renu Jethi</td>
<td>Training on Navigating ICTs for Agricultural Extension</td>
<td>MANAGEMENT, Hyderabad</td>
</tr>
<tr>
<td>September 05-25, 2017</td>
<td>Dr. R.P. Yadav</td>
<td>Summer school training programme on Developing strategies for doubling farm income in low rainfall areas</td>
<td>ICAR-CAZRI, Jodhpur</td>
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<tr>
<td>September 11-20, 2017</td>
<td>Mr. Mahipal Choudhary</td>
<td>Training on Experimental designs and statistical data analysis</td>
<td>ICAR-IASRI, New Delhi</td>
</tr>
<tr>
<td>October 12-November 13, 2017</td>
<td>Dr. Hanuman Ram and Mr. Manoj Parihar</td>
<td>Institute Orientation Training</td>
<td>ICAR-VPKAS, Almora</td>
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<tr>
<td>October 24-November 13, 2017</td>
<td>Dr. J.P. Aditya</td>
<td>Training on Enhancing germplasm use through prebreeding, evaluation and frontier</td>
<td>PAU Ludhiana</td>
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<tr>
<td>November 15, 2017 - February 15, 2018</td>
<td>Dr. Hanuman Ram</td>
<td>Professional Attachment Training</td>
<td>ICAR-NBPGR, New Delhi</td>
</tr>
<tr>
<td>Duration</td>
<td>Participant</td>
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<tr>
<td>November 16 - December 6, 2017</td>
<td>Dr. V.S. Meena</td>
<td>ICAR Sponsored Training Workshop on Advances in simulation modeling and climate changes research towards knowledge-based agriculture</td>
<td>ICAR-IARI, New Delhi</td>
</tr>
<tr>
<td>November 16, 2017 - February 15, 2018</td>
<td>Mr. Manoj Parihar</td>
<td>Professional Attachment Training</td>
<td>ICAR-IISS, Bhopal</td>
</tr>
<tr>
<td>November 30, 2017</td>
<td>Dr. P.K. Mishra</td>
<td>One day training-cum-awareness workshop on J-Gate @ CeRa for Northern Region</td>
<td>DKMA, New Delhi</td>
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<tr>
<td>December 28, 2017 - January 17, 2018</td>
<td>Dr. B.M. Pandey</td>
<td>CAFT on Recent developments in statistical modelling and forecasting in agriculture</td>
<td>ICAR-IIFSR, Modipuram</td>
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<td>December 29, 2017- January 18, 2018</td>
<td>Dr. Rajashekara, H.</td>
<td>CAFT training program on Whole genome sequencing of plant pathogens: Methods and Applications</td>
<td>ICAR-IARI, New Delhi</td>
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<tr>
<td>January 22, 2017 -February 02, 2018</td>
<td>Dr. R.K. Khulbe</td>
<td>DST-GoI sponsored training programme on Managing Innovation and Technology for Competitiveness</td>
<td>ASCI, Hyderabad</td>
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<td>February 02-22, 2018</td>
<td>Dr. Venkatesan, M.</td>
<td>CAFT training program on Bio-pesticides for crop protection and improvement: Emerging technology to benefit farmers in Department of Plant Pathology</td>
<td>GBPUA&amp;T, Pantnagar, Uttarakhand</td>
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<tr>
<td>February 13, 2018 - March 05, 2018</td>
<td>Drs. N.K. Hedau &amp; Chaudhari Ganesh Vasudeo</td>
<td>Winter school training programme on Molecular breeding for higher productivity, quality, food colorants, nutraceutical and bioactive health compounds in vegetable crops</td>
<td>ICAR-IARI, New Delhi</td>
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<tr>
<td>March 06-19, 2018</td>
<td>Dr. K.K. Mishra</td>
<td>Training program on Management of plant genetic resources</td>
<td>ICAR-NBPGR, New Delhi</td>
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</table>

**Technical Staff**

<table>
<thead>
<tr>
<th>Duration</th>
<th>Participant</th>
<th>Topic</th>
<th>Venue</th>
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<tr>
<td>September 13-22, 2017</td>
<td>Mr. O.P. Vidhyarthi</td>
<td>Training Programme on Competence enhancement on motivation and positive thinking</td>
<td>ICAR-NAARM, Hyderabad</td>
</tr>
<tr>
<td>September 18-27, 2017</td>
<td>Dr. Pankaj Nautiyal</td>
<td>Training on Application of remote Sensing and GIS in NRM for technical officials</td>
<td>ICAR-IISWC, Dehradun, Uttarakhand</td>
</tr>
<tr>
<td>September 19-23, 2017</td>
<td>Sh. Vikram Singh</td>
<td>Competency enhancement programme on automobile maintenance, road safety and behavioural skill development for vehicle drivers of ICAR</td>
<td>ICAR-CIAE, Bhopal</td>
</tr>
<tr>
<td>September 22-27, 2017</td>
<td>Ms. Renu Sanwal</td>
<td>Training Programme on Computer Application for technical Staff of ICAR</td>
<td>ICAR-IASRI, New Delhi</td>
</tr>
<tr>
<td>September 22-29, 2017</td>
<td>Mr. H.C. Joshi</td>
<td>Model Training Course on Climate resilient agro-technologies for enhanced crop and water productivity under water- deficit agro-ecologies</td>
<td>ICAR-IARI, New Delhi</td>
</tr>
<tr>
<td>Duration</td>
<td>Participant</td>
<td>Topic</td>
<td>Venue</td>
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<tr>
<td>October 03-10, 2017</td>
<td>Smt. Nidhi Singh</td>
<td>Integrated crop management practices for enhancing productivity, resource-use efficiency, soil health and livelihood security</td>
<td>ICAR-IARI, New Delhi</td>
</tr>
<tr>
<td>October 03-12, 2017</td>
<td>Sh. Prahlad</td>
<td>Training on Layout and maintenance of field experiments and recording observation</td>
<td>ICAR-IARI, New Delhi</td>
</tr>
<tr>
<td>November 27 - December 01, 2017</td>
<td>Sh. Birendra Puri Gosami</td>
<td>Automobile Maintenance, Road Safety and Behavioural Skills&quot; for Regular Drivers in Technical grades of ICAR</td>
<td>ICAR-CIAE, Bhopal</td>
</tr>
<tr>
<td>December 05-18, 2017</td>
<td>Sh. Narayan Ram, Sh. Chandan Singh Kanwal and Sh. Ramesh Singh Kanwal</td>
<td>Training on Good agricultural practices for enhancing resource - use efficiency and farm productivity</td>
<td>ICAR-IARI, New Delhi</td>
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<td><strong>Administrative staff</strong></td>
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<tr>
<td>August 18, 2017</td>
<td>Mrs. Radhika Arya</td>
<td>Orientation Training Programme on Goods and Service Tax</td>
<td>ISTM, New Delhi</td>
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<td>August 28-29, 2017</td>
<td>Mr. H.L. Meena</td>
<td>EAT modules of PFMS from Central Sector Schemes</td>
<td>INGAF, New Delhi</td>
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<tr>
<td>August 30 - 01 September, 2017</td>
<td>Mr. Y.S. Dhanik,</td>
<td>General Financial Rules-2017 for officers of ICAR</td>
<td>ISTM, New Delhi</td>
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<td>December 18-20, 2017</td>
<td>Mr. Abhinav Singh</td>
<td>Advanced MS-Excel for Officers and Staff</td>
<td>ISTM, New Delhi</td>
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<td>January 05-11, 2018</td>
<td>Mr. C.C. Joshi</td>
<td>Enhancing efficiency and behavioural skills of stenographers Grade-III, FA, PS, PPS and Sr. PPS of ICAR</td>
<td>ICAR-NBSS&amp;LUP, Regional Centre, Kolkata</td>
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11. Awards & Recognitions

- The Institute contingent participated in the ICAR North Zone Sports Tournament – 2017 held at ICAR-Indian Institute of Sugarcane Research, Lucknow from 30 October to 02 November 2017 and bagged 13 medals (7 Gold, 3 Silver and 3 Bronze) in different events. Overall, the Institute stood 2nd among 24 participating institutes in the tournament. Miss Manisha Arya was judged the best women player as well as best athlete of the tournament. The gold medals were won by Miss Manisha Arya (100 m race, 200 m race, long jump, single’s badminton), Miss Usha Birdi (Chess), Dr. Vijay Singh Meena (Javellin throw) and women’s double badminton jointly by Miss Manisha Arya and Usha Birdi. A team comprised of Drs. Rajeshakra H., V.S. Meena, Mahipal Choudhary and Shyam Nath won silver medal in 4 x 100 m (men) relay race.
The Institute contingent participated in the ICAR Inter-Zonal Sports Tournament – 2017 held at ICAR–National Academy of Agricultural Research Management, Hyderabad from February 21 – 25, 2018 and bagged 5 medals (1 Gold, 3 Silver and 1 Bronze) in different events. Ms. Usha Birdi won gold medal in chess (women). Miss Manisha Arya won silver medals in 200 m race and single's badminton while Dr. Vijay Singh Meena won bronze medal in Javelin throw. The silver medal of women's double badminton was won by Miss Manisha Arya and Usha Birdi.

Dr. D.C. Joshi was awarded Australian Centre of International Agricultural Research (ACIAR) Scholarship 2017.

Dr. Sher Singh got first position for invited lecture in the seminar on “Emerging trends in Hi-tech hill horticulture in changing climate” at CITI Regional Station, Mukteshwar during March 06-07, 2018.

Dr. Nirmal Chandra received Outstanding Scientist Award (2017) in “IJTA 5th International Conference on Agriculture, Horticulture, and Plant Science” held at Rishikesh, Uttarakhand during June 24-25, 2017.

Dr. Anirban Mukherjee received Young Scientist Award by Indian Society of Extension Education in the ISEE National Seminar on “Doubling farmers' income and farm production through skill development and technology application” held at Bihar Agricultural University, Sabour, Bhagalpur, Bihar during November 28-30, 2017.

Dr. J. Stanley received Outstanding Scientist in Agricultural Entomology from Venus International, Chennai on November 11, 2017.

