Annual Report 2019

ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan
(An ISO 9001:2015 Certified Institute)
Almora - 263 601, Uttarakhand
www.vpkas.icar.gov.in

भाकृअनुप
ICAR

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PREFACE

Innovations and their successful diffusions are main drivers of economy. In agriculture, it includes improved varieties, cultivation methods, efficient machines and effective diffusion techniques. Informal knowledge and informal institutions are also parts of the agricultural economy of the hills. Agriculture in the Himalayan region is slowly diversifying from traditional cereal based system to a blend of cereal and commercial crops like fruits and vegetables-based system. This not only increases farm income but also increases demand for fresh innovations in productivity, natural resource management, mechanization, health and nutrition of farmers, etc. Change in climate is partially being addressed through measures like water conservation, pollinator conservation, introduction of new crops, etc. However, crop damages by wild animals like monkey and wild boar are still rampant in hills.

During the last year, the Institute worked on various aspects of yield improvement of agricultural and horticultural crops, their protection and processing. In addition, focus on water harvesting, nutrition and drudgery reduction of women farmers, off-farm income generation, use of solar energy in farm mechanization, innovative extensions using ICT were more precise and location specific. Although not in its mandate, scientists in the Institute took up the challenge to address the increasing wild animal menace. Several new technologies were tested; some of them were introduced based on their effectiveness and ease of use. Awareness meetings across the society were held to develop effective combat strategy.

Seed is the most important component of a production increase. It was ensured by the ICAR-VPKAS that all the indented requirements are fulfilled. Working with the underprivileged, the institute provided material and technology support to farmers in the far-flung areas of North West and North East Hills. In addition, on and off-farm trainings, front-line demonstrations and awareness programmes were carried out to educate the farmers, line department officials and students who have been our clients. Skill development programmes for youths were conducted to increase availability of trained manpower in agriculture.

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

Place: Almora
Date: January 2020

(A. Pattanayak)
Director

Unity of Life in the words of Padmabhushan Professor Boshi Sen

Padmabhushan Professor Boshi Sen 1887 to 31.08.1971

"Since we are hoping to evolve our conception of the unity of life let us inquire, 'What is life? To our primitive ancestors anything moving was living- the Sun, the Moon, the rushing river, the hurricane. Our legacy has been many poetic imageries. As our knowledge increases alike in depth and extent, we find it extremely difficult to define life. We say life is something that happens. But we do know that life starts its career with a single cell. Some forms of life even end their cycle as an individual cell."

"The higher we ascend in the evolutionary scale, we find multi-cellular organisms. These also begin with an individual cell. After fertilization, it multiplies and differentiates and develops into the adult structure. With this simple beginning, diverse structures and organs are formed with specified functions – attaining the climax of complications in man."

"From the study of the forms, diversity and not unity would seem to be the scheme of life. But form is not all of life. Life has other functions. To develop a living thing, it must gather energy from outside and transform it to make it its own and must also eliminate the unusable excess. To survive, it must adjust itself to the ever-changing environment. It is from the survey of functions that the unit emerges as an individual organism. The different organs of the body do not work for different masters but for the organism."

"But man is not content with merely surviving. There is something in us which propels us, consciously or unconsciously to our higher destiny. Thought and feeling are at once our great encumbrances and assests. These lead us on to dismal depths and rare altitudes. Is there any integarting background for our thoughts and emotions? That is the subjective background of our being. To know this, we have to become both the subject and object of investigation- the capacity to isolate the object of investigation from the external disturbances and at the same time the capacity to perceive with greater minuteness and refinement. This in plain words means control of our senses. With perfect control of our senses, a unity of a different quality emerges and is felt with the whole being. Then we perceive our real nature, which is full of bliss – existence, knowledge and bliss absolute."

(Taken with the permission of Author of the book – Nearer Heavan than Earth – The Life and Times of Bosi Sen and Gertrude Emerson Sen)

CONTENTS

Executive Summary

During the year, ten varieties of different crops were notified. These include two centrally released hybrids of maize - *Vivek* Maize Hybrid 57 (6,766 kg/ha) and VL Sweet Corn Hybrid 2 (10,347 kg/ha green cob) and four varieties of wheat & barley for Uttarakhand - VL *Gehun* 967 (1,988 kg/ha), *VL Gehun* 3004 (4,388 kg/ha), VL *Gehun* 2014 (5,207 kg/ha) and VLB 130 (2,100 kg/ha) in the main cereals group. In millets, finger millet variety VL *Mandua* 380 (2,000 kg/ha) was notified for Uttarakhand. Likewise, in soybean VL *Soya* 89 (2,324 kg/ha) was notified for Himachal Pradesh and Uttarakhand hills. In garden pea, VL *Sabji Matar* 13 (11,500 kg/ha) and VL *Sabji Matar* 15 (12,800 kg/ha) were notified for organic condition of Uttarakhand.

A total of nine varieties were identified for release in organic production condition of Uttarakhand hills. These include two varieties of wheat- VL *Gehun* 2029 (2,431 kg/ha, timely sown rainfed conditions) and VL *Gehun* 2028 (2,270 kg/ha, timely sown rainfed conditions); three varieties of rice - VL *Dhan* 210 (2,157 kg/ha, rainfed upland spring sown conditions), VL *Dhan* 211 (2,088 kg/ha, upland spring sown conditions) and VL *Dhan* 159 (1,964 kg/ha, rainfed upland June sown conditions) in the main cereal group. In pulses, VL *Masoor* 150 (841 kg/ha) of lentil and VL *Matar* 64 (990 kg/ha) were identified for release in timely sown rainfed condition. Likewise, in finger millet VL *Mandua* 378 (2,290 kg/ha) was identified for Uttarakhand. In vegetables, VL Cherry Tomato 1 with an average yield of 25,000-30,000 kg/ha under open-field condition and 40,000-50,000 kg/ha under polyhouse condition is the first variety of cherry tomato identified for release in the country by the AICRP - Vegetable crops. To popularize the newly released hybrids and varieties, Front Line Demonstrations (FLDs) were conducted in a total of 94.2 ha (79.2 ha area in Uttarakhand and 15.0 ha in other states). The newly released hybrids and varieties recorded a yield advantage of 37-52% in maize, 20.5% in wheat, 21.6% in rice, 36-50% in millets, 25-30% in soybean and 45-55% in black soybean over the local varieties in farmers' field. In 2018, 337.0 q seeds of various crops were produced, and in 2019 318.7 q seeds were supplied to seed producers and farmers. These seeds were supplied to clients across various states in India for both production and research purpose.

Significant progress was made in maize doubled haploid production. More than 600 doubled haploid lines of normal corn, sweet corn and QPM were generated during *kharif* 2018 and evaluated during *kharif* 2019. Eleven induction crosses involving normal corn, sweet corn and double/triple-trait biofortified hybrid combinations have been generated during *kharif* 2019, which are expected to yield another 550-600 DH lines during *kharif* 2020.

Studies on maintaining soil fertility as well as sustainability of rainfed wheat-soybean cropping system indicated that application of 67 kg P/ha/year through FYM or 58 kg P/ha/year through vermicompost (VC) is adequate to achieve the same wheat equivalent system grain yield as can be obtained by adding the recommended P (110 kg/ha) through SSP. The highest wheat equivalent grain yield of rainfed wheat-soybean cropping system was recorded with the application of 'P' through VC (67 kg/ha) provided 18% higher than the recommended NPK. Application of P-enriched compost @125% of the recommended P with seed inoculation of *Pseudomonas fragi* CS11RHI provided 50 and 53% higher microbial biomass carbon (552 $\mu g\ g^{-1}$ soil) and soil respiration (1,603 $\mu g\ CO_2\ g^{-1}$ soil) than the recommended SSP treated plot under irrigated soybean based cropping systems

(soybean-wheat, soybean-lentil and soybean-toria). These were finally reflected in the higher grain yield of different crops.

Research on cultivation methods of wheat showed that spraying of 0.5% $ZnSO_4.7H_2O$ at tillering and dough stage helped in harvesting 25% higher grain yield of irrigated wheat than without spraying. Seed drill sowing of rainfed wheat recorded 25% higher grain yield compared to broadcasting (2,096 kg/ha). Zero tillage sowing of wheat provided 3% more grain yield than conventional tillage (2,474 kg/ha). The dust mulching provided 8% higher wheat yield compared to no mulch (2,420 kg/ha). For the control of weeds in maize crop, a post-emergence spraying of tembotrione @ 120 g/ha (10,864 kg/ha) at 25DAS provided 6% higher grain yield and 33% less weed competition index as compared to the recommended pre-emergence spraying of atrazine (1500 g a.i./ha) followed by post-emergence spraying of 2,4-D amine (400 g a.i./ha). Hence, the post-emergence spraying of tembotrione @ 120 g/ha at 25DAS can substitute the recommended atrazine+2,4-D amine for weed control in maize. Experiment on the use of bioinoculant/bio-fertilizer indicated that inoculation of wheat seed with cold tolerant PGP *Pseudomonas* sp. PPERs23 recorded significantly higher grain yield of VL *Gehun* 804 (2,129 kg/ha) and VL *Gehun* 907 (2,110 kg/ha) than control. Bacterization with cold tolerant PGP consortium C2 recorded higher grain yield of VL *Gehun* 804 (2,130 kg/ha) and VL *Gehun* 953 (2,090 kg/ha) compared to uninoculated control. However, inoculation with consortium C4 provided higher yield of VL *Gehun* 907 (2,418 kg/ha).

For the availability of forage grass in hills, two varieties, *i.e.* Setaria-25 (*Setaria anceps*) and Palam perennial rye-1 (*Lolium perenne*) were identified. In fruit based agri-horti system, higher grain and fodder yield of dual-purpose wheat was recorded under open condition compared to lemon, pear, plum and apricot. The highest grain yield of wheat was recorded from VL *Gehun* 804 compared to VL *Gehun* 892, VL *Gehun* 829 and VL *Gehun* 907 under peach based agri-horti system during *rabi* season. In *kharif* season, significantly higher grain yield (1.80 t/ha) was recorded by VL *Mandua* 149 than rest of the finger millet varieties. In pecannut-based agroforestry system, variety *RCT*-1 recorded significantly higher turmeric yield (15.09 t/ha) compared to *Pant pithab* and *Swarna.* The pecan nut based agri-horti system provided higher soil enzyme activity (dehydrogenase, urease, phosphatase and β-glucosidase) compared to open condition. Significantly higher green fodder (20.70 t/ha) and wood yield (11.30 t/ha) was recorded in cutting of oak at 3 m height than others, except in cutting at 2 m height for wood yield. The highest green fodder of *Setaria kazungula* (5,583 kg/ha) was obtained under *Quercus lecuotrichophora*, compared to *Grewia optiva, Morus alba, Bauhinia retusa* and *Melia azedarach* based silvi-pastoral system. Pollarding at 3-meter height produced the highest green leaves (2,591 kg/ha) compared to coppicing, pollarding at 1-meter height and pollarding at 2-meter height.

Under conservation agriculture practices, zero tillage recorded higher wheat yield (3,223 kg/ha) compared to conventional tillage (2,646 kg/ha), but the reverse was the trend for rice. Application of recommended NPK+10 t FYM/ha to the wheat crop and growing soybean on residual fertility provided significantly higher wheat grain yield (3,625 kg/ha) compared to the application of recommended NPK to both season crops. Five years' mean annual discharge was 140% higher during 2015-19 in comparison to discharge recorded before treatment inception in 2000. This was obtained by harvesting roof and surface water in trenches along with plantation on the sides of trenches. The irrigation water requirement of 346-376, 131-189, 1.4, 1.3, 78.6, 93.5, 104.1, 176, 96.9 and 16.2 mm was estimated for rice, wheat, maize, soybean, vegetable pea, *rajma*, barley, tomato, french bean and chili crop, respectively using CROPWAT Model of FAO. The Google Earth derived Digital Elevation Models (DEMs) could be used for investigation and preliminary analysis with low initial investment and is suitable for hydrological and other water resources modelling.

The modified version of VL *Syahi Hal* "VL Metallic Plough", was found more suitable for both upland and irrigated valley conditions. For threshing of maize cobs, a maize sheller (VL Maize Sheller) has been designed with shelling capacity of 115 kg grain/h and 93% efficiency. This sheller can shell grain of maize without breaking the cob wood, which is mainly used by farmers as fuel wood. Animal feed block machine was improved for a block of 250×250×150 mm with a tropozoidel shape. It was also used to prepapre wheat straw block to grow oyster mushroom. VL hand fork and VL line maker was modified for better penetration and soil coverage.

During the year, severe rust disease was observed in garlic at Mukteshwar, whereas, medium to high incidence of purple blotch (20-30%) was noticed on both onion and garlic during March-April at experimental farm, Hawalbag. Frogeye Leaf Spot (FLS) on soybean reached up to 77.7% infection index in a few entries by September. In rice, leaf and neck blast were moderate to severe (30-50%) and high severity (>40% incidence) of false smut occurred naturally in all the experimental trials as well as at farmer's field. In finger millet, leaf, neck and finger blast were moderate to severe. Under polyhouse conditions, medium infestation of whiteflies in tomato was found during May, while in capsicum high infestation of mites was recorded during September. Low to medium incidence of root-knot nematode in rice, tomato, chilli and brinjal was recorded. Severe incidence (60-70%) of rust in *Parthenium* caused by *Puccinia abrupta* var. *partheniicola* was observed in February.

Magnaporthe sp. infecting rice have cross infectivity on wheat (VL *Gehun* 907, VL *Gehun* 892, VL *Gehun* 829 and Agra local) and barley (BL-2) varieties/genotypes under artificial inoculation conditions but not on finger millet. Out of the 51 rice genotypes, four (VL 8654, A 57, GSR-125 & GSR-142) and five genotypes (VL 31817, VL 31851, VL 31916, VL 31997 & GSR-132) were highly resistant to leaf and neck blast, respectively. Out of 162 hill germplasm collections of finger millet, 24 germplasms (14.81%) were found moderately resistant to leaf blast. The frequency distribution of neck blast and finger blast ranged 0 to 31.5 and 0 to 32.4, respectively. The identified resistance sources include GPU45, VL347, VHC 4171, VHC 4180 and VHC 4200. The entries, *viz.* GPU45, VRB-MF-859, VRB-MF-1816, VHC 3595, VHC 3607, VL 324 and VL 3796 were highly resistant to finger blast (<1% incidence). A field evaluation of bioagents and chemical fungicides against banded leaf and sheath blight of maize revealed maximum germination (88%) in seed treatment with *Pseudomonas fluorescens* (Pant bioagent 2). A minimum disease index (39.7%) was observed with seed treatment and spraying of *Pseudomonas* sp. PCRP7(2), while, least sclerotia were developed in carbendazim treatment.

During May to October, the trapped beetle diversity comprised of 33 species predominanted by *Anomala* sp. (13.1%) and *A. dimidiata* (12.1%). The catches of *A. dimidiata* were found to have decreased over previous years and become the second species in predominance. An *in-vitro* plate compatibility assay among selected insecticides and four potent *Bacillus thuringiensis* (Bt) (VLBt27, VLBt38, VLBt109 and VLBt135) showed that all the tested insecticides were toxic to *Bt,* except nimbecidine and spinosad. An outgel assay after native polyacrylamide gel electrophoresis (PAGE) was standardized and a 130 kDa protein band with chitinase activity was identified in four potent *Bt* isolates. An entomopathogenic fungi, *Alternaria alternata* strain VLH1, isolated from infected insect cadavers of greenhouse whitefly (*Trialeurodes vaporariorum*) is highly toxic against greenhouse whitefly and different aphid species.

The casing application of *Pseudomonas* strains NARs9, NPRs3, NARs1 resulted in 116.1, 54.6 and 46.1% higher yield of *Macrocybe gigantea.* The casing incorporation of siderophore producing *Pseudomonas* strains PPERs23, PGRs1 and NARs1 enhanced *Agaricus bisporus* yield by 39.6, 36.9 and 36.4%, respectively as compared to uninoculated control with positive correlation. At farmers' field, casing incorporation of *Pseudomonas* strain NARs9 provided higher *Agaricus bisporus* fruiting body yield (850g per bag) with 85% biological efficiency.

Impact of mobile SMS advisory service in uptake of agriculture extension information was studied using ex-post-facto research design in which selected farmers were trained in identification of crop diseases in rice and advisories were sent through mKisan SMS portal regularly for two years. Mobile phones were found most suitable for collecting and disseminating advisory and market information. Information need assessment of farmers showed that seeds/planting materials, manure/fertilizer use, and credit facilities are the areas where more information is needed. Effectiveness of mKisan SMS advisory services in addressing the information need of the stakeholders was reflected with level of satisfaction (82%) and awareness created among the users on the potential use of ICTs (60%). An android based mobile application 'e-sanchar' has been developed and demonstrated among farmers to cater the information needs of the farmers. Attitude of the farmers towards "e-sanchar" mobile application shows that 71.8% of the respondents have favorable attitude towards 'e-sanchar' mobile application.

The drudgery scores derived for various activities in paddy cultivation indicate highest drudgery for transplanting activity closely followed by weeding, harvesting and uprooting tasks. Assessment of energy expenditure rate of farm women in various activities of paddy cultivation categorized transplanting as heavy activity. Improved sickle 'VL Sickle' with small bent and wide bent were tested for their feasibility and drudgery reduction over local sickle in wheat harvesting. VL Sickle with small bent performed better in terms of area covered (10.4% more) and energy expenditure rate (22.7% less) in comparison to local sickle. Use of VL Line Maker in finger millet decreased Body Part Discomfort (BPD) among farm women by 60%. Nutrition sensitive agriculture interventions were introduced among farm women of high hills for more diversified and nutritive dietary pattern along with enhanced agricultural productivity and securing health and nutrition of the target group. After the implementation of nutrition sensitive agricultural intervention, MDD-W score reached to 5.5 and more than 90 per cent of women achieved minimum dietary diversity.

A study was conducted with farmers of areas with and without intervention, to compare the differences between choices made by farmers under unconstrained condition and farmers actual (constrained) practices of recommended agricultural practices in finger millet cropping system. In the absence of constraints (unconstrained condition), almost all farmers choose to practice improved varieties, right sowing time, proper irrigation and right stage of harvesting in finger millet and lentil crops. Whereas, in case of seed treatment, seed rate, method of sowing, disease and pest management; farmers are still hesitant to adopt recommended agricultural practices. Number of farmers adopting improved agricultural practices increased due to the demonstrations of improved finger millet varieties along with package of practices. However, only 29% farmers adopted line sowing as mixed cropping of finger millet with pulses like horse gram and black gram is prevalent in the area.

Farmers Producer Organisation (FPO) "*Vivekananda Krishi Utapadan Swayatt Sahakarita*" registered under self reliant cooperative act and formed with more than 100 farmers marketed vegetables like tomato, cabbage, cauliflower, raddish, onion, brinjal, potato, ginger and cucumber in local and nearby markets with higher prices. The FPO is also instrumental in collective purchase of inputs and collective efforts to control and eradicate *Tuta absoluta* from the area.

Farm advisory services were provided regularly through toll-free Farmers' Helpline Service (Telephone No. 1800-180-2311), Need based SMS service, m-Kisan portal and Krishi Samridhi Radio programme. Presently more than 4000 farmers are registered in m-Kisan portal and 700 farmers are registered in the institute initiated need based SMS services. 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-VPKAS, Almora Campus

Experimental Farm, ICAR-VPKAS, Hawalbag Campus

VPKAS: A Profile

ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan (ICAR-VPKAS), Almora is a premier institution conducting agricultural research mainly for the hilly region North-Western (NW) Himalayan states (Himachal Pradesh and Uttarakhand) and Union Territory (Jammu-Kashmir and Ladakh) of India. However, it also extends its technological support to other hilly regions (North Eastern States) of the country. The growth and development of the Institute over the years has been phenomenal. Established by Padamabhusan Professor Boshi Sen, the Institute originally functioned as a 'one man' laboratory with limited resources. In 1959, the laboratory was transferred to U.P. Government, and subsequently to ICAR in 1974. The Institute headquarter is located at Almora (29°33' N and 79°39' E and 1,600 m amsl) in Uttarakhand. The Experimental Farm is located at Hawalbag, 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 96 years of service to the nation, has several pioneering achievements to its credit. The most notable ones are:

i. Development of first hybrid 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.

vii. Development of protected cultivation hub and uplifting daily wage earners to entrepreneurs.

viii. Insect trap (White Grub Beetle Trap) (Patent No: IN290170) patented.

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 crop improvement in the hill region, by developing 159 improved varieties of 25 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 45 & 53, Vivek QPM 9, VL *Amber* pop corn, VL Baby Corn 1 of maize; VL *Gehun* 616, VL *Gehun* 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 grain amranth, VL *Arhar* 1 of pigeon pea and VL *Ugal* 7 of buckwheat. During 2019, Cherry Tomato **VL Cherry Tomato 1** has been identified by AICRP on vegetable crops for release by CVRC. **This is the first all India identification of a Cherry tomato variety in the country.** The Institute has also developed matching production and protection technologies for these varieties.