Dr. K.K. Mishra and Mr. Tilak Mondal received Best Poster Award in National symposium on “Mushrooms trends and innovations in mushroom science” at ICAR-DMR, Solan during April 27-28, 2017.

Dr. Anuradha Bhartiya and Dr. V.S. Meena received Dr. Boshi Sen Memorial Award for “Best Scientific Staff” for year 2016-17 on July 04, 2017.

Mr. Harish Chandra Joshi, SMS-Plant Protection, KVK Bageshwar received Prof. Boshi Sen memorial award for Outstanding Technical Staff.
Mr. Medni Pratap Singh, Farm Manager, KVK Bageshwar received Prof. Boshi Sen memorial award for Outstanding Technical Staff.

Sri Anand Singh Adhikari and Sri Surendra Singh Gwal were awarded for their outstanding work. Sri. N.C. Belwal and Sri Pan Ram were also awarded for their services to the Institute.

Dr. Sher Singh, Dr. N.K. Hedau and Er. D.C. Mishra were felicitated for their special assignments.

Dr. Renu Jethi received Best Poster Award in 1st International Extension Education Congress on “New Horizons of Extension: Challenges and Opportunities” at Bhubneshwar during February 1-3, 2018.

KVK-Bageshwar received second prize in Krishi Vikas Pradarshani during Uttarayani Mela 2018 at Bageshwar.

KVK-Bageshwar received third prize in agriculture exhibition in Kisan Mela organized by ILSP Ajeevika and agriculture department Bageshwar jointly at Bageshwar.
12. Linkages & Collaborations

The Institute has effective linkage and collaboration with the following organizations:

12.1. Local Institution in the Area
- Defence Institute of Bio-energy Research (DIBER), Haldwani, Uttarakhand.

12.2. National Institutes and Agricultural Universities
- ICAR-Indian Agricultural Research Institute, New Delhi.
- ICAR-Central Rice Research Institute, Cuttack, Odisha.
- ICAR-Indian Institute of Wheat & Barley Research, Karnal, Haryana.
- ICAR-Indian Institute of Rice Research, Hyderabad, Telangana.
- ICAR-Indian Institute of Maize Research, Ludhiana, Punjab.
- ICAR-Indian Institute of Pulses Research, Kanpur, U.P.
- ICAR-Indian Institute of Soil and Water Conservation, Dehradun, Uttarakhand.
- ICAR-Central Institute of Temperate Horticulture, Mukteshwar, Uttarakhand.
- ICAR-National Bureau of Agriculturally Important Microorganism, Mau, U.P.
- G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand.
- CSK-Himachal Pradesh Krishi Vishwa Vidyalaya, Palampur, H.P.
- Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, H.P.
- Sher-e-Kashmir University of Agriculture & Technology, Srinagar, J&K.
- ICAR-National Centre for Integrated Pest Management, New Delhi.
- ICAR-Central Institute of Post Harvest Engineering and Technology, Ludhiana, Punjab.
- ICAR-Central Institute of Agricultural Engineering, Bhopal, M.P.

12.3. International Organizations
- IRRI, Manila, Philippines
- CIMMYT, Mexico
- ICRISAT, Hyderabad, India
- ICARDa, Syria
- ICIAR through ICAR-ACIAR Work plan.

12.4. Extension & Development Agencies
- State Department of Agriculture, Uttarakhand.
- Indian Farmers Fertilizer Cooperative.
- National Agricultural Bank for Rural Development.
- Mahindra & Mahindra Subh Labh Services.
- Private agencies
- NGOs
- Food Corporation of India (FCI)
- Department of Agricultural and Cooperation
13. Important Committees of The Institute

13.1. Committees

13.1.1. Academic Council

Chairman – Director

Members (Official Side) – Dr. K.R. Dhiman, Ex. Vice Chancellor, Dr. Y.S. Parmar University of Horticulture & Forestry, Nauni, Solan (H.P)

Members (Staff Side) – Dr. B.M. Pandey, Pr. Scientist; Renu Jethi, Scientist; Mr. Y.S. Dhanik, Senior Administrative Officer; Mr. H.L. Meena, Administrative Officer; Mr. Tej Bahadur Pal, ACTO; Mrs. Radhika Arya, Assistant Administrative Officer

13.1.2. Research Advisory Committee (RAC)

Chairman – Dr. K.R. Dhiman, Ex. Vice Chancellor, Dr. Y.S. Parmar University of Horticulture & Forestry, Nauni, Solan (H.P)

Members – Assistant Director General (FFC), Indian Council of Agricultural Research, Krishi Bhawan, New Delhi; Dr. J.P. Singh, Professor (Horticulture), GBPUA&T, Pantnagar, Uttarakhand; Dr. Arun Kumar Sharma, Ex. Director, ICAR-NBAIM, Mau, U.P.; Dr. B.S. Mahapatra, Professor (Agronomy), GBPUA&T, Pantnagar, Uttarakhand; Dr. K.K. Satpathy, Ex. Director, ICAR-NIRJAFT, Kolkata; Dr. H.C. Bhattacharyya, Director Extension, Assam Agricultural University, Jorhat, Assam; Director, ICAR-VPKAS, Almora, Uttarakhand.

Member Secretary – Dr. J.K. Bisht, Pr. Scientist & In-Charge (PME Cell)

13.1.3. Institute Management Committee (IMC)

Chairman – Director, ICAR-VPKAS, Almora

Members – Assistant Director General (Seeds), ICAR, New Delhi; Joint Director of Agriculture, Govt. of Uttarakhand; Director of Agriculture, Govt. of Jammu & Kashmir; Director, Directorate of Extension Education, GBPUA&T, Pantnagar; Dr Sanjay Kumar, Principal Scientist, ICAR-Indian Agricultural Institute, New Delhi; In-Charge, NBPGR Regional Station, Nainital; Dr. J.K. Bisht, ICAR-VPKAS, Almora; Dr. Lakshmi Kant, ICAR-VPKAS, Almora; The Finance & Accounts Officer, IVRI, Bareilly

Member Secretary – Administrative Officer

13.1.4. Institute Technology Management Committee (ITMC)

Chairman – Director

Members – All the Scientists of ICAR- VPKAS, Almora

Member Secretary – In-charge (PME Cell)
Members – Head, Crop Improvement; Head, Crop Production; Dr. Prem Kumar, Pr. Scientist, ICAR-DCFR, Bhimtal; In-charge (PME Cell)

Member Secretary – Dr. Lakshmi Kant, Pr. Scientist

13.7. Institute Technology Management Unit (ITMU)
Chairman – Dr. Lakshmi Kant, Pr. Scientist & Head, Crop Improvement Division

Members – Drs. J.K. Bisht, Pr. Scientist & I/c Head, Crop Production Division; R.K. Khulbe, Sr. Scientist; Sher Singh, Sr. Scientist; Finance and Accounts Officer

13.8. Study Leave Committee
Chairman – Dr. Lakshmi Kant, Pr. Scientist & Head (CID)

Member – Drs. K.K. Mishra, Pr. Scientist and Sher Singh, Sr. Scientist

13.9. PERMISNET/PIMSICAR/HYPM
Nodal Officer – Dr. Renu Jethi, Scientist

13.10. Committee for Monitoring of Field Experiments
Chairman – Director, ICAR-VPKAS, Almora

Members – All the Scientists of ICAR-VPKAS, Almora

Member Secretary – In-charge (PME Cell)

13.11. Vigilance Cell
Dr. K.K. Mishra, Pr. Scientist

13.12. Grievance Cell
Chairman – Dr. Lakshmi Kant, Pr. Scientist & Head (CID)

Members – Dr. Anuradha Bhartiya, Scientist; Farm Coordinator; Administrative Officer; Finance & Accounts Officer

13.13. Women Cell
Chairman – Dr. Renu Jethi, Scientist

Members – Dr. N.K. Hedau, Pr. Scientist; Smt. Anju Pangti, Announcer, AIR, Almora; Shri. H.L. Meena, I/c FAO; Mrs. Radhika Arya, Assistant Administrative Officer

13.14. Purchase Advisory Committee (PAC)
Chairman – Dr. P.K. Mishra, Pr. Scientist

Members – Drs. B.M. Pandey, Pr. Scientist; Dibakar Mahanta, Scientist; Finance & Accounts Officer; Administrative Officer

Member Secretary – Assistant Administrative Officer (Store)

13.15. Standing Purchase Committee (SPC)
Chairman – Dr. J.K. Bisht, Pr. Scientist & I/c Head (CPD)

Members – Dr. A.R.N.S Subbanna, Scientist; Finance & Accounts Officer; Administrative Officer

Member Secretary – Assistant Administrative Officer (Store)

13.16. Technical Vetting/Screening Committee
Chairman – Dr. R.K. Khulbe, Sr. Scientist

Members – Drs. J. Stanley, Scientist; J.P. Aditya, Scientist; Renu Jethi, Scientist; Finance & Accounts Officer; Administrative Officer

Member Secretary – Assistant Administrative Officer (Store)

13.17. Institute Bio-safety Committee (IBSC)
Chairman – Director, ICAR-VPKAS, Almora

Members – Dr. S.K. Nandi, Scientist (F), GBPNIHESD, Kosi-Katarmal (DBT nominee); Dr. Ila Bisht, Professor & Head, Kumaon
13.18. House Allotment Committee
Chairman – Dr. J.K. Bisht, Pr. Scientist and I/c Head (CPD)
Members – Dr. B.M. Pandey, Pr. Scientist; Mr. H.L. Meena, Administrative Officer
Member Secretary – Mr. T.B. Pal, ACTO

13.19. Public Information Cell
Public Information Officer – Dr. J.K. Bisht, Pr. Scientist & I/c Head, CPD; Dr. B.M Pandey, Pr. Scientist; Shri Y.S. Dhanik, Senior Administrative Officer.

13.20. Public Information Officer (KVK, Chinyalisaur and Bageshwar)
Program Coordinator, KVK, Bageshwar
Program Coordinator, KVK, Uttarkashi

13.21. SSC NARS
Nodal Officer – Dr. Kushagra Joshi, Scientist

13.22. mKisan
Supervisor – Dr. Nirmal Chandra, Pr. Scientist & In-charge, Social Science Section

13.23. Institute Swachchhta Abhiyan Committee
Chairman – Dr. Nirmal Chandra, Pr. Scientist & In-charge, Social Science Section
Member – Dr. Kushagra Joshi, Scientist and Mr. T.B. Pal, ACTO

13.24. Human Resource Development
Nodal Officer – Dr. P.K. Mishra, Pr. Scientist

13.25. Research Data Management
Nodal Officer – Dr. P.K. Mishra, Pr. Scientist
Co-Nodal Officer – Dr. Renu Jethi, Scientist
Members – Drs. Sher Singh, Sr. Scientist and K.K. Mishra, Pr. Scientist

13.26. Institute Germplasm Identification Committee
Chairman – Dr. L. Kant, Pr. Scientist & Head, Crop Improvement Division
Member – Drs. P.K. Mishra, Pr. Scientist; K.K. Mishra, Pr. Scientist and R.K. Khulbe, Sr. Scientist

13.27. Innovation Cell
Nodal Officer – Dr. P.K. Mishra, Pr. Scientist
Members – Dr. Renu Jethi, Scientist; I/c Finance & Accounts Officer; Administrative Officer
## 14. List of Publications

### 14.1. Scientific Paper Published in Peer Reviewed Journals/ Proceedings

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<th>Research Papers</th>
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14.2 Papers in Proceedings


14.3. Book/ e-Book


14.4. Popular Articles


**14.5. Book Chapters**


14.6. Institute Publications
- *Krishi Calender 2018*
- VPKAS Newsletter Vol. 21 (No. 1 & 2) 
- ICAR-VPKAS Profile

14.7. Extension Literature
- पौधालावस एवं पौधाला चालन की निर्दिष्ट (100/2017)
- मंदुनाटा मालिश हेतु विवेक गिलेट शेखर एवं पर्यव (101/2017)
- कृषि प्रसंस्करण संग्रह (105/2017)
- भगर्नेत्र विकास के पथ पर : संस्थान द्वारा सकल प्रवास (112/2017)
- Wheat Package of practices for higher productivity (106/2017)
- Barley Package of practices for higher productivity (107/2017)
- स्वीटकॉर्न की वैज्ञानिक खेती (108/2017)
- बेबीकॉर्न की वैज्ञानिक खेती (109/2017)
- मक्का उत्पादन की उन्नत तकनीकी (110/2017)
- एकत्र क्राः संक्रमण मक्का का बीज उत्पादन (111/2017)
- संक्रमण से सिद्धि

14.8 Technical Bulletin

14.9. T. V. Talk
- Millet Field Cultivation at Tunakot, Tipola, Almora on 19th May TV Talk, Chaupal, DD Kisan, New Delhi
- *Parvatiya kshetron mein Plasticulture ki kheti*
- *Parvatiya kshetron mein Krishri Yantra*
- *Parvatiya kshetron mein Chava upadana*
- Bhagartola under MGMG and HMNEH programme 19th June TV Talk, Chaupal, DD Kisan, New Delhi
- Soil Health Card, PMFBY, Swachata Abhiyan at ICAR-VPKAS, Almora on 20th May TV Talk, Chaupal, DD Kisan, New Delhi
- Ginger & Turmeric Farming in hilly areas on 4th October TV Talk, Chaupal, DD Kisan, New Delhi
- Integrated Pest Management on 4th October TV Talk, Chaupal, DD Kisan, New Delhi
- Water Conservation & Irrigation Management in hilly area on 4 October TV Talk, Chaupal, DD Kisan, New Delhi
- Fodder tree management in hills on 4th October TV Talk, Chaupal, DD Kisan, New Delhi
- *Parvatiya kshetron mein grutva adharith sichai pranali*

14.10. Peer recognition to ICAR-VPKAS Scientists as Receivers of Articles

**Above NAAS Rating 8**

**Above NAAS Rating 7**
- Journal of Microbiology (7.92), Crop Protection (7.83), Journal of Economic Entomology (7.82), Environmental Monitoring and Assessment (7.69), Scientia Horticulture (7.62), Current Microbiology (7.32), 3Biotech (7.36).
15. List of Ongoing Projects

15.1. Institute’s Core Research Projects from October 2017

15.1.1. Enhancement in the Productivity of Major Hill Crops
- Genetic Enhancement of Maize for Yield and Nutritional Quality Using Integrated Breeding Approach (Dr. R.K. Khulbe, PI)
- Enhancement of Genetic Potency of Rice for Productivity, Biotic and Abiotic Stresses for North-West Himalaya (Dr. J.P. Aditya, PI)
- Genetic Improvement of Wheat and Barley for Higher Productivity, Quality Traits, Abiotic and Biotic Stresses (Dr. Lakshmi Kant, PI)
- Trait Mining and Genetic Improvement of Small Millets and Potential Crops in the Context of Climate Change (Dr. D.C. Joshi, PI)
- Enhancement of Genetic Potency in Important Vegetable Crops for North-West Himalayan Ecosystem (Dr. Dibakar Mahanta-PI)
- Genetic Improvement of Pulses & Oilseeds for Higher Productivity, Quality, Biotic and Abiotic Stresses for North-Western Himalayan Hills (Dr. Anuradha Bhartiya, PI)
- Germplasm Evaluation in Major Hill Crops for Nutritional and Physiological Parameters through Basic Techniques (Dr. R.S. Pal, PI)

15.1.2. Natural Resource Management for Enhancing the Productivity
- Crop Management for Higher Soil Quality and Sustainability in Indian Himalayas (Dr. Dibakar Mahanta-PI)
- Enhancing Productivity and Profitability of Major Hill Crops through Efficient Resource Utilization (Dr. Sher Singh, PI)
- Agro-forestry and Fodder Production Management with Emphasis on Utilization of Marginal Lands in Hills (Dr. J.K. Bisht, PI & Sub-project PI - Dr. R.P. Yadav)
- Water Harvesting and Effective Utilization of Water for Enhancing Crop Productivity and Input Use Efficiency (Dr. S.C. Panday, PI)
- Farm Mechanization and Post-harvest Management for Mountain Regions (Er. Shyam Nath, PI)

15.1.3. Integrated Management of Diseases and Pests of Hill Crops
- Studies on Physico-chemical Properties and Microbial Dynamics of Compost and Casing Soil in Relation to Fructification and Yield of White Button Mushroom (Agaricus bisporus) (Dr. K.K. Mishra, PI)
- Race Profiling, Variability and Management of Major Plant Pathogens of Hill Crops (Dr. Rajashekar, H., PI)
- Biointensive Management of Major Polyphagous Pests of Uttarakhand Hills (Dr. ARNS Subbanna, PI)

15.1.4. Socio-economic Studies, Transfer of Technology and Information Technology
- Socio-Economic Issues of Hill Farming and Extension Methods (Dr. Nirmal Chandra, PI)
- Impact of Constrained and Unconstrained Choices on Adoption of Improved Agricultural Practices by Farmers (Dr. Renu Jethi, PI)
- Technological Interventions for Mitigating Drudgery and Improving Nutritional Status of Hill Farmwomen (Dr. Kushagra Joshi, PI)
15.2. Externally Funded Projects

15.2.1. ICAR-NAIF funded Project
- Genetic Transformation and Development of Elite Transgenic Maize (Zea mays L.) for Biotic and Abiotic Stresses Tolerance (Mr. Rakesh Bhowmick upto Jan. 2018, Drs. A. Pattanayak & J. Stanley)

15.2.2. Consortium Research Platform (CRP) Projects
- ICAR-CRP on Molecular Breeding in Maize (Drs. R.K. Khulbe, R.S. Pal, Rajasekara H & Mr. Rakesh Bhowmick upto Jan. 2018)
- CRP on Agrobiodiversity, PGR Management, Component II – Wheat (Dr. Raghu BR upto June 2017)

15.2.3. DUS Project
- DUS/GOT trials in kidney bean (Dr. Anuradha Bhartiya)

15.2.4. AICRP/ Network Projects
- Post Harvest Technology for Value Addition and Marketing of Agricultural Produce (Drs. Sher Singh, Er. Shyam Nath, Jitendra Kumar (w.e.f., April 15, 2017) & Kushagra Joshi)
- Use of Plastics in Agriculture Particularly in Protected Cultivation, Water Harvesting and Packaging (Drs. Sher Singh, Er. Shyam Nath & Jitendra Kumar (w.e.f., April 15, 2017))
- All India Network Project on Soil Arthropod Pests (Drs. J. Stanley & A.R.N.S. Subbanna)

15.2.5. AMAAS Projects
- Bioprospecting for Microbial Products that Effects Cold Alleviation and Growth (Dr. Pankaj K. Mishra)

15.2.6. ICAR-FCI Sponsored Project
- Study on Determining Storage Losses of Food Grains in FCI and CWC Warehouses and to Recommend Norms for Storage Losses in Efficient Warehouse Management (Dr. Sher Singh)

15.2.7. NMHS Project

15.2.8. NMSHE Project

15.2.9. DST Funded SERB Young Scientist Project
- Habitat Management for Non-Apis Bee Pollinator Conservation (Dr. J. Stanley)

15.2.10. NABARD Funded Project
- Formation and Promotion of Farmers’ Producer Organization (Dr. Renu Jethi)

15.2.11. DAC Funded Project through ICAR-NCIPM
- Efficacy of Phosphine Fumigant Against Storage Pests of Pulses, Wheat, Rice and Coffee Beans; and Residue Analysis for Quarantine and Long-term Storage Purpose (Dr. J. Stanley)
16. Consultancy, Patents & Commercialization of Technology

16.1. Patent Granted

VL White grub Beetle Trap designed and developed by ICAR-VPKAS, Almora was granted a Patent (IN290170). The Patent was filed on 15.11.2007 and was given registration No. 2404/DEL/2007. The patent for light trap was granted on 30.11.2017, which happens to be the first patent of the institute.