Since last five years, 24 improved varieties (10 central & 14 state release) of various crops like, wheat (VL *Gehun* 953, VL *Gehun* 967, VL *Gehun* 2014 and VL *Gehun* 3004), maize (Central VL Maize Sweet Corn1, Central maize VL Baby corn 2, Central Maize VL 55 and *Vivek* Maize Hybrid 57 & VL Sweet Corn Hybrid 2), barley (VLB 94 & VLB 130), rice (VL *Dhan* 156 & VL *Dhan* 158), millets (VL *Mandua* 348, VL *Mandua* 376, VL *Mandua* 379 & VL *Mandua* 380), oilseeds (VL *Soya* 77, VL *Bhat* 201, VL *Soya* 89) and vegetable (*Vivek Matar* 12, *VL Sabji Matar 13*, *VL Sabji Matar 15* & VL *Shimla Mirch* 3) were released for cultivation.

In addition, 12 high yielding disease resistant varieties have been identified for release at central/ state level. These includes wheat (VL 967, VL 2014, VL 2015, VL 3004), soybean (VL *Bhat* 202, VL *Soya* 76), lentil (VL *Masoor* 148, VL *Masoor* 150), fieldpea (VL *Matar* 61), finger millet (VL *Mandua* 380), barnyard millet (VL *Madira* 205) and grain amaranth (VL *Chua* 101). During last five years, 773.94 q of breeder, 57.10 q of nucleus and 74.65 q of truthfully labelled 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 baby corn, 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 sequentially. A new hybrid developed from such inbreds VL Sweet Corn 2 has been identified for release. 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. Presently 16,805 native and exotic accessions of 25 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 sequence, 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 in maize, soybean in finger millet and pea, lentil or toria in wheat were found more profitable than pure crops.

Long term 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.

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. In addition, cultivation of turmeric under pine forest, sloping silvi-horti and oak high density plantation have been introduced.

Low cost polyhouse technology has been developed for protected cultivation. Crops and seedlings can successfully be grown during winter in the polyhouses, otherwise, which, is not possible outside due to prevailing low temperature. Package and practices for growing vegetables under low cost polyhouse have been developed and standardized. A new design for making the polyhouse portable is under study. 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 in soybean. Viral diagnosis, based on symptomatology, showed presence of nearly 50 viral diseases affecting different crops grown in hills. Constant vigil is kept to-prevent wide-spread damage by new pests like tomato pin worm, fall army worm of maize etc. Indigenous *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 is the most menacing insect of the region devastates several rainfed *kharif* crops. More than 75 species of this insect have been recorded in Uttarakhand. Insect trap (Patented: IN290170) and the entomopathogenic *Bacillus cereus* WGPSB-2 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 4000 field demonstrations were conducted to show 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. Two FPOs developed by the institute are serving as models for effective marketing system.

The Institute has to its credit a technological options publication entitled, "*उत्तर पश्चिमी पर्वतीय क्षेत्रों में कृषि उत्पादकता 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. The Institute has been adjudged as the "**Best Performing Centre Award" for the year 2017-18 for small millets research**. On 91st Foundation Day Function of Indian Council of Agricultural Research, the scientists of ICAR-VPKAS, Almora were conferred three national awards. The first award, **Fakhruddin Ali Ahmed Award for Outstanding Research in Tribal Farming Systems**. The second award, **Pandit Deen Dayal Upadhyay Zonal Krishi Vigyan Protshahan Puraskar**, was given to Krishi Vigyan Kendra, Chinyalisaur (Uttarkashi) for its outstanding work in the area of agricultural technology extension and farmers training among 71 KVKs of union territories (Jammu-Kashmir, Ladakh) and states (Himachal Pradesh, Punjab and Uttarakhand) in Zone I. Dr Jitendra Kumar, Scientist received **Jawaharlal Nehru Award for P.G. Outstanding Doctoral Thesis Research in Agricultural and Allied Sciences** for his outstanding Ph.D. thesis research on 'Development of indigenous sensor based irrigation system for improving agricultural water productivity' in the area of Land & Water Management Engineering.

A hybrid maize—Pusa *Vivek* QPM 9 Improved that is claimed to be the world's first ever rich in lysine and tryptophan as well as pro-vitamin A, which was developed at IARI, New Delhi using *Vivek* QPM9 as the base variety. Normal Maize kernels have 8-10% protein and, within that, 1.5-2.5% lysine and 0.3-0.4% tryptophan. Pro-vitamin A content, too, is only 1-2 parts per million (ppm). The new maize hybrid has 2.67% lysine and 0.74% tryptophan in the protein (as was in Vivek QPM 9), besides 8.15 ppm of pro-vitamin A. **"The original hybrid (*Vivek* QPM 9) was developed by the ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan at Almora, Uttarakhand**. The improved version retains the *Opaque-2* gene that enhances lysine and tryptophan content, and another gene *crtRB1*, which results in higher levels of carotenoids (β-carotene, α-carotene and β-cryptoxanthin) that convert into vitamin A in the body.

The bio-fortified hybrid is not genetically modified, as both the *Opaque-2* and *crtRB1* genes are incorported from maize lines and not any alien/unrelated plants or microorganisms. It has been mainly developed for J-K, Ladakh, Himachal Pradesh, Uttarakhand and the North-East states (original recommendation zone of *Vivek* QPM9) with 93-95 days maturity and average and potential yield of 5.6 and 8 tonnes per hectare, respectively. It is also suited for growing in the southern states and Maharashtra, where the average and potential yields are higher (5.9 and 9.4 tonnes) with only 83-85 days duration.

IARI Scientists team with Pusa Vivek QPM 9 produce

1.4. Insitute Facilities

Laboratories

The institute has well-equipped facilities for plant breeding, biotechnology, agricultural chemistry and microbiology at Almora and Boshi Sen Field Research Platinum Jubliee Laboratory with entomology, plant pathology, agronomy, soil science, quality testing, agricultural engineering laboratories, seed processing plant and germplasm storage module at Hawalbag.

Research Farm

Prof. Boshi Sen Field Research Laboratory and Research Farm is located at Hawalbag about 13 km from Almora on the 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, out of which about 44.5 ha (including fodder) is cultivable land. In addition, a number of new laboratories were developed to accommodate the activities of various disciplines in the Field Research Laboratory at Hawalbag. These include short-term cold storage module, post-harvest technology unit, mushroom composting tunnel, high tech polyhouses, *etc.*

Incubation Centre – Cum - Fabrication Unit

During 2018-19, the Institute has established one workshop-cum-training centre under the Scheduled Caste Sub Plan (SCSP) programme. The centre has been established to update the skill of local blacksmiths/artisans and to train the unemployed youth of the Scheduled Caste (SC) in the field of mechanization. The centre has been equipped with major machines like lathe machine, shaper machine, numerically controlled hydraulic sheet cutting machine, milling machine, radial drill machine and other small day to day use machines/ tools.

Institute Library

A total of 4,209 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 are also archived. The library subscribed 16 foreign and 57 Indian periodicals until 2016. At present the library subscribes to ten Indian journals. There are about 4,000 bound periodicals in the library. The library is also providing current awareness service to the scientist of the institute and other outside research and development professionals visiting the institute. The Institute as a whole is a member of ICAR e-resource network CeRA.

Agricultural Knowledge Management Unit (AKMU)

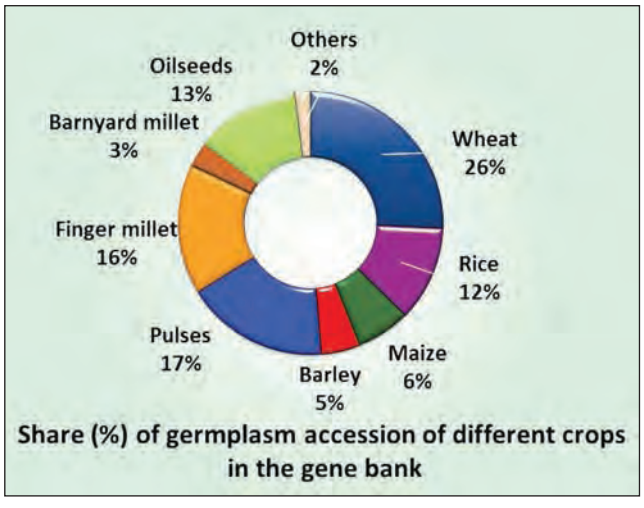
Local Area Network has been set up at the institute consisting of more than 100 nodes with 10 Mbps Internet Lease line connection at both the campus. AKMU maintains institute website which can be accessed at http://vpkas.icar.gov.in. AKMU also provides toll free Farmers' Helpline Service for farmers. Farm advisory services are provided regularly through toll-free Farmers' Helpline Service (Telephone No. 18001802311). The Institute is also serving farmers through Need Based Mobile SMS service since July 2016. Farmers are registered for receiving SMS and are grouped based on crop grown, location and activities engaged in. Presently more than 700 farmers are registered for the service. Need based information are sent to farmers on different contents like varieties, crop protection measures, nutrient management, farmers fairs/field days, seed production, government schemes, etc.

IPT&M Unit

The unit co-ordinates activities of institute technologies. To showcase institute technologies to industry and other stakeholder for further mass multiplication and commercialization through Agri-innovate India Ltd, New Delhi. In addition, a Technology License Agreement (TLA) with M/s Doon Trunk House, Jakhan Devi, Almora for manufacturing and commercialization of VL-White Grub Beetle Trap-1 for 4 years, TLA with *Navsrijan Bahuuddeshiya Swayatt Sahkarita*, Almora for manufacturing and commercialization of VL *Syahi Hal* for 3 years and TLA with Punjab Agricultural Implements Private Limited for manufacturing and commercialization of *Vivek* Millet Thresher-cum-Pearler for 3 years were signed. A Material Transfer Agreement (MTA) was signed with Bioseed Research India (A Division of DCM Shriram Ltd), Hyderabad for production and distribution of CMVL Baby Corn 2 seeds for 4 years.

Gene Bank/Medium Term Storage (MTS) Module

In the MTS module of ICAR-VPKAS, Almora, presently 16,805 germplasm accessions of 25 crops have been maintained. The germplasm comprised land races, obsolete varieties, genetic stocks, promising breeding lines and seed of national & international nurseries. A total 70 germplasm accessions, comprising barley (21), mustard (12), wheat (15), french bean (2), buck wheat (7), coriander (1), maize (1), barnyard millet (1) were collected during 2019-20 from hill region of Uttarakhand for its characterization and further utilization in crop improvement programmes.