The trap is designed specifically based on the behaviour of the white grub/scarab beetles (as these insects are attracted to light), so as to trap the scarab beetles excluding other insects, which also get attracted to the light. Scarab beetles hover around the light source in circular fashion and thus, three hitting fins are arranged to have maximum success in hit and capture. The uniqueness of the trap lies on the space given between the light source and the hitting fins and the gap between the funnel stem and the collection pot. The space between the light source and the hitting fins allow the beneficial insects being weak fliers and attracted towards light to pass on and not getting hit and trapped. The gap between the stem of the funnel and collection pot allows some other insects to escape. The trap is found to capture 68% of scarab beetles, 32% others (mostly of Isoptera and Lepidoptera) and a negligible number of beneficial insects to the tune of <0.8%, which shows it as a white grub specific trap. The trap is made of 24 guage tin sheets and the hitting fin itself will act as a light reflector at night.

16.2. Commercialization of Institute Varieties and Machines

Plant varieties Vivek Maize Hybrid 39, Vivek Maize Hybrid 43 and Vivek Maize Hybrid 45 were registered with PPV&FRA, New Delhi with registration no. 49, 48 and 249 of 2016 respectively. A meeting for techno-commercial assessment and preparation of standard terms of ICAR-VPKAS Technologies was organized on December 05, 2017 at Agri-innovate India Ltd, New Delhi.
17. RAC, IMC & IRC Meetings

17.1. Research Advisory Committee (RAC) Meeting

The XXI Research Advisory Committee (RAC) meeting of VPKAS, Almora was held on February 26-27, 2018 under the Chairmanship of Dr. K.R. Dhiman, Ex. Vice Chancellor, Dr. Y.S. Parmar University of Horticulture & Forestry, Nauni, Solan. The RAC members present in the meeting were Dr. D.K. Yadava, ADG (Seeds); Dr. H.C. Bhattacharyya, Director of Extension Education, Assam Agricultural University, Jorhat; Dr. A.K. Sharma, Ex. Director NBAIM, Mau; Dr. J.P. Singh, Professor (Horticulture), College of Agriculture, GBPUA&T, Pantnagar; Dr. B.S. Mahapatra, Prof. Agronomy, GBPUA&T, Pantnagar and Dr. J.C. Rana, National Coordinator, UN Environment-GEF Project Bioversity International-India. The meeting was also attended by HODs and all scientists of the Institute. The meeting began with the welcome and brief introduction of the Chairman and members of the RAC by Dr. A. Pattanayak, Director, ICAR–VPKAS, Almora. Dr. K.R. Dhiman, RAC Chairperson, in his opening remarks showed concern for shrinking natural resources in hill agro-ecosystem and said that climate change is evident and careful planning need to be done for sustaining agriculture. He emphasized on practices for conservation of traditional fruits and vegetables. He further said that creation of seed villages for horticultural crops can be a potential work area. The scientific fraternity can identify zone and crop species as

RAC Meeting and visit to PHET Lab
per the agro-climatic conditions. He showed his concern for aversion of youths from agriculture in hilly areas. For this, the challenge is to device strategies for entrepreneurship in agriculture for youths to retain them in agriculture. Opinion was expressed that in addition to the crops grown in the institute, the potential of some other economically viable crops like butter bean, which fetches high market price and rice bean having high seed multiplication rate, can be explored. Dr A. Pattanayak, Director of the Institute made a presentation on the institute activities and the achievements. He showed that the productivity of cereals and oilseeds in North-Western Himalayan region is lower than the national average, whereas pulses productivity is higher in the region especially Himachal Pradesh and Uttarakhand. The productivity of cereals requires due attention whereas pulses are important for hills in terms of soil health improvement and providing nitrogen to the succeeding crop. Dr. J.K. Bisht, Member-Secretary, presented the ‘Action Taken Report (ATR)’ on the recommendations of last RAC held on August 25-26, 2016, which was approved by the RAC. After that presentations by the respective Heads of the divisions (Crop Improvement & Crop Production)/ In-charges of the Crop Protection and Social Science Sections were made.

17.2. Institute Management Committee (IMC) Meeting

The Institute Management Committee Meeting was held on December 27, 2017 under the chairmanship of the Director, ICAR-VPKAS, Almora.

17.3. Evaluation of Experiments by Field Monitoring Team

The monitoring of field experiments conducted in *rabi* 2016-17 and *kharif* 2017 on April 3, 2017 and September 27, 2017, respectively. All the scientists participated and monitored the experiments. The progress was reviewed by the Director.

17.4. Institute Research Council (IRC) Meeting

The Institute Research Council (IRC) meeting for *kharif* 2017 and *rabi* 2017-18 were held on June 17, 2017 and November 7, 2017, respectively under the Chairmanship of the Director ICAR-VPKAS, Almora.
17.5. Institute Bio-safety Committee (IBSC) Meeting

The Institute Bio-safety Committee (IBSC) meeting was held on November 03, 2017 under the chairmanship of the Director, ICAR-VPKAS, Almora. Institute is working on two projects viz., i) Development of transgenic maize for biotic and abiotic stresses and, ii) development of transgenic rice expressing CSFV2 gene. The project on maize is funded by ICAR-National Agricultural Science Fund (NASF), whereas the project on rice is funded by the institute (ICAR-VPKAS, Almora, Uttarakhand).

Putative transgenics of maize (T0) expressing Cry1Ac and putative transgenics of Rice (T1) are being grown in transgenic greenhouse. A new experiment was proposed by Mr. Rakesh Bhowmick, Scientist on genome editing of Rice and maize by CRISPR/Cas technology. The new gene construct carrying Cas9 gene will be imported from ICGEB, New Delhi for conducting experiments. This proposal was accepted by the IBSC committee member.
## 18. Participation of Scientists in Conferences, Seminar, Symposia & Meetings

<table>
<thead>
<tr>
<th>Name</th>
<th>Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drs. R.K. Khulbe and D. Mahanta</td>
<td>Diamond Jubilee 60&lt;sup&gt;th&lt;/sup&gt; AICRP Maize workshop, MPUAT, Udaipur, April 02-04, 2017</td>
</tr>
<tr>
<td>Dr. Dibakar Mahanta</td>
<td>Monitoring of AICRP &lt;i&gt;rabi&lt;/i&gt; maize crop, PAU, Ludhiana and CCSHAU-RS, Karnal, April 06-07, 2017</td>
</tr>
<tr>
<td>Dr. Sher Singh</td>
<td>Meeting of World Bank Consultants’ Team organized by GRAMYA, Phase-II, Almora division, April 8, 2017</td>
</tr>
<tr>
<td>Dr. J.K. Bisht</td>
<td>State level review meeting taken by honorable Minister Shri Radha Mohan Singh, union minister of agriculture &amp; farmers welfare, Gov. India at Chief Secretary meeting room at Dehradun, April 13, 2017</td>
</tr>
<tr>
<td>Dr. Nirmal Chandra</td>
<td>Krishi Mela at Motihari (Bihar) from April 13-19, 2017</td>
</tr>
<tr>
<td>Drs. B.M. Pandey, R.K. Khulbe and Rajashekara, H.</td>
<td>Annual Group Meeting of AICRP on small millets at University of Agricultural Sciences, GKVK, Bengaluru from April 14-15, 2017</td>
</tr>
<tr>
<td>Drs. R.K. Khulbe and Anuradha Bhartiya</td>
<td>Kharif 2017 SVT Workshop at Directorate of Agriculture, Dehradun on April 17, 2017</td>
</tr>
<tr>
<td>Dr. J.K. Bisht</td>
<td>National group meeting of AICRP on forage crops at CSKHPKV, Palampur from April 18-19, 2017</td>
</tr>
<tr>
<td>Dr. Rajesh Khulbe</td>
<td>NSP (Crops) Annual Workshop at SKRAU, Bikaner from April 22-23, 2017</td>
</tr>
<tr>
<td>Dr. J.K. Bisht</td>
<td>LRC meeting of Defence Institute of Bio energy Research, as expert member at Haldwani on April 25, 2017</td>
</tr>
<tr>
<td>Dr. Dibakar Mahanta</td>
<td>Workshop on Integrated Farming System at ICAR-RC for NEH, Umiam, Meghalaya on April 27, 2017</td>
</tr>
<tr>
<td>Drs. Sher Singh and Anuradha Bhartiya</td>
<td>47th Annual Group Meeting of AICRP on Soybean held at GBPUA&amp;T, Pantnagar, May 2-4, 2017</td>
</tr>
<tr>
<td>Dr. Anuradha Bhartiya</td>
<td>Arid legume workshop at GBPUA&amp;T, Pantnagar during 6-8 May, 2017</td>
</tr>
<tr>
<td>Drs. Lakshmi Kant, J.K. Bisht, B. M. Pandey, and N.K. Hedau</td>
<td>Review meeting of the Uttarakhand State under the Chair of Hon’ble Union Minister for Agriculture and Farmer Welfare at Dehradun on May 12, 2017</td>
</tr>
<tr>
<td>Dr. Rajesh Khulbe</td>
<td>RKVY meeting at Secretariat, Dehradun on May 13, 2017</td>
</tr>
<tr>
<td>Drs. B.M. Pandey and N.K. Hedau</td>
<td>Meeting with Member, Niti Aayog with official of different department of the state under the Chair of Hon’ble Agriculture Minister, Govt. of Uttarakhand at Dehradun on May 23, 2017</td>
</tr>
<tr>
<td>Dr. J.K. Bisht</td>
<td>SLPSC meeting of PMRKY taken by Additional chief Secretary, Dehradun May 31, 2017</td>
</tr>
<tr>
<td>Dr. Rajesh Khulbe</td>
<td>RKVY meeting at Secretariat, Dehradun on May 31, 2017</td>
</tr>
<tr>
<td>Dr. V.K. Sachan</td>
<td>Annual Zonal Workshop of KVKs of Zone IV at ATARI, Kanpur (UP) on June 8-10, 2017</td>
</tr>
<tr>
<td>Dr. Sher Singh</td>
<td>Fourth Meeting of Indian Grain Storage Working Group (IGSWG) at New Delhi, June 11-12, 2017</td>
</tr>
<tr>
<td>Drs. B.M. Pandey and N.K. Hedau</td>
<td>Programme on “Sabka Sath Sabka Vikas” held at Ranikhet on June 12, 2017</td>
</tr>
<tr>
<td>Name</td>
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<tr>
<td>Drs. V.K. Sachan and Pankaj Nautiyal</td>
<td>Meeting on Doubling Farmers Income at GBPUA&amp;T, Pantnagar, on June 16, 2017</td>
</tr>
<tr>
<td>Dr. Nirmal Chandra</td>
<td>‘IJTA 5th International Conference on Agriculture, Horticulture and Plant Science held at Rishikesh, Uttarakhand during June 24-25, 2017</td>
</tr>
<tr>
<td>Dr. Anuradha Bhartiya</td>
<td>Fifth International Conference on Agriculture, Horticulture and Plant Science (ICAHPS-2017) held at Rishikesh, Uttarakhand during 24-25 June, 2017</td>
</tr>
<tr>
<td>Dr. J.K. Bisht</td>
<td>Meeting of IDWG at Uttarakhand Secretariat Dehradun under the chairmanship of Additional Principal Secretary on July 19, 2017</td>
</tr>
<tr>
<td>Dr. J.K. Bisht</td>
<td>Meeting related potential linked credit plan organized by NABARD at ICAR-VPKAS, Almora on July 21, 2017</td>
</tr>
<tr>
<td>Dr. J.K. Bisht</td>
<td>Meeting of NRBKS at Almora on July 28, 2017</td>
</tr>
<tr>
<td>Dr. Sher Singh</td>
<td>ICAR - IFAD Interaction Workshop on “Integrating Renewable Energy Technology for Smallholder Agriculture in India” at NASC Complex New Delhi on August 03, 2017</td>
</tr>
<tr>
<td>Dr. R.K. Khulbe</td>
<td>CRP Biofortification Maize project meeting at IARI, New Delhi on August 7, 2017.</td>
</tr>
<tr>
<td>Dr. V.K. Sachan</td>
<td>Annual Zonal Workshop of NICRA project at ICAR-ATARI, Zone I, Ludhiana on August 18, 2017</td>
</tr>
<tr>
<td>Dr. R.K. Khulbe</td>
<td>Seed Rolling Plan meeting at Directorate of Agriculture, Dehradun on August 21, 2017</td>
</tr>
<tr>
<td>Dr. L. Kant</td>
<td>56th AII India Wheat and Barley Research Workers meeting at BHU Varanasi from 25-August 28, 2017</td>
</tr>
<tr>
<td>Dr. Dibakar Mahanta</td>
<td>Workshop on “Ever Greening India”, NASC Complex, New Delhi, August 31-September 01, 2017</td>
</tr>
<tr>
<td>Dr. J.K. Bisht</td>
<td>National group meeting of AICRP on forage crops at UAS, Bangaluru. September 4-5, 2017.</td>
</tr>
<tr>
<td>Dr. V.K. Sachan</td>
<td>Workshop on Developing Krishi Mithras at MANAGE, Hyderabad (Telangana) on September 4, 2017.</td>
</tr>
<tr>
<td>Dr. Anuradha Bhartiya</td>
<td>MULLaRP workshop at IGKV, Raipur during September 8-9, 2017.</td>
</tr>
<tr>
<td>Drs. B.M. Pandey and N.K. Hedau</td>
<td>Himalayan Diwas at Dehradun during September 9-10, 2017</td>
</tr>
<tr>
<td>Dr. J.K. Bisht</td>
<td>EFC meeting at Krishi Bhawan, New Delhi during September 15-16, 2017</td>
</tr>
<tr>
<td>Dr. Sher Singh</td>
<td>“Kaushal Vikas Se Krishi Vikas” – National Workshop on Skill Development in Agriculture at Chandigarh, September 15, 2017</td>
</tr>
<tr>
<td>Dr. V.K. Sachan</td>
<td>Orientation workshop conducted by Agriculture Skill Council of India (ASCI) at Chandigarh on September 15, 2017</td>
</tr>
<tr>
<td>Drs. L. Kant and Anuradha Bhartiya</td>
<td>Rabi SVT meeting at Directorate of Agriculture, Dehradun on September 22, 2017.</td>
</tr>
<tr>
<td>Dr. R.K. Khulbe</td>
<td>AICRP Small Millets monitoring at RAU, Dholi and BAU, Ranchi from September 26-30, 2017.</td>
</tr>
<tr>
<td>Dr. Renu Jethi</td>
<td>National Workshop on Developing a roadmap for agricultural knowledge management in India at New Delhi from September 27-28, 2017.</td>
</tr>
<tr>
<td>Dr. L. Kant</td>
<td>AICRP NSP (crops) monitoring at SKUAST-Srinagar, SKUAST-Jammu, CSKHPKV, Palampur and PAU, Ludhiana during October 8-17, 2017.</td>
</tr>
<tr>
<td>Dr. J.K. Bisht</td>
<td>Meeting with D.M. Almora regarding Naula (spring), Almora October 10, 2017.</td>
</tr>
<tr>
<td>Name</td>
<td>Training</td>
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</tr>
<tr>
<td>Dr. Sher Singh</td>
<td>Participated in the Himveer Wives Welfare Association (HWWA) Fair 2017 of ITBP at New Delhi on October 14, 2017</td>
</tr>
<tr>
<td>Dr. R.K. Khulbe</td>
<td>Maize QRT meeting at IIMR, Ludhiana on October 15, 2017</td>
</tr>
<tr>
<td>Drs. J.K. Bisht, Sher Singh and Er. Shyam Nath</td>
<td>Meeting with District Magistrate, Almora regarding pine needle management, October 16, 2017</td>
</tr>
<tr>
<td>Dr. R.K. Khulbe</td>
<td>NASF DH project review meeting at NASC, New Delhi on October 16, 2017</td>
</tr>
<tr>
<td>Dr. J.K. Bisht</td>
<td>LRC meeting of Defence Institute of Bio energy Research, Haldwani as an expert member on October 23, 2017</td>
</tr>
<tr>
<td>Dr. Sher Singh and Er. Shyam Nath</td>
<td>QRT meeting of AICRP on PHET and AICRP of PET at MPUA&amp;T, Udaipur from October 26-27, 2017</td>
</tr>
<tr>
<td>Dr. J.K. Bisht</td>
<td>RAIBER: 17: Year: Uttarakhand Calling at C.M. House, Dehradun on October 6, 2017</td>
</tr>
<tr>
<td>Dr. V.K. Sachan</td>
<td>Workshop on Agricultural extension system in Uttarakhand at SAMETI, GBPUAT, Pantnagar on October 31, 2017</td>
</tr>
<tr>
<td>Drs. B.M. Pandey and P.K. Mishra</td>
<td>Meeting with stakeholders of agriculture sector of Uttarakhand state under Manthan: Sankalp se Siddhi Programme at Secretarat, Dehradun on November 8, 2017</td>
</tr>
<tr>
<td>Dr. Pankaj Nautilyal</td>
<td>Two days workshop on “Integrated Development and Conservation of Medicinal and Ornamental Plants” at Dehradun during November 10-11, 2017</td>
</tr>
<tr>
<td>Dr. R.K. Khulbe</td>
<td>NASF DH project Cost Committee meeting at KAB-I, New Delhi on November 21, 2017</td>
</tr>
<tr>
<td>Dr. L. Kant</td>
<td>Director Niti Aayog regarding grading of KVKs at KVK Kafligair on November 24, 2017</td>
</tr>
<tr>
<td>Drs. Sher Singh and Jitendra Kumar</td>
<td>Interaction meeting with members of World Bank on Implementation Review and Support Mission to GRAMY – II project area at Almora on November 30, 2017</td>
</tr>
<tr>
<td>Dr. Anuradha Bhartiya</td>
<td>International Conference on Global Research Initiatives for Sustainable Agriculture and Allied Sciences (GRISAAS-2017) at MPUAT, Udaipur, Rajasthan during December 02-04, 2017</td>
</tr>
<tr>
<td>Dr. L. Kant</td>
<td>Techno-Commercial assessment and Expert Committee meeting at AgroInnovate Indian Ltd office New Delhi on December 5, 2017</td>
</tr>
<tr>
<td>Drs. R.P. Yadav and Jitendra Kumar</td>
<td>Institute stall exhibition in ex-serviceman rally in Almora on December 06, 2017</td>
</tr>
<tr>
<td>Dr. Sher Singh and Er. Shyam Nath</td>
<td>13th Annual Workshop of AICRP on Plasticulture Engineering &amp; Technologies, BAU, Ranchi from December 06-07, 2017</td>
</tr>
<tr>
<td>Dr. J.K. Bisht</td>
<td>Cutting management training cum goshti at Danpau, Jaunshar Dehradun on December 16, 2017</td>
</tr>
<tr>
<td>Dr. Dibakar Mahanta</td>
<td>12th Annual Group Meeting of Network Project on Organic farming at ICAR-IIFSR, Modipuram from December 18-19, 2017</td>
</tr>
<tr>
<td>Dr. Pankaj Nautilyal</td>
<td>Meeting on Doubling Farmer Income at Uttarkashi chaired by Secretary Agriculture Govt. of Uttarakhand on January 02, 2018</td>
</tr>
<tr>
<td>Drs. R.P. Yadav and V.S. Meena</td>
<td>Meeting with district officials regarding Kosi river rejuvenation at Vikas Bhawan, Almora on January 11, 2018</td>
</tr>
<tr>
<td>Dr. Pankaj Nautilyal</td>
<td>Workshop on “Farmer Right and Agrobiodiversity Exhibition at IISR, Lucknow on January 15, 2018</td>
</tr>
<tr>
<td>Dr. L. Kant</td>
<td>Meeting with Sri Satpal Maharaj ji Honourable Minister of Tourism state Govt. regarding Mere Gaon Mere Tirth on January 17, 2018</td>
</tr>
<tr>
<td>Dr. Pankaj Nautilyal</td>
<td>State Level Executive Committee (SLEC) of HMNEH at Secretariat Dehradun on January 25, 2018</td>
</tr>
<tr>
<td>Dr. Chaudhari Ganesh Vasudeo</td>
<td>State Horticulture Variety Release Committee Uttarakhand, Directorate of Horticulture and Food processing, Uttarakhand at Dehradun on February 10, 2018</td>
</tr>
<tr>
<td>Name</td>
<td>Training</td>
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<tr>
<td>Dr. Anuradha Bhartiya</td>
<td>Soybean workshop at IGKV, Raipur from March 15-17, 2018</td>
</tr>
<tr>
<td>Drs. L. Kant and Anuradha Bhartiya</td>
<td>SVRC meeting on at Directorate of Agriculture, Dehradun on February 05, 2018</td>
</tr>
<tr>
<td>Dr. V.K. Sachan</td>
<td>International Conference on Sustainability of Small holder Agriculture in developing counties under changing climatic scenario- ARICON-18 held at CSAUAT Kanpur from February 14 –17, 2018</td>
</tr>
<tr>
<td>Dr. Gaurav Papnai</td>
<td>Trade Facilitation Centre, Varanasi organized by ICAR-IIVR and Deptt. of Agriculture, Govt. of UP during February 23-25, 2018</td>
</tr>
<tr>
<td>Dr. Pankaj Nautiyal</td>
<td>Spring festival (Flower show) at Rajbhawan Dehradun, organized by Deptt of Horticulture, Govt. of Uttarakhand on February 24, 2018</td>
</tr>
<tr>
<td>Drs. N.K. Hedau and Chaudhari Ganesh Vasudeo</td>
<td>Seminar on <em>Badalti Jalvayu mein Uccha Takniki Bagwani ke Ubharate Rujhan</em> (Emerging trends in Hi-tech Hill Horticulture under Changing Climate), organized by ICAR-CITTHRS, Mukteshwar during March 6-7, 2018</td>
</tr>
<tr>
<td>Dr. L. Kant</td>
<td>International Women’s day function at Nagar palika, Almora on March 8, 2018</td>
</tr>
<tr>
<td>Dr. Pankaj Nautiyal</td>
<td>12th Uttarakhand State Science &amp; Technology Congress organized by UCOST, Dehradun on March 08-09, 2018</td>
</tr>
<tr>
<td>Dr. V.K. Sachan</td>
<td>National Conference on KVK at New Delhi from March 16 -17, 2018</td>
</tr>
<tr>
<td>Dr. L. Kant</td>
<td>Annual Breeder Seed Review Meeting on March 26, 2018</td>
</tr>
<tr>
<td>Dr. L. Kant</td>
<td>Wheat &amp; barley Field day at NBPGR, Isapur farm, New Delhi on March 27, 2018</td>
</tr>
<tr>
<td>Dr. L. Kant</td>
<td>Wheat &amp; barley Field day at IIWBR, Karnal on March 28, 2018</td>
</tr>
<tr>
<td>Drs. Nirmal Chandra, Kushagra Joshi and G.S. Bisht</td>
<td>Kisan Mela organized by Agriculture Department, Pithoragrh at Pithoragarh from March 29-30, 2018</td>
</tr>
</tbody>
</table>