Share (%) of germplasm accession of different crops in the gene bank

Staff

The staff position of the Institute as on 31.12.2019 is given below:

Positions	Sanctioned	Filled	Vacant
RMP	01	01	-
Scientific	60	38	22
Technical	44	28	16
Administrative	24	17	07
Supporting	35	41	-06
Total	164	125	39

Finance

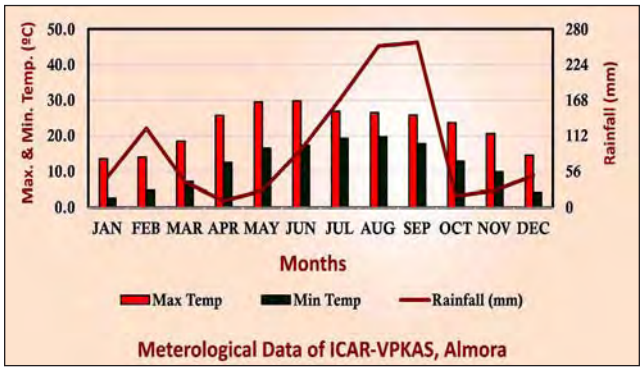
The budget outlay for January to December 2019 (Rs. in lakhs) is given hereunder:

Item	Allocation	Expenditure
Grant-in-General	450.00	333.73

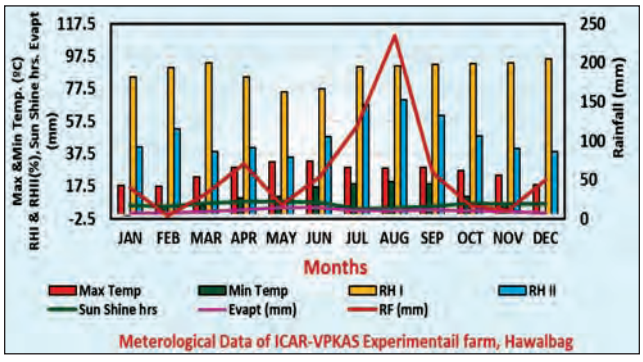
1.5. Weather and Crop Season

At Almora, the mean maximum daily temperature during *kharif* season (May to October) ranged from 23.6^{0}C (October) to 29.8^{0}C (July) and mean minimum daily temperature varied from 12.8^{0}C (October) to 19.7^{0}C (August). During *kharif*, about 815.6 mm rainfall was received. The maximum rainfall was received during September (269.0 mm) followed by August (253.4 mm). The mean maximum daily temperature during *rabi* season (November to April) ranged from 13.5^{0}C (January) to 25.7^{0}C (April) and the mean minimum daily temperature from 2.6^{0}C (January) to 12.5^{0}C (April), respectively. During *rabi*, about 295.0 mm of rainfall was received, however the maximum rainfall was received during February (123.6 mm). The total rainfall for the entire year was 1111.1 mm.

At the Experiemntal Farm Hawalbag, the mean maximum daily temperature during *kharif* season (May to October) ranged from 27.2^{0}C (October) to 32.9^{0}C (June) and mean minimum daily temperature varied from 11.2^{0}C (October) to 20.3^{0}C (August). During *kharif* about 501.65 mm rainfall was received. The maximum rainfall was received during August (235.0 mm) followed by July (119.3 mm). The mean maximum daily temperature during *rabi* season (November to April) ranged from 17.6^{0}C (February) to 29.1^{0}C (April) and the mean minimum daily temperature from -1.0^{0}C (January) to 10.2^{0}C (April), respectively. During *rabi*, about 207.52 mm of rainfall was received. The total rainfall for the entire year was 709.17 mm.



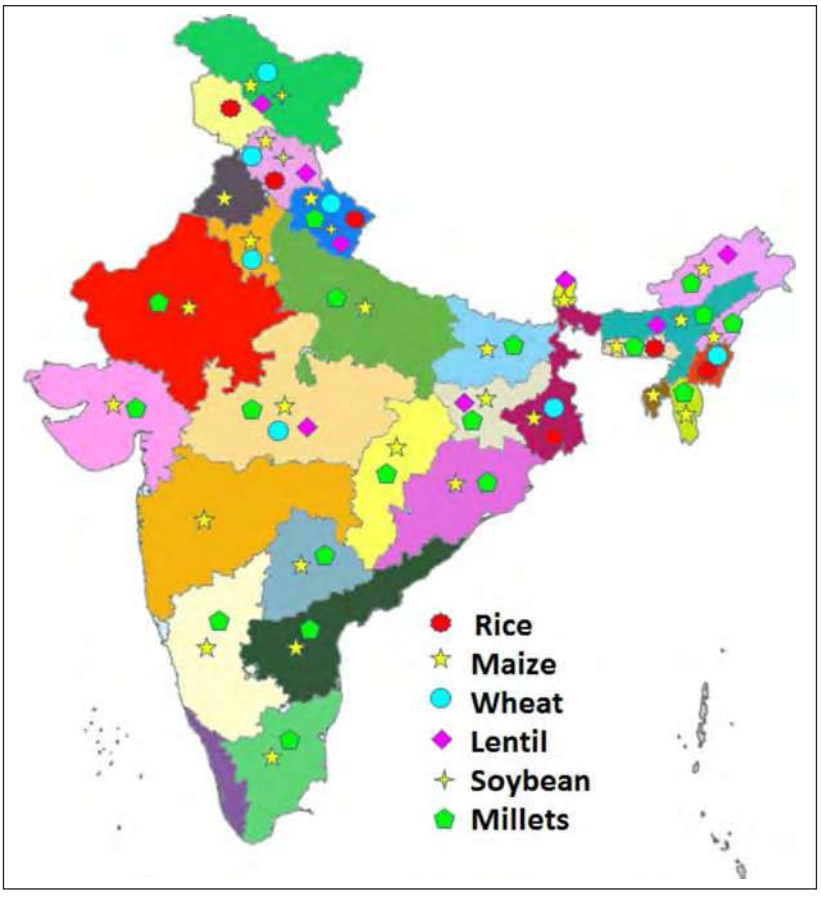
Meterological Data of ICAR-VPKAS, Almora



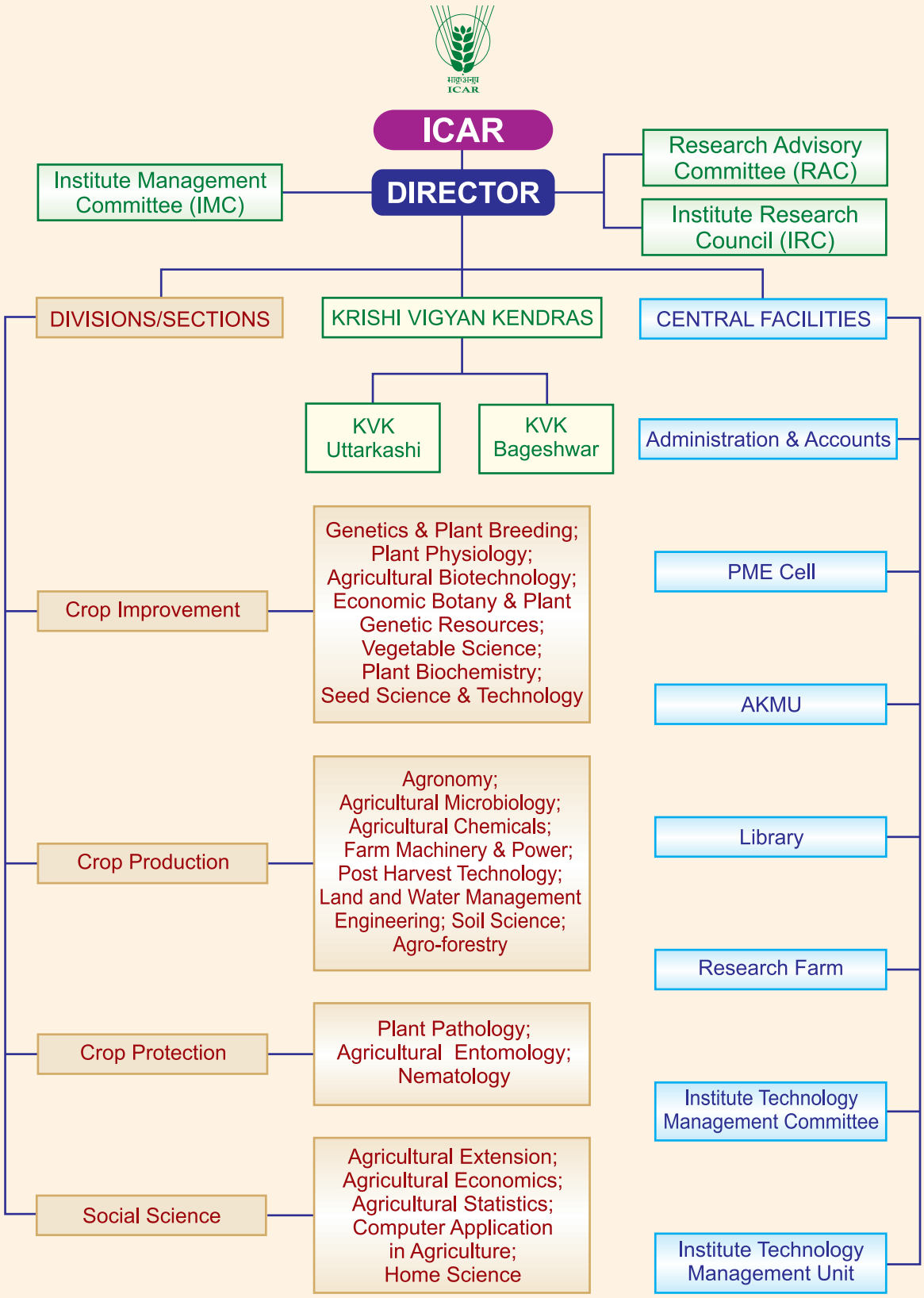
Meterological Data of ICAR-VPKAS Experimental farm, Hawalbag

Recommendation Domain of the Varieties Developed during Last Five Years Outside the Mandated Area

Since 2015, 24 improved varieties of various crops were developed. Among them, 10 were released through the Central Sub-Committee on Crop Standards, Notification and Release of Varieties and 14 were released through the State Variety Release Committee. The recommendation domain of these varieties includes the states beyond the mandate area of institute for example, western and southern states of the country, *viz.* Gujarat, Rajasthan, Chattisgarh, Madhya Pradesh. Haryana, Western Uttar Pradesh, Karnataka, Tamilnadu, Telengana, Andhra Pradesh, Delhi, Maharashtra, Bihar, Jharkhand, Odisha and states of North-Eastern hill region. This indicates the strength of varietal improvement programme of the Institute and success of well-planned strategies adopted by the scientists to develop widely adapted varieties for the entire hill region. It also shows that the Institute is marching towards a status of Centre of Excellence in varietal development for hills.



ICAR-VPKAS varieties recommended in states of India



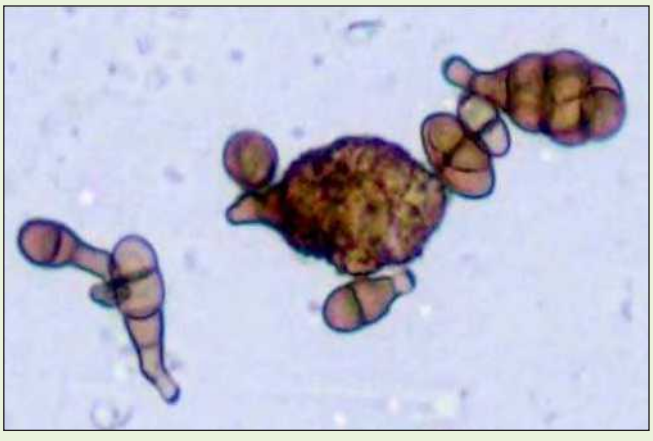
Organizational Setup, ICAR-VPKAS, Almora, Uttarakhand

ACHIEVEMENTS

VL QPM Hybrid 59

VL Cherry Tomato 1 (VT - 95)

VL *Masoor* 150



Spores of *A. alternata* VLH1

Crop of *Macrocybe gigantea*

Vivek Maize Sheller

2. Enhancement in the Productivity of Major Hill Crops

Research Projects

- Genetic Enhancement of Maize for Yield and Nutritional Quality Using Integrated Breeding Approach *[Drs. R.K. Khulbe, Devender Sharma (w.e.f., 11 July 2019), Rajashekara, H., R.S. Pal, Rakesh Bhowmick (w.e.f., 18 October 2019) & D. Mahanta]*
- Enhancement of Genetic Potency of Rice for Productivity, Biotic and Abiotic Stresses for North West Himalayas *[Drs. J.P. Aditya, Rajashekara, H., Anuradha Bhartiya (on maternity leave w.e.f., Jan to May 28, 2019), Vijay Singh Meena & Asha Kumari (w.e.f., 18 October 2019)]*
- Genetic Improvement of Wheat and Barley for Higher Productivity, Quality Traits, Abiotic and Biotic Stresses. *[Drs. L. Kant, Navin Chander Gahtyari, K.K. Mishra, D. Mahanta & Renu Jethi (w.e.f., 18 October 2019)]*
- Trait Mining and Genetic Improvement of Small Millets and Potential Crops in the Context of Climate Change *[Drs. D.C. Joshi, Rajashekara, H. & R.P. Meena]*
- Genetic Improvement of Pulses & Oilseeds for Higher Productivity, Quality, Biotic & Abiotic Stresses for North-Western Himalayan Hills *[Drs. Anuradha (on maternity leave w.e.f., Jan to May 28, 2019), K.K. Mishra (upto 17 October 2019), Sher Singh, A.R.N.S. Subbanna, J.P. Aditya, R.S. Pal & B. Jeevan (w.e.f., 18 October 2019)]*
- Enhancement of Genetic Potency in Important Vegetable Crops for North Western Himalyan Ecosystem *[Drs. N.K. Hedau, Chaudhari Ganesh Vasudeo, Hanuman Chowdhary, K.K. Mishra, B.M. Pandey, J. Stanley, R.S. Pal, Hanuman Ram, Ashish Kumar (w.e.f., 18 October 2019) & Amit Kumar (w.e.f., 18 October 2019)]*
  - ➤ Heterosis Breeding in Onion & Capcicum *[Dr. Chaudhari Ganesh Vasudeo-PI]*
  - ➤ Development of Promising Whole Pod Edible Pea Genotypes & Cherry Tomato *[Dr. Hanuman Ram-PI]*
- Germplasm Evaluation in Major Hill Crops for Nutritional and Physiological Parameters through Basic Techniques *[Drs. Ramesh Singh Pal, Anuradha Bhartiya (on maternity leave w.e.f., Jan to May 28, 2019), J.P. Aditya, Manoj Parihar, Devender Sharma (w.e.f., 18 October 2019), Navin Chander Gahtyari (w.e.f., 18 October 2019) Hanuman Ram (w.e.f., 18 October 2019) & Asha Kumari (w.e.f., 11 July 2019)]*
- Seed Production *[Drs. L. Kant, R.K. Khulbe & Chaudhari Ganesh Vasudeo]*

2. Enhancement of 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 condition in the North-Western Hills. The union territory of Jammu & Kashmir; the states of Himachal Pradesh and Uttarakhand (Hills) with a total area of 625 th ha and production of 1,189 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 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 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

Notification of Varieties

VL Sweet Corn Hybrid 2 (FSCH 75) was notified vide S.O. 3220(E) dated 05.07.19 for the union territory of Jammu & Kashmir; the states of Himachal Pradesh, Uttarakhand (Hills), Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura (North Eastern Hill Region).

Identification of Varieties

VL QPM Hybrid 59 (FQH 106) is an early maturing (85-90 days in mid-hills) and high yielding single-cross Quality Protein Maize (QPM) hybrid identified for cultivation in Uttarakhand hills. FQH 106 (3,327 kg/ha) exhibited yield superiority of 17% over *Vivek* QPM 9 (2,823 kg/ha) under organic condition in SVT during 2016-18. It exhibited high responsiveness to inorganic fertilizers and recorded optimal yield performance of 11,400 kg/ha at N:P:K dose of 150:60:60. It possesses a mean tryptophan, lysine and protein content of 0.77, 3.33 and 8.91%, respectively. FQH 106 has yellow, semi-flint and medium bold grains (avg. 1000-grain wt. 325 g). It exhibited moderate resistance against turcicum and maydis leaf blight.

2.1.1.1. Elite Lines under Maize Improvement Programme

During *kharif* 2019, a total of 158 entries were evaluated in SVT and Station Trials. The entries performing better than the checks in the trials as follows:

Trial	Promising entries	Checks
State Varietal Trial (Hills)	MH 1208 (7,491 kg/ha) MH 1204 (7,464 kg/ha) MH 1204 (7,224 kg/ha)	
Station Trials		
Normal Corn	FH 3947 (9,111 kg/ha), FH 3941 (9,071 kg/ha) FH 3951 (8,753 kg/ha)	VMH 45 (7,033 kg/ha) DKC 7074 (7,711 kg/ha

Normal Corn (DH)	FDH 3 (9,072 kg/ha), FDH 7 (8,837 kg/ha), FDH 17 (7,929 kg/ha)	VMH 45 (7,983 kg/ha) DKC 7074 (8,380 kg/ha)
Quality Protein Maize	FQH 186 (9,629 kg/ha), FQH 178 (8,696 kg/ha), FQH 185 (8,578 kg/ha)	*Vivek* QPM 9 (8,088 kg/ha), Pusa *Vivek* QPM 9 Improved (7,856 kg/ha)
Sweet Corn	FSCH 147 (14,615 kg/ha) FSCH 144 (14,282 kg/ha) FSCH 142 (13,385 kg/ha)	CMVLSC 1 (10,477 kg/ha), Misthi (12,496 kg/ha)
Provitamin A	FPVH 1 (7,248 kg/ha) FPVH 3 (7,112 kg/ha) FPVH 11 (6,577 kg/ha)	Pusa *Vivek* QPM 9 Improved (7,137 kg/ha), FH 3626 (7,253 kg/ha)
Low Phytate	FLPH 18 (7,248 kg/ha) FLPH 19 (7,112 kg/ha) FLPH 21 (6,577 kg/ha) FLPH 24 (6,577 kg/ha)	Pusa *Vivek* QPM 9 Improved (7,968 kg/ha), VMH 43 (8,583 kg/ha)
Inbred	V 495 (5,887 kg/ha) V 496 (5,767 kg/ha) V 461 (5,762 kg/ha) V 4QL 407 (5,582 kg/ha)	V 373 (5,703 kg/ha)

2.1.1.2. Breeding Materials/Development of New Strains

Development of composites

QPM One hundred and three high tryptophan (>0.80%) agronomically superior progenies of VL QPM Composite 2 (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 practised in experimental QPM composite. A total of 152 progenies possessing high tryptophan (>0.69%) and desired agronomic traits (85-90 days maturity, 200-210 cm plant height, flint grain, good cob size (16-19 cm length, 14-16 cm girth) were selected.

Development of normal and specialty corn inbred lines

- To develop short duration productive inbred lines, inbreeding was initiated in 5 promising open pollinated populations. Fifty-three progenies 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.
- Three hundred and three progenies of different homozygosity levels (45 S_1, 26 S_2, 21 S_3, 94 S_4, 33 S_5, 55 S_6, 23 S_7 and 9 advance generation lines) were evaluated and 284 (27 S_2, 41 S_3, 94 S_4, 37 S_5, 52 S_6, 21 S_7 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 *E. turcicum* (disease score <2.5) were retained for further selection and inbreeding.
- Eight advance generation elite inbred lines (V 509, V 510, V 511, V 512, V 513, V 514, V 515 and V 516) possessing early maturity (52-56 days to 50% silking), short stature (140-170 cm), high vigour and resistance to turcicum leaf blight (disease score <2.5) were established and used in hybridization.
- Selection and inbreeding was continued in 69 (13 S_3, and 56 S_6) different homozygosity inbred lines of sweet corn and 74 desirable lines (15 S_3, 19 S_4 and 36 S_7 and 4 advance generation) 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.

Development of new single-cross hybrids

- Eighteen new normal corn hybrid combinations were generated involving 10 existing elite lines

and 7 new promising lines identified during the season.

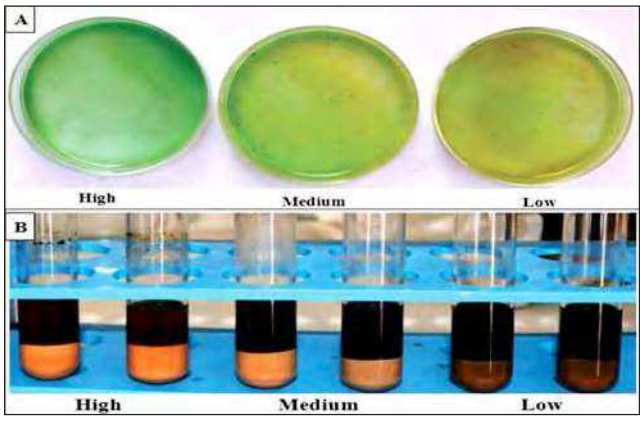
- Six new sweet corn hybrid combinations and five new QPM hybrid combinations were also generated using elite VL lines and new promising lines.

2.1.2. Germplasm Resources: Evaluation and Maintenance

- One hundred and one gene bank accessions were rejuvenated.
- Sixteen local accessions and 3 composites from Kashmir were evaluated and maintained.