- Drs. Nirmal Chandra, A.R.N.S. Subanna, Kushagra Joshi and Jitendra Kumar prepared a Tableau depicting the activities and achievements of the institute on Republic Day (26th January, 2018). The institute tableau was judged best and given first prize.
19. Workshops, Senimars, Farmers’ Days Organized

World Environment Day celebration at ICAR-VPKAS, Almora

The celebration of World Environment Day was observed at ICAR-VPKAS, Almora on 05-06-2017 with intent to create awareness among school children about the causes of environmental pollution and to encourage the efforts for environment protection. Dr. O. P. Yadav, Director, ICAR-CAZRI, Jodhpur graced the occasion as chief guest and said that increasing population and human needs are leading to environmental degradation. Dr. A. Pattanayak, Director, ICAR-VPKAS, Almora emphasised the need of planting trees to reduce environment pollution and efficient use of natural resources. World Environment Day was celebrated with the students of Government Inter College, Hawalbagh. About 20 students of different age groups participated in the program. On this event, plantation of saplings was done by the students in the institute premises and theme lectures were delivered by Dr. Raghu B.R., Dr. R.P. Yadav and Dr. S.C. Panday, and students were made aware about UN convention on climate change, impact of deforestation on environment and water conservation strategies.

International Day of Yoga

International Day of Yoga was successfully organized in the morning on 21st June, 2017 at ICAR-VPKAS Headquarter, Almora and its Experimental Farm at Hawalbagh as per the Common Yoga Protocol (CYP) developed by the Ministry of AYUSH, Government of

Plantation of saplings

Yoga session at ICAR-VPKAS
India. At the start of the Yoga programme, Dr. Sher Singh, Sr. Scientist and Nodal Officer of the programme briefed the participants about the general guidelines of the Common Yoga Protocol (CYP). The Yoga programme began with the prayer followed by loosening exercises, Yogaasana, Kapalbhaati, Pranayama, Dhyana/ Meditation and ended with Sankalpa followed by Shaanti Paatha.

ICAR-VPKAS, Almora celebrated 94th foundation day

The Institute celebrated 94th foundation day on July 04, 2017. In the beginning, all the staff of the Institute remembered the founder member of the Institute Sri Boshi Sen at Kundan House and paid tribute Ex-Director Dr. Harish Chandra Joshi.

Dr. Arunava Pattanayak, Director of the Institute briefed the Institute's achievements for the last year. He felt proud to say that ICAR-VPKAS has got credit of second position in release of crop varieties *i.e.* 28 amongst all the ICAR Institutes during 2011-17. Former Directors of the Institute and special guests, Dr. J.C. Bhatt and Dr. H.D. Dube also graced the occasion. The chairman of the occasion, Swami Som Devanand ji prayed Swami Vivekananda and praised the developmental works of ICAR-VPKAS. The chief guest, Dr. P.P. Dhyani, Director, GBPNIHE&SD, Kosi-Katarmal, Almora, told that the Institute is playing a pivotal role in the development of hill agriculture. He emphasized to focus more on quality research to uplift the livelihood of hill farmers. Keeping in mind the loss of productivity, wild animal menace, shortage of green fodder, deficit in fertility and increasing in waste land; he urged to bring changes in hill agriculture policy so that progress of the hill farmers could be made significantly. On the occasion, two varieties namely Central Maize VL Baby corn 2 and VL Dhan 158 were released by the chief guest. Progressive farmers and meritorious students were also awarded on the occasion. The function ended with traditional mango feast started by the founder Director.

Report on New India Movement “Sankalp Se Siddhi” Programme KVK (ICAR-VPKAS), Kafligair

New India Movement “Sankalp Se Siddhi” programme was organized by KVK, Kafligair on August 28, 2017. Hon'ble Union Minister of states of Textile Shri Ajay Tamta was the chief guest of the programme. Smt Ranjana Verma District Magistrate, Bageshwar Zeela Panchayat Adhayaksh Shri Harish Chandra Singh Aithani, MLA Bageshwar Shri Chandan Ram Das and Dr A. Pattanayak, Director, ICAR-VPKAS graced the function. Shri Ajay Tamta emphasized on the implementation of new technologies in the field of agriculture like use of websites, mobile apps, E-NAM in the marketing of Agricultural produce. After addressing the gathering the chief guest, other dignitaries and farmers took the ‘Sankalp se Siddhi’ pledge. A total of 550 farmers and 60 Officers from central and state departments of Bageshwar district participated in the programme.
KVK (ICAR-VPKAS), Chinyalisaur

“Sankalp Se Siddhi” programme was organized at KVK, Kafligair, which was presided by Hon’ble Kedar Singh Rawat, MLA Yamunotri constituency. Shri. G.S. Chaudhary, AGM, NABARD and Dr Rajababu Gupta, Senior Veterinary Officer were also present in the function. After addressing the gathering the chief guest, other dignitaries and farmers took the ‘Sankalp Se Siddhi’ pledge. A total of 450 farmers and state department officials of district Uttarkashi participated in the programme.

- Under Swachhta Abhiyan, Swachhata Pakhawara is being organized at ICAR- VPKAS, Almora during September 15 to October 02, 2017. Under this, various activities, like Seva Diwas, Cleanliness Awareness Programme, Competitions, goshthi etc. are being organized.
- ICAR-VPKAS organized kharif and rabi Kisan Mela was at Experimental Farm, Hawalbag on October 7, 2017 and March 23, 2018, respectively with great enthusiasm. Shri Raghunath Singh Chauhan, Hon’ble Deputy Speaker, Uttarakhand Vidhan Sabha and MLA, Almora and Smt. Iva Ashish Shrivastava, District Magistrate, Almora, respectively were the Chief Guests of the function. Dr. A. Pattanayak, Director of the Institute, while welcoming the guests and farmers briefed about the achievements and technologies developed by the institute, along with the training programmes and frontline demonstrations conducted. On the occasion Chief guest released the Institute Krishi Calender and extension leaflets “मका उत्पादन की उन्नत तकनीकी” एवं “कृषि प्रसारकरण केंद्र पर्यावरण क्षेत्रों में ग्रामीण रोजगार हेतु एक बेहतर विकल्प” and two maize varieties VL 55 and Central Maize VL Baby Corn 2 were lunched for farmers. Smt Kamala Rautela, a progressive farmer from Village Chinna, Kafligair was honoured. More than 500 farmers participated in the Kisan Mela.

- Under Swachhta Pakhawara Swachhata is being organized at ICAR- VPKAS, Almora during September 15 to October 02, 2017. Under this, various activities, like Seva Diwas, Cleanliness Awareness Programme, Competitions, goshthi etc. are being organized.
A model training course on “Improved Crop Production Technologies in Hill Agriculture” was organized at ICAR-VPKAS during November 13-20, 2017. A total of 24 candidates across the country from five states viz., Jammu and Kashmir (2), Himachal Pradesh (2), Nagaland (2), Delhi (2) and Uttarakhand (16) participated in the MTC. The participants included Assistant Agricultural Officers, Sub-Divisional Agriculture Officers, Extension Assistants (Agriculture), Agriculture Development Officers and Research Assistants working in the State Department of Agriculture of different states. The MTC included 37 lectures/exposure visits/laboratory visit, etc. covering different aspects of hill agriculture. Out of total 34 resource persons, 11 were from outside the Institute. Out of 37 topics, 13 (35%) were covered by Level-I while remaining 24 were covered by Level-II resource persons. The course will help the participants in implementing different technologies in their respective areas and thus may strengthen the doubling farmers income programme of the respective states. All the participants were satisfied with the content as well as delivery of different topics.

On birth anniversary of Nation's first President and first Union Agriculture Minister, Bharat Ratna Dr. Rajendra Prasad, December 03, 2017 was observed as Agricultural Education
Day at Experimental farm, Hawalabag. With intent to promote the spirit of agriculture and allied subjects among the students and motivate them to take agriculture as discipline in higher studies, education day was celebrated with more than 45 students of Koormanchal Academy, Kosi. Apart from this, various competitions like essay writing, drawing competition and extempore on agriculture related topics were organized.

- A two days in-house Capacity Building Training program was organised for the Skilled Supporting Staff of ICAR-VPKAS, Almora at Experimental Farm, Hawalbag during December 4 - 5, 2017 and thirty-four SSS participated in training.

- World Soil day was celebrated on December 5, 2017 at the institute. On the occasion Shri Raghunath Singh Chauhan, Hon’ble Deputy Speaker, Uttarakhand Vidhan Sabha and MLA, Almora was the Chief Guest. Soil health card was distributed to farmers of Jur-Kafun and soil testing kit was demonstrated to the farmers.

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**Pledge Ceremony of Constitution Day at ICAR-VPKAS, Almora, Uttarakhand**

As per directions received from Secretary, Government of India, Ministry of Social Justice and Empowerment, Deptt. of Social Justice and Empowerment, New Delhi, constitution day was celebrated on 27 November 2017. A pledge ceremony was arranged to read out the ‘Preamble’ to the constitution at Almora and Hawalbag Campus and KVK, Chinyalisaur, Uttarkashi and KVK, Kafligair, Bageshwar. All the staff members at Almora and Hawalbag Campus and KVK, Chinyalisaur, Uttarkashi and KVK, Kafligair, Bageshwar took the pledge in presence of senior most officers in respective places.
भारत सरकार, गृह मंत्रालय, राजमार्ग विभाग द्वारा केंद्रीय सरकार के कार्यालयों, उपक्रमों आदि में सरकार की राजमार्ग नीति के कार्यान्वयन हेतु प्रतिवर्ष राजमार्ग वाचिक कार्यक्रम जारी किया जाता है। इस कार्यक्रम में राजमार्ग के उत्तरार्द्ध प्रयोग हेतु वर्ष के लिए लक्ष्य निर्धारित किये जाते हैं। इन लक्ष्यों को प्राप्त करने एवं राजमार्ग नीति की प्रश्न तिमाही में समीक्षा करने हेतु संस्थान में राजमार्ग कार्यान्वयन समिति का गठन किया गया है। इस समिति की प्रश्न तिमाही में बैठक की जाती है तथा संस्थान द्वारा राजमार्ग के क्षेत्र में की गयी प्रगति की समीक्षा तिमाही प्रगति सिपोट के आधार पर की जाती है। राजमार्ग वाचिक कार्यक्रम की विभिन्न मदद में ‘क’ एवं ‘ख’ क्षेत्र के साथ हिंदी पत्रकार के लिए 100 प्रतिशत का लक्ष्य रखा गया है तथा ‘ग’ क्षेत्र के साथ 65 प्रतिशत का लक्ष्य रखा गया है। संस्थान द्वारा ‘क’ क्षेत्र के साथ लगभग 70-80 प्रतिशत ‘ख’ ने क्षेत्र साथ 60-65 प्रतिशत तथा ‘ग’ क्षेत्र के साथ 50-60 प्रतिशत प्रति व्यवहार किया जा रहा है। राजमार्ग अभिषिक्त की दारा 3(3) का अनुपालन सुनिश्चित किया जा रहा है। वाचिक कार्यक्रम में नोटिंग के लिए 75 प्रतिशत का लक्ष्य रखा गया है, जबकि संस्थान द्वारा 95 प्रतिशत से अधिक नोटिंग का कार्य हिंदी में किया जा रहा है। संस्थान द्वारा संचालित सभी प्रशिक्षण कार्यक्रमों में व्याख्या हिंदी में तैयार किए जाते हैं तथा सभी प्रशिक्षण कार्यक्रम हिंदी में ही समाप्त होते हैं। संस्थान राजमार्ग कार्यान्वयन समिति की सभी 4 बैठकें समाप्ति समय में की जाती हैं। वर्ष 2017-18 के दौरान ये बैठकें 29.06.2017, 25.09.2017, 20.12.2017 एवं 31.03.2018 को आयोजित की गयीं।

संस्थान में कार्यरत कार्यक्रमों को हिंदी की ओर रूचि बढ़ाने एवं अपना अधिक से अधिक दैनिक कार्य हिंदी में करने के लिए प्रोत्साहित करने हेतु संस्थान में 14 सितम्बर 2017 से 13 अक्टूबर 2017 तक 'हिंदी चेतना मास' का आयोजन किया गया। चेतना मास के दौरान अनेक कार्यक्रम जैसे- नोटिंग, ड्राफ्टिंग प्रतियोगिता, हिंदी टोकन प्रतियोगिता आदि का आयोजन किया गया। चेतना मास के दौरान दिनांक 25.09.2017 एवं 10.10. 2017 को राजमार्ग संगठित का आयोजन किया गया, जिससे व्यक्तित्व कल्पना प्राप्त एवं तत्कालीन प्रभाव प्रतियोगिताओं का आयोजन किया गया। इन कार्यक्रमों में हिंदी व अहिंदी भाषी क्षेत्रों के कार्यक्रमों के उत्साह के साथ सहभागिता की।

भारत सरकार, राजमार्ग विभाग द्वारा संस्थान के नए राजमार्ग कार्यान्वयन समिति की अयोजना का आयोजन किया गया है। संस्थान द्वारा नरकास के छापी बैठकें निर्धारित समय पर आयोजित की जाती है। वर्ष 2017-18 के दौरान ये बैठकें 27.07.2017 एवं 20.12.2017 को आयोजित की गयीं। वर्तमान में समिति के सदस्य कार्यकारियों की संख्या 32 है जिसमें केंद्रीय सरकार के शौच संस्थान, विभाग, राष्ट्रीयस्तंभ बैंक, उपक्रम, सरकार बल आदि समलित है। वर्ष के दौरान नरकास का राजमार्ग प्रकार हिंदी के प्रमाण अंक का प्रारंभ किया गया। संस्थान द्वारा राजमार्ग विभाग मासी गयी गयी सूचनाएं निर्धारित समय पर मेज़े जाती है तथा राजमार्ग सूचना प्रवचन प्रणाली के अंतर्गत सभी सूचनाओं आन तालिक प्रशिक्षण की जाती है। संस्थान नरकास के सभी सदस्य कार्यक्रमों के बीच हिंदी को आगे बढ़ाने के लिए सामन्जस्य स्थापित करने का निरन्तर प्रयास कर रहा है।
21. Distinguished Visitors

- Dr. D.K. Agarwal, Director (Act), ICAR-IISS, Mau on May 01, 2017.
- Shri Chaman Kumar, IAS (Retd.), Ex AS & FA, ICAR, 80, New Moti Bagh, New Delhi-110023 on June 03, 2017.
- Dr. Desh Beer Singh, Director ICAR-CITH, Srinagar, J&K on Feb. 02, 2018.
- Dr. H.S. Gupta, Ex Director General, Borlaung Institute for South Asia on August 08, 2017.
- Dr. Parag Dhakate, Conservator of Forests, Western Circle, Haldwani on March 08, 2018.
- Dr. O.P. Yadav, Director, ICAR-CAZRI, Jodhpur, Rajasthan at Experimental Farm, Hawalbag on June 05, 2017.
- Dr. Major Singh, Director, ICAR-DOGR, Pune visited breeder seed crop of VL Lahn 2 at HATS, Mukteshwar on May 26-27, 2017.
- Dr. R.K. Singh, PC, AICRP on Plasticulture visited Mukteshwar Farm, Experimental Farm, Hawalbag on May 04-05, 2017.
- Dr. Joykrushna Jena, DDG (Animal Science) visiting the Mukteshwar Farm, June 26, 2017.

- Honorable Minister State (Textiles) and Member of Parliament, Almora - Pithoragarh Parliament Constituency, Shri Ajay Tamta at experimental farm, ICAR-VPKAS, Hawalabag on August 27, 2017.

- Shri Raghunath Singh Chauhan, Hon’ble Deputy Speaker, Uttarakhend Vidhan Sabha and MLA, Almora at Experimental farm on World Soil Health Day, December 5, 2017.