Biofortification in maize for high Fe and Zn

Maize is one of the primary sources of calories and protein. Besides, micronutrients such as iron and zinc in maize kernels are very important for human nutrition. A rapid staining method was standardized for screening the genotypes for Fe and Zn content in the grain with Perl's Prussian Blue and Dithizone (DTZ: 1,5-diphenyl thiocarbazone) reagents, respectively. The intensity of developed colour was visually scored. Based on colour intensity, out of the total 103 genotypes (comprising normal corn and QPM inbreds of national and international origin, and few local OPVs), 34 were scored as high, 57 were medium and 12 were scored low for the Fe content (A), while 27, 57, 19 inbred lines were scored high, medium and low (B) for Zn content. Eight inbred lines, *viz*. BS-21-2-3-1, V336, V351, V372, BAJIM-063-1-3, BAJIM-06-6, CML176 and CML180 were scored high for both Fe and Zn content. ICP-MS or AAS will be used to verify these preliminary results for future use of the promising genotypes in maize breeding programme.



Rapid iron screening by Prussian Blue (A) and Zinc by DTZ (B) staining

2.1.3. Details of Germplasm Shared

The details of inbreds shared with various NARS institutes are as given below:

Details of maize inbreds shared with NARS institutes

Institute	Germplasm
Indian Institute of Maize Research, Ludhiana (for DUS)	VQL 1, VQL 2, V 373, V 345, V 346, V 341, V 335, CM 212 and CM 152
Indian Institute of Maize Research, Ludhiana (for SNP genotyping)	CM 212, CM 145, CM 152, CM 153, V 25, V 341, V 351, V 346, V 335, V 345, V 372, V 373, V 390, V 391, V 405, V 407, V 409, VQL 1, VQL 2, VSL 4 and VSL 16
IARI	VSL 4 and VSL 16

2.1.4. Crop Protection Investigations

During *kharif* 2019, maize entries from coordinated trials were evaluated for turcicum leaf blight (*Exserohilum turcicum*) pathogen under artificial inoculation conditions. Plants were inoculated with pathogen in whorl after 30 days of sowing and allowed for symptom expression and disease development; later disease data were taken in a 1-9 scale (Table 2.1.1).

Table 2.1.1. Resistant sources for turcicum leaf blight disease

Trial name	No of entries	Highly resistant entries (1 Score)
AVT-I Normal Maize (EM)	9	FH 3875, LMH 5119 (Filler) and VMH 45 (C)
NIVT- Normal Maize 62 (Medium Maturity)	24	AH1625, AH1634, AH4167, AH8245 R, AH8452, DH323, DH324, DKC8205, DKC8209, HKH372, JKMH1481, LMH4119, LMH4219, LMH4319, LMH4419, DHM121 (C), BIO 9544 (C), CMH08-292 (C) and VMH 45 (C)
AVT-I- Normal Maize (Medium Maturity)	10	LMH1417, BIO 9544 (C) and CMH08-292 (C)

NIVT Normal Maize 63-64 (Early Maturity)	30	AH 8178, AH 8323, DH 322, FH 3900, H 118, LMH1946 and BIO 605(C)
QPM trial	18	APH1, APQH1, FQH165, LQPMH 219, LQPMH 319, LQPMH 118, SQPMH2, APQH 9 (C), HQPM 7 (C) and HQPM1 (C)
Sweet corn trial	12	FSCH 128
Baby corn	10	AH 5021, AH 7043, DBCH326, LBCH 119, CMVL BC2 (C), HM 4 (C) and VMH 45 (C)
Pop corn	10	VMH 45 (C)
Trap nursery (MPT 15 Trial)	10	CM 501, BML 7, LM 14 and IIMR SBT POOL
Germplasm evaluation OPV	14	KDM25, L315, L316, RCM 1-61, RCM 1-76, VL QPM composite 2 and Hemant (C)

2.1.5. Agronomic Investigations

Performance of pre-released baby corn genotypes under varying planting density and nutrient levels

Four genotypes of baby corn (CMVL BC 2, AH 7043, AH 5021 & HM 4) were evaluated with two planting densities (50 cm x 15 cm and 50 cm x 12 cm) and two fertilizer levels (150-60-60 and 225-90-90 kg/ha N-P_2O_5-K_2O). Among genotypes, AH 7043 produced (3,486 kg/ha) significantly higher baby corn yield than the rest of the genotypes. The fertilizer level of 225-90-90 kg/ha N-P_2O_5-K_2O provided significantly higher baby corn yield (16%) compared to 150-60-60 kg/ha N-P_2O_5-K_2O (2,040 kg/ha). The planting density of 50 cm x 12 cm (2,540 kg/ha) provided 28% more baby corn yield than 50 cm x 15 cm (12,657 kg/ha).

In North-Western Himalayan hills, rice is a major *kharif* crop grown in 0.59 million hectares with production of about 1.27 million tonnes and productivity 2,134 kg/ha. The highest area of rice is covered by Jammu & Kashmir (0.27 m ha), whereas highest production (0.64 mt) and productivity (2,566 kg/ha) are found in Uttarakhand. In North-Eastern Himalayan States, *viz*. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura the annual rice production is around 7.66 million tonnes from an area of about 3.44 million hectares with average productivity 2,226 kg/ha during 2017-18. The average productivity of rice in NW and NE Himalayan states is far behind than the national average productivity.

2.2. Rice

In North-Western Himalayan hills, rice is a major *kharif* crop grown in 0.59 million hectares with production of about 1.27 million tonnes and productivity 2,134 kg/ha. The highest area of rice is covered by Jammu & Kashmir (0.27 m ha), whereas highest production (0.64 mt) and productivity (2,566 kg/ha) are found in Uttarakhand. In North-Eastern Himalayan states, *viz*. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura the annual rice production is around 7.66 million tonnes from an area of about 3.44 million hectares with average productivity of 2,226 kg/ha during 2017-18. The average productivity of rice in NW and NE Himalayan states is far behind than national average productivity.

2.2.1. Varietal Improvement

2.2.1.1. Variety Identified for Release

VL *Dhan* 210 (VL 11364) has been identified for release under rainfed upland spring sown rice for organic condition of Uttarakhand. It recorded an average grain yield of 2,157 kg/ha under organic condition, which was 37.6% higher than the best check VL *Dhan* 207 (1,569 kg/ha). It has long slender grain. It is developed from cross VLD 207/ VL 30424. It has 90-110 cm plant height and resistant to blast.

VL *Dhan* 211 (VL 11574) has been identified for release under rainfed upland spring sown for organic condition of Uttarakhand. On the average of three years of testing, it has exhibited yield potential of 2,088 kg/ha under organic condition. It has recorded yield advantage of 33% over VL *Dhan* 207 and 39% over VL *Dhan* 209. It is a cross of VLD 209/VL 30424 and has short bold grains and resistance against blast.

VL *Dhan* 159 (VL 20083) is an early maturing genotype developed from a cross between VL 66/ HPR 2143. It was identified for release under rainfed upland June sown rice of Uttarakhand hills. It has yield potential of 1,964 kg/ha under organic condition and recorded 21.74% yield superiority over the best check VL *Dhan* 221. It has long bold grain with plant height 95-100 cm and maturity 100-115 days. It has shown resistance against leaf and neck blast, brown leaf spot, sheath rot, false smut, leaf scald and stem borer.

2.2.1.2. Elite Lines under All India Coordinated Rice Improvement Programme

Coordinated hill trials are evaluated under low (≤ 950 m amsl), medium (951 to 1500 m amsl) and high (≥1501 m amsl) elevation hills. Hill trials are conducted under transplanted irrigated and direct seeded upland areas. The hill trials are classified into two groups, *viz.* early and medium based on crop duration. Total nine trials, *viz*. AVT-2E (H), AVT-1E (H), IVT-E (H), AVT-2M (H), AVT-1M (H), IVT-M (H), AVT-1U (H), IVT-U (H) and IVT (L) were conducted as a part of multi-locational trials under AICRIP.

AVT-2E (H) consisted with 7 entries, 4 test entries and 3 checks, *i.e. Vivek Dhan* 62 (National check), VL *Dhan* 65 (Regional check for North and South), RC Maniphou 11 (Regional check for North East) and local (VL *Dhan* 85). The mean grain yield of this trial ranged from 2,016 kg/ha (entry no 2105) to 4,859 kg/ha (entry no. 2103). In AVT-1E (H) fifteen entries were evaluated including checks and entry no 2207 gave the highest yield 5,532 kg/ha. Twenty-three entries were tested in IVT-E (H) including checks and highest yield 4,929 kg/ha was observed in entry no. 2301 followed by entry no. 2317 (4,929 kg/ha) and entry no. 2303 (4,893 kg/ha). Our entries, *viz*. VL 32308, VL 32303, VL 32300, VL 32292 were tested in second year (AVT-1E) of testing and entries, *viz.* VL 32462, VL 32463, VL 32465, VL 32434 were tested in first year (IVT-E) in irrigated early duration trial. Advance Variety Trial 2-Medium hills (AVT 2-M H) comprised ten entries including seven test entries and *Vivek Dhan* 62 as National Check, VL *Dhan* 65 (Regional check for North and South), RC Maniphou 11 (Regional check for North East) and local check (VL *Dhan* 61). Entry no. 2409 was the highest yielder (4,893 kg/ha) in this trial. Eleven entries including checks were evaluated in AVT-1M (H) and the highest yielder (5,029 kg/ha) was entry no. 2509 whereas in IVT-M (H) twenty-three entries were tested and highest yield (6,232 kg/ha) was recorded in entry no. 2617. In medium duration, our three entries namely VL 32131, VL 40387 and VL 32130 were tested in third year (AVT-2M) of testing and VL32329 was in second year (AVT-1M) of testing whereas, entries VL 32454, VL 32470, VL 32471, VL 40530 were tested in first year (IVT-M) of testing. The Advanced Varietal Trial-1 Upland hills (AVT 1-U-H) consisting of ten entries and initial varietal trial-upland hills (IVT-U(H)) constituted with fifteen entries involving checks, *viz*. *Sukaradhan* 1 (National Check), *Vivek Dhan* 154 (Zonal check for North and South), *Bhalum* 1 (zonal check for North East) and local check (VL *Dhan* 221) were conducted and both trials were severely affected by weeds at early stage consequently poor plant stand and very low yield was obtained. Entry VL 20073 was in third year of testing and VL 20254 was in second year (AVT-1U) of testing whereas, four entries VL 20432, VL 20541, VL 20559, VL 20561 were tested in first year (IVT-U) of testing in case of rainfed upland June sown trial. A separate trial, Initial Varietal Trial Landraces (Hills) IVT- LR

(H) was constituted to congregate and make use of the rice landraces available with different breeders working on hill rice. IVT-LR (H) comprised of 17 test entries and the mean grain yield of this trial ranged from 333 kg/ha (entry no. 2915) to 3,958 kg/ha (entry no. 2616).