Demonstration of soil testing kit
22. Scientific, Technical & Administrative Staff

Dr. A. Pattanayak, Director

**Crop Improvement Division**
Dr. Lakshmi Kant, Principal Scientist (Plant Breeding) & Head
Dr. N.K. Hedau, Principal Scientist (Horticulture-Vegetable Science)
Dr. R.K. Khulbe, Senior Scientist (Plant Breeding)
Dr. Jay Prakash Aditya, Scientist (Plant Breeding)
Dr. Anuradha Bhartiya, Scientist (Plant Breeding)
Dr. Ramesh Singh Pal, Scientist (Biochemistry)
Mr. Rakesh Bhowmick, Scientist (Agriculture Biotechnology)
Dr. Chaudhari G. Vasudeo, Scientist (Vegetable Science)
Dr. D.C. Joshi, Scientist (Plant Breeding) (*w.e.f. August 02, 2017*)
Dr. Hanuman Ram, Scientist (Vegetable Science) (*w.e.f. October 12, 2017*)

**Crop Production Division**
Dr. J.K. Bisht, Principal Scientist (Agronomy) & I/c Head
Dr. S.C. Panday, Principal Scientist (Soil Science)
Dr. P.K. Mishra, Principal Scientist (Microbiology)
Dr. B.M. Pandey, Principal Scientist (Agronomy)
Dr. Sher Singh, Senior Scientist (Agronomy)
Dr. Dibakar Mahanta, Scientist (Agronomy)
Dr. Ram Prakash Yadav, Scientist (Agroforestry)
Mr. Tilak Mondal, Scientist (Agricultural Chemistry)
Dr. Vijay Singh Meena, Scientist (Soil Science)
Mr. Mahipal Chaudhary, Scientist (Soil Science)
Er. Shyam Nath, Scientist (Farm Machinery & Power)

Dr. Jitendra Kumar (Soil and Water Conservation Engineering) (*w.e.f. April 15, 2017*)
Mr. Manoj Parihar (Soil Science) (*w.e.f. October 12, 2017*)

**Crop Protection Section**
Dr. K.K. Mishra, Principal Scientist (Plant Pathology) & I/c
Dr. J. Stanley, Senior Scientist (Agril. Entomology)
Dr. A.R.N.S. Subbanna, Scientist (Agril. Entomology)
Dr. Venkatesan, M., Scientist (Plant Nematology)
Dr. Rajashekar, H., Scientist (Plant Pathology)

**Social Science Section**
Dr. Nirmal Chandra, Principal Scientist (Agril. Extension) & I/c
Dr. Renu Jethi, Scientist (Home Science Extension)
Mr. Anirban Mukherjee, Scientist (Agril. Extension) (on study leave)
Dr. Kushagra Joshi, Scientist (Home Science/FRM)

**Coordinators**

**Library**
Dr. P.K. Mishra

**AKMU**
Dr. Renu Jethi

**PME Cell**
Dr. J.K. Bisht, In-Charge
Dr. P.K. Mishra, Coordinator

**Farm**
Dr. B.M. Pandey (Hawalbagh)
Drs. N.K. Hedau & Sher Singh (Mukteshwar)
Vehicle
Mr. T.B. Pal

Guest House
Dr. B.M. Pandey (Hawalbagh)
Mr. T.B. Pal (Almora)

Maintenance
Mr. T.B. Pal

Krishi Samridhi Radio Programme
Dr. Kushagra Joshi

Technical Officers
Shri T.B. Pal,
Shri L.D. Malkani,
Shri S.K. Arya,
Shri D.S. Gosai,
Shri M.C. Pant,
Shri D.C. Mishra,
Dr. G.S. Bisht,
Shri N.K. Pathak,
Shri D.S. Panchpal,
Shri Daya Shankar,
Shri S.L. Arya,
Shri G.S. Bisht,
Smt Renu Sanwal,
Shri O.P. Vidhyarthi,
Shri M.S. Rautela,
Shri C.S. Kanwal,
Shri B.S. Nagarkoti,
Shri J.K. Arya,
Shri R.S. Kanwal
Shri Narayan Ram

Assistant Administrative Officer
Mrs. Radhika Arya

Finance & Accounts Officer
Mrs. Shakku Goswami (upto August 08, 2017)
Mr. H.L. Meena, I/c FAO (w.e.f. August 09, 2017)

Stores
Mr. Bahadur Ram (up to December 31, 2017)
Mr. Sanjay Kumar Arya (w.e.f. January 01, 2018)

Managerial Staff at KVK, Chinyalisaur
Dr. V.K. Sachan, Programme Coordinator
Dr. Pankaj Nautiyal, ACTO, Horticulture
Ms. Manisha, SMS, Home Science
Dr. Gaurav Papnai, SMS, Agril. Extension

Managerial Staff at KVK, Bageshwar
Dr. Kamal Kumar Pandey, ACTO, Horticulture
Dr. N.K. Singh, ACTO, Veterinary Science
Mr. H.C. Joshi, ACTO, Plant Protection
Shri Medni Pratap Singh, Farm Manager/T-5

New Colleagues
Dr. Jitendra Kumar (Soil & Water Conservation Engineering) on April 15, 2017
Ms. Usha Birdi, Assistant on July 27, 2017
Dr. D.C. Joshi, Scientist (Plant Breeding) on August 02, 2017
Dr. Hanuman Ram, Scientist (Vegetable Science) on October 12, 2017
Mr. Manoj Parihar, Scientist (Soil Science) on October 12, 2017

Retirement
Mr. Sunder Singh Kanwal, Assistant on June 30, 2017
Mr. Pan Ram, Technical Officer on July 31, 2017
Mr. N.C. Belwal, ACTO on October 31, 2017
Mr. Bahadur Ram, Administrative Officer on December 31, 2017
Mr. P.S. Mehra, Technical Officer on January 31, 2018
Mr. Bachi Singh, Skilled Supporting Staff on January 31, 2018

Transfer
Dr. Raghu, B.R. Scientist to ICAR- Central Research Institute of Horticulture Research, Bengaluru on June 24, 2017
Smt. Shakku Goswami, Finance & Accounts Officer to ICAR-IVRI, Bareilly on August 8, 2017.

Promotion
Dr. B.M. Pandey, Sr. Scientist to Pr. Scientist w.e.f. 02.07.2015
Dr. J. Stanley, Scientist to Sr. Scientist w.e.f. 07.01.2017
Dr. Jay Prakash Aditya, Scientist to Scientist (Higher RGP) w.e.f. 07.01.2014
Dr. Anuradha Bhartiya, Scientist to Scientist (Higher RGP) w.e.f. 21.04.2015
Dr. K. K. Mishra, Sr. Scientist to Pr. Scientist w.e.f. 01.02.2017
Shri S.K. Arya, STO to ACTO w.e.f. 17.04.2016.
Shri Dev Singh Panchpal, TO to STO w.e.f. 15.02.2017
Shri Vijay Pal Singh, TA to STA w.e.f. 29.06.2016
Shri Krishan Lal, TA to STA w.e.f. 29.06.2016
Shri Nagendra Kumar Pathak, TO to STO w.e.f. 01.01.2017
Shri Jagdish Kumar Arya, STA to TO w.e.f. 17.01.2016
Shri Hari Govind, STO to ACTO w.e.f. 22.08.2010
Shri B.D. Pandey (Retired) STO to ACTO w.e.f. 24.02.2011
Shri N.C. Belwal (Retired), STO to ACTO w.e.f. 24.02.2011
Shri L. D. Melkani, STO to ACTO w.e.f. 01.01.2015
Shri M.S. Khati (Retired), STO to ACTO w.e.f. 07.06.2012
Shri Ramesh Singh Kanwal, STA to TO w.e.f. 10.07.2017
Shri Narayan Ram, STA to TO w.e.f. 27.08.2017
Shri Manoj Bhatt, TA to STA w.e.f. 13.07.2017
Shri J.P. Gupta, TA to STA w.e.f. 09.08.2017
Shri Daya Shankar, TO to STO w.e.f. 05.10.2017
Smt. Radhika Arya, Assistant to AAO w.e.f. 27.07.2017
Shri Sundar Ram, Sr. Clerk to Assistant w.e.f. 25.07.2017
Shri Charu Chandra Joshi, Steno to Personal Assistant w.e.f. 12.12.2017
Smt. Nidhi Singh, Prog. Asst. (Lab Technician) to T5 w.e.f. 08.01.2018
Shri Medni Pratap Singh, Farm Manager/T-5 w.e.f. 11.01.2018

Regularization
Shri Bhagwan Ballabh, Skilled Supporting Staff on 01.03.2017

Study Leave
Mr. Rakesh Bhowmick, Scientist (Agricultural Biotechnology) (w.e.f., 03.01.2018)
Mr. Tilak Mondal, Scientist (Agricultural Chemistry) (w.e.f., 10.08.2017)

Obituary
With profound grief, we inform you that Shri R.C. Budhlakoti, CLTS suddenly passed away on January 7 and Shri Bhawani Ram, Skilled Supporting Staff passed away on February 20, 2018. They served ICAR-VPKAS for about 30 years.
23. Human Resource Development (HRD)
For
ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan,
Almora-263601, Uttarakhand, India
(2017-18)

A. Physical targets and achievements

<table>
<thead>
<tr>
<th>Category</th>
<th>Total No. of Employees</th>
<th>No. of trainings planned for 2017-18 as per ATP</th>
<th>No. of employees undergone training during April-Sept 2017</th>
<th>No. of employees undergone training during Oct 2017 to March 2018</th>
<th>Total no. of employees undergone training during April 2017 to March 2018</th>
<th>% realization of trainings planned during 2017-18</th>
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</thead>
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<td>Scientist</td>
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<td>4</td>
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<td>7</td>
<td>14</td>
<td>14</td>
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<td>3</td>
<td>2</td>
<td>5</td>
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<td>Total</td>
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<td>14</td>
<td>20</td>
<td>34</td>
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B. Financial targets and achievements (All employees)

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<tr>
<th>RE 2017-18 for HRD (Rs.)</th>
<th>Actual Expenditure up to March 31, 2018 for HRD (Rs.)</th>
<th>% Utilization of allotted budget</th>
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<td>2</td>
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<td>3*100/2=4</td>
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<td>2,26,124.0</td>
<td>2,26,124.0</td>
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C. Number of trainings organized for various categories of ICAR employees including winter/summer schools and short term trainings

<table>
<thead>
<tr>
<th>Category</th>
<th>No. of trainings organized during April 2017 to September 2017</th>
<th>No. of trainings organized during October 2017 to March 2018</th>
<th>Total no. of trainings organized during April 2017 to March 2018</th>
<th>No. of participants (Only ICAR employees)</th>
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<td></td>
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<td>Organizing Institute</td>
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<td>2</td>
<td>3</td>
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<td>Col. 3+4=5</td>
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Annual Report
2017-2018