2.2.1.3. Elite Lines under State Rice Improvement Programme

State Varietal Trials were conducted under organic condition with recommended organic fertilizer dose, *i.e.* 40 t/ha FYM for irrigated early and medium trial, 30 t/ha FYM for rainfed upland June sown trial. Three trials, *viz*. June sown rainfed upland, irrigated early duration and irrigated medium duration were conducted under SVT and 4 enteries (VL 113644 & VL 11574) and (VL 20083 & VL 20073) were identified for spring sown rainfed upland and rainfed upland June sown conditions, respectively. Rainfed upland June sown trial comprised of 7 test entries including two checks *Vivek Dhan* 154 and VL *Dhan* 156 and entry no. 1004 recorded highest grain yield (2,135kg/ha). Four entries, *viz*. VL 20432, VL 20541, VL 20559 and VL 20561 were in the first year of testing, however two entries (VL 20254 & VL 20229) were promoted to second year of testing. In SVT, irrigated transplanted early trial, 14 entries including four checks *Vivk Dhan* 82, VL *Dhan* 85, *Govind* and *Pant Dhan* 6 were evaluated and grain yield ranged 2,437 kg/ha (entry no. EPH 802) to 4,097 kg/ha (entry no. EPH 805). Two entries (VL 32110 and VL 32112) and one entry (VL 32303) were promoted for third year and second year of testing, respectively. In irrigated transplanted early duration trial four entries (VL 32462, VL 32463, VL 32465 and VL 32434) were tested in first year of testing.

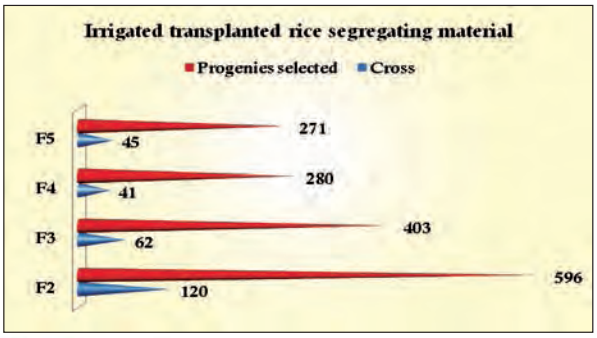
In SVT, irrigated transplanted medium duration trial 10 entries were evaluated including two checks *Vivek Dhan* 62 and *Pant Dhan* 26 and grain yield ranged 2,386 kg/ha (entry no. MPH 902) to 3,878 kg/ha (entry no. MPH 907). Entry VL 32094 was promoted for third year of testing, whereas 4 entries (VL 32454, VL 32470, VL 32471, VL 40530) were tested in the first year of testing.

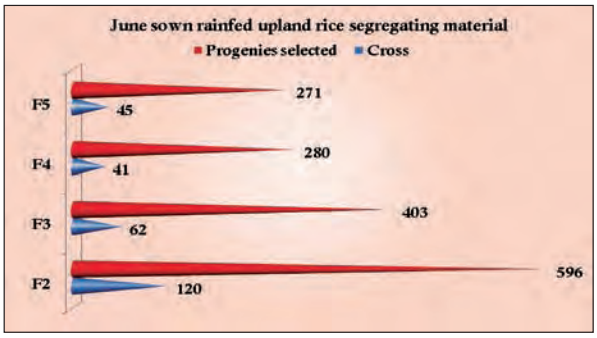
2.2.1.4. Breeding Materials/Development of New Strains

Advance breeding lines were evaluated against the recently released check varieties to identify suitable promising lines based on grain yield, resistance to major diseases like blast and brown spot. Selected promising lines from advance station trials under rainfed upland June sown condition {VL 20613 (2,458 kg/ha) and VL 20614 (2,328 kg/ha)} were evaluated against the check VL *Dhan* 157 (2,133 kg/ha). In irrigated condition, the promising lines for early duration, *i.e.* VL 32560 (4,505 kg/ha) and VL 32594 (4,745 kg/ha) were tested against the check VL *Dhan* 86 (3,964 kg/ha); and VL 32596 (5,104 kg/ha) and VL 32511 (4,984 kg/ha) were evaluated for medium duration condition compared to the check VL *Dhan* 68 (4,794 kg/ha). These lines were resistant to blast and brown spot having desirable plant height of semi dwarf (irrigated <110 cm, upland <90 cm) to intermediate (irrigated 110-130 cm and upland 90-125 cm) with maturity of 100-120 days (for irrigated early & rainfed upland June sown situation) and 125-140 days (for irrigated medium condition).

Segregating Breeding Materials

Total 2,394 progenies derived from 383 crosses were selected in F_2 to F_5 generations under rainfed upland and irrigated transplanted ecosystem based on desired traits like early (100-120 days) and medium (121-140 days) maturity, semi dwarf (irrigated <110 cm, upland <90 cm) to intermediate (irrigated 110-130 cm, upland 90-125 cm) plant height, drought tolerance (0-3 score of leaf drying), disease (0-5 score) and insect resistance (0-3 score) (Fig. 2.2.1.).





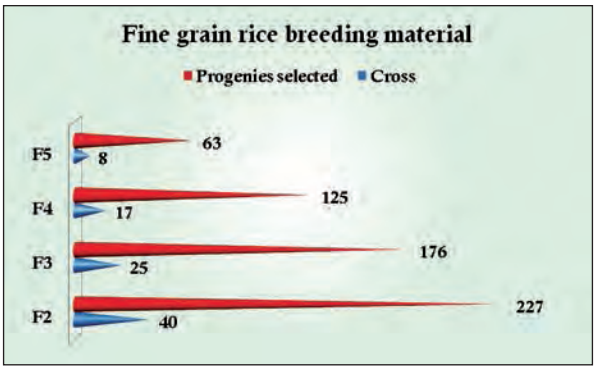


Fig. 2.2.1. Details of breeding materials under rainfed and irrigated ecosystem

2.2.2. Crop Protection Investigations

During *Kharif* 2019, different rice entries from station and coordinated trials were evaluated for leaf blast, neck blast and brown leaf spot diseases under natural conditions. The blast disease was evaluated under Uniform Blast Nursery (UBN) and brown leaf spot screening was performed in sick plots (Table 2.2.1).

Table 2.2.1. Promising lines identified for brown leaf spot and blast disease of rice

Trial/Nursery	No. of Entries	Promising lines identified		
		Brown leaf spot	Leaf blast	Neck blast
Advance station trial for June sown rainfed condition	18	Vivek *Dhan* 154, Vivek *Dhan* 157, VL 20608, VL 20611, VL 20612, VL 20613, VL 20614, VL 20615, VL 20616, VL 20618, VL 20620, VL 20685 and VL 20687	Vivek *Dhan* 157, VL 20615, VL 20684 and VL 20685	Vivek *Dhan* 154, Vivek *Dhan* 157, VL 20607, VL 20608, VL 20611, VL 20612, VL 20613, VL 20614, VL 20615, VL 20685 and VL 20687
Advance station trial for transplanted rice	22	VL *Dhan* 86, VL 32473, VL 32474, VL 32577	VL *Dhan* 86, VL 32473, VL 32474, VL 32475, VL 32510, VL 32517, VL 32515, VL 32521, VL 32522, VL *Dhan* 68, VL 32525, VL 32558, VL 32560, VL 32574, VL 32577, VL 32580 and VL 32585	VL 32473, VL 32474, VL 32511, VL 32514, VL 32521, VL 32522, VL *Dhan* 68, VL 32525, VL 32558, VL 32560, VL 32573, VL 32574, VL 32577, VL 32580, VL 32585, VL 32594 and VL 32596
VL rice blast screening nursery (VLRBSN)	80	12 entries were highly tolerant	35 entries were highly resistant	65 entries were highly resistant
National Screening Nursery for hills (NSNH)	120		41 entries were highly resistant	84 entries were highly resistant
National Hybrid Screening Nursery (NHSN)	108	4 entries were highly tolerant	16 entries were highly resistant	38 entries were highly resistant
Donor Screening Nursery (DSN)	150	CR 4053-24-40-1, CR 4054-26-2-1, CR-4054-26-6-1, Vikramarya, CH-45, Benibhog and Tetep	MSM-SB-52, UBKVR-15 (IET - 24173), RP-Patho-2, RP-Patho-7, RP Patho-8, RP-Patho-10, RP-Patho-11, RP-Bio Patho-1, RP-Bio Patho-7, RP-Bio Patho-8, RP-Bio Patho-9,	--

			RP-Bio Patho-10, RP-Bio Patho-11, RP-Bio Patho-12, HL18WS-23-15, HL18WS-20-4, RMS-R-6, RMS-R-7, RMS-R-8, RMS-R-9, RMS-R-10, RMS-R-11, RMS-R-16, RMS-R-17, Tetep and Phoghak	
National Screening Nursery (NSN-1)	353	--	96 entries were highly resistant	--
National Screening Nursery (NSN-2)	672	--	170 entries were highly resistant	--

2.2.3. Physiological Investigation

A study was conducted to analyze the effect of severe cold stress in 19 genotypes of rice. Plants grown under normal time of sowing (June) in Mallahata were considered as control condition. Whereas, severe cold stress was imposed by growing the genotypes at HATS, Mukteshwar at an altitude of 2286 m amsl. In severe cold stress, total soluble sugar (1.378-3.515 mg g^{-1}FW) and total protein content (0.037-0.392 mg g^{-1} FW) in leaves were recorded at anthesis stage compared to control (0.215-3.407 mg g^{-1} FW and 0.039-0.299 mg g^{-1} FW, respectively). Similarly, physio-biochemical parameters like Relative Water Content (88.25–95.87% and 87.63-93.81%), Membrane Stability Index (90.53-95.37% and 72.93-87.84%), Malondialdehyde content (10.75-15.18 nmol/ml FW and 8.67-9.98 n mol/ml FW) were recorded at flowering stage in severe cold stress and control conditions, respectively. The panicles were fully exerted in rice under control condition, whereas none of the genotypes showed fully exerted panicles under severe cold stress. Only few genotypes showed proper anther dehiscence and viable pollens. Only 5 genotypes out of 19, *viz*. GGAFByeo, Local Black, Yami- Nami, IRCTN 91-82, Nanglwai showed partial grain filling under severe cold stress with reduced (<30%) spikelet fertility.

2.3. Wheat

Wheat is the most important cereal crop of *rabi* season and is grown over an area of 0.98 million ha in NW Himalayas with an average productivity of 2,033; 1,638 and 2,587 kg/ha in the union territory/states of Himachal Pradesh, Jammu & Kashmir and Ladakh and Uttarakhand, respectively. Its average productivity of 2,086 kg/ha is much below the national productivity of 3,200 kg/ha in 2016-17. These levels of production and productivity can be raised if high yielding varieties having resistance/tolerance to biotic (yellow, brown rust and loose smut) and abiotic (drought and cold) stresses are adopted along with suitable production and protection technologies.

2.3.1. Varietal Improvement

2.3.1.1. Varieties Identified

VL 2029 has been developed as a new high yielding strain through direct selection from a cross MUNAL #1/FRANCOLIN #1. It has been identified for release under timely sown rainfed organic production conditions of Uttarakhand hills. It has an average yield potential of 2,431 kg/ha, which was 18% higher than the best check VL *Gehun* 953 (2,053 kg/ha) over three years of testing in UK hills. VL 2029 is also highly resistant to yellow and brown rust diseases.

VL 2028, a new high yielding strain was developed from a cross FRANCOLIN #1*2/MUU. It has been identified for release under timely sown rainfed organic production conditions of Uttarakhand. It has an average yield potential of 2,270 kg/ha which was 10.55% higher than the best check VL *Gehun* 953 (2,053 kg/ha) over three years of testing in UK

hills. VL 2028 is also highly resistant to yellow and brown rust diseases.

VL 3010, a new high yielding strain was developed from a winter x spring wheat cross RAJ 4083/ NESSER/SAULES:KU 32. It has been identified for release under irrigated late sown production conditions of Uttarakhand. It has an average yield potential of 5,819 kg/ha which was 6.16% higher than the best check UP 2526 (5,481 kg/ha) over three years of testing in UK plains. VL 3010 is also highly resistant to yellow and brown rust diseases.

2.3.1.2. Elite Lines under All India Coordinated Wheat Improvement Programme

The newly developed wheat strains were tested for their adaptability with respect to grain yield, disease resistance and other desirable attributes under the rainfed as well as irrigated timely sown and restricted irrigation late sown conditions in nine yield evaluation trials.

Rainfed conditions

Five entries were tested in AVT timely sown trial. The test entry HS 652 (2,020 kg/ha) ranked 4th and the best check HS 562 (2,440 kg/ha) was the top yielder. In timely sown IVT trial, 16 entries were tested and the best check HS 562 (3,400 kg/ha) was the top yielder and entry VL 2035 (3,080 kg/ha) ranked 3rd. Ten entries were evaluated in the late sown restricted irrigation AVT (pre-sown irrigation only) trial, and entry, *viz*. VL 3021 (3,230 kg/ha) yielded better than the best check, *viz*. VL *Gehun* 892 (3,150 kg/ha).

Irrigated conditions

Five entries were evaluated under AVT timely sown trial and the check HS 562 (3,720 kg/ha) was the top yielder and the test entry HS 652 (3,530 kg/ha) ranked 4th.

2.3.1.3. Elite Lines under State Wheat Improvement Programme

Rainfed organic conditions

Eleven entries were tested under SVT organic timely sown trial. VL 2028 (2,448 kg/ha) and VL 1014 (2,242 kg/ha) recorded a yield advantage of 11.93% and 2.48% over the best check VL *Gehun* 953 (2,187 kg/ha). On the basis of three years testing, VL 2029 and VL 2028 were identified for release.

Irrigated organic conditions

Eleven entries were evaluated under the irrigated SVT organic timely sown trial and none was superior to the latest variety VL *Gehun* 953 (3,649 kg/ha).

2.3.1.4. Elite Lines under Station Trials

Initial station yield evaluation trials, one trial each under 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 timely sown rainfed trial, 42 entries were tested and VW 1827 (3,800 kg/ha) was found superior to the best check HS 562 (3,600 kg/ha). Seventeen entries were evaluated under the

late sown restricted irrigation (pre-sown irrigation only) trial and VW 1850 (4,490 kg/ha), VW 1844 (4,260 kg/ha) and VW 1853 (4,190 kg/ha) were the top three entries better than the best check HS 490 (2,990 kg/ha). Forty-two entries were evaluated under irrigated timely sown trial and VW 1801 (5,190 kg/ha) was significantly better in grain yield than the best check HS 562 (5,050 kg/ha).

Fifty-six new bulks were evaluated in different station trials under the rainfed as well as irrigated conditions and 7 promising strains entered in different All India Coordinated Trials of Northern Hills Zone.

Development of new strains/breeding materials

Development of high yielding disease resistant (yellow & brown rust and loose smut) genotypes suitable for rainfed and irrigated timely sown and restricted irrigation late sown conditions of Northern hill zone are the major objectives of the programme. Two hundred and ninety-seven fresh crosses [97 spring x spring (S×S) and 200 winter × spring (W×S) wheat] including direct, back crosses and three-way crosses were successfully made by utilizing diverse donors of winter and spring wheats. Two hundred thirteen better performing F_1 hybrids, consisting of 58S×S and 155W×S were identified after evaluation of 387 F_1 hybrids.

Selected bulk pedigree method was followed to handle the breeding materials. F_3 and F_5 generations were grown under low fertility and rainfed conditions. Two hundred thirteen F_2's (58 S×S and 155 W×S) and 362 bulk progenies of 362 crosses (195 W×S and 167 S×S) in F_3 to F_5 generations and 440 single plant progenies (260 S×S) and (180 W×S) of 117 crosses in F_6 and subsequent generations were planted for evaluation and further selection. The infector rows were planted in and around the breeding materials and inoculated following syringe-inoculation method of rust inoculation, which was mixture of prevalent pathotypes received from IIWBR, RS Flowerdale, Shimla, H.P. The heavy rust infection facilitated the selection and on overall basis, 399 bulk and 365 individual plant progenies from F_3 generations onward were selected. They will be further evaluated during the ensuing season.

2.3.1.5. Breeding for Quality Wheat

Awareness regarding quality is increasing day by day. In wheat, high protein and micro-nutrient content, good *chapati* and biscuit making quality, *etc.* are some of the important desirable quality traits. Therefore, efforts were made to incorporate these traits in future genotypes through hybridization with the proven donors. QLD 101, QLD 102 and QLD 103 (protein yield 45-52 g), QLD 100 (high Sedimentation value), VL *Gehun* 858, VL *Gehun* 907, FLW 16 and FLW 3 (*chapati* quality) were used as donors for the respective traits and were crossed with well adapted genotypes. Thirty-nine fresh crosses were attempted during *rabi* 2018-19. Quality analysis of 187 F_6 bulks derived from such crosses was completed. The quality parameters of promising F_6 bulks are given in Table 2.3.1.

2.3.1.6. Improvement of Spring Wheat through Introgression from Winter Wheat Gene Pool

Twenty-eight winter and facultative wheat were selected for their high grain yield, tillering, ear length, grain number per ear and disease resistance were planted in a crossing block at experimental farm, ICAR-VPKAS, Hawalbag and crossed to spring wheats known for their high yield potential,

Table 2.3.1. Promising F_6 bulks with desirable quality parameters

Sample No	Protein (%)	Carbohydrate (%)	Fat (%)	Moisture (%)	β-carotene (ppm)	Zeleny sedimentation value (ml)
BN 661	11.22	66.25	2.48	13.97	1.69	48
BN 642	11.21	68.19	2.37	13.88	1.51	46
BN 659	11.21	68.73	2.26	13.98	1.77	48
BN 1065	11.16	68.40	2.42	13.73	1.79	44
BN 648	11.07	69.38	2.33	13.84	1.72	46
BN 835	11.02	71.82	2.25	13.88	1.57	60
BN 1109	11.01	70.56	2.41	13.74	1.62	50

disease resistance (rust resistance in particular) and adaptation to the major wheat-growing regions of the country. Seventeen three-way crosses were also attempted with the F_1 of the previous year by crossing them with the selected spring wheat. A total of 75 crosses were successfully made during *rabi* 2018-19.

In addition to this, 106 F_1s made during rabi 2017-18 were planted and 69 were retained for growing their F_2 generation during the next crop season. A total of 70 F_2's retained during last season, were raised during *rabi* 2018-19 and finally, 68 F_2's was bulked.

These 55 F_2 bulks were shared with 14 cooperators in three major wheat growing zones (Northern Hill Zone, North Eastern Plain Zone and Central Zone) of the country for evaluation and further selection under different biotic and abiotic stresses. The utilization report revealed that these materials were used from 33.11% at different cooperating centers and a total of 1646 plants were selected.

2.3.1.7. Genetic Resources - Evaluation and Maintenance

Two national nurseries comprising of 196 entries were evaluated. Three entries for rust resistance & test weight; 2 entries for rust resistance, grain yield & grain number; 3 for test weight and 2 for rust resistance, grains per spike & test weight were selected from National Genetic Stock nursery (NGSN) for their use as a donor in hybridization programme. In Elite International Germplasm Nursery (EIGN), 19 genotypes were selected for evaluation and utilization for introduction.

Off-season nursery

Two hundred and seventy advance lines of wheat were planted at Lahaul Spiti, Himachal Pradesh as well as Wellington, Tamil Nadu during *kharif* 2019, for screening against yellow and brown rust, respectively. Heavy yellow rust epiphytotic facilitated the screening and yellow rust severity up to 80S was recorded. Finally, 150 lines having yellow rust score <20S were selected for evaluation during the ensuing season. In CRP molecular breeding wheat project, F_1s of inter crosses between (VL *Gehun* 907/*Yr* 10/ 5*Datatine) X (VL *Gehun* 907/FLW 1) and (VL *Gehun* 892/*Yr*10/5* Datatine) X (VL *Gehun* 892/FLW 1) were planted and advanced.

2.3.2. Crop Protection Investigations

Wheat samples of yellow rust collected from different locations of Uttarakhand and analysed at IIWBR regional station Flowerdale showed that the frequency of pathotype 238S119 was maximum followed by 110S119. Analyses of wheat brown rust samples showed that pathotypes belonging to 3 major groups 12, 77 and 162. There was increase in the proportion of pathotype 77-9.

Based on rigorous screening under Multiple Disease Screening Nursery (MDSN) at multilocations, the following genotypes have been identified as confirmed source of resistance for multiple diseases:

Resistant to diseases	Genotypes
Resistant to all three rusts+powdery mildew+flag smut	VL 3014
Resistant to stem and leaf rust+karnal bunt	VL 3013
Resistant to leaf blight+powdery mildew+flag smut+karnal bunt+head scab	VL 1013
Moderately resistant to foliar blight	VL 907, VL 3021
Resistant to karnal bunt	VL 3019, VL 3021
Resistant to powdery mildew	VL 1014, VL 3021

More than one thousand six hundred wheat and barley entries of different coordinated and station nurseries were screened under artificial epiphytotic conditions. These include wheat disease monitoring nursery (earlier trap nursery), SAARC, Loose Smut Expression Nursery (LSEN), VL rust screening nursery, Powdery Mildew Screening Nursery (PMSN), Elite Plant Pathological Screening Nursery (EPPSN), Multiple Disease Screening Nursery (MDSN) and Hill Bunt Screening Nursery (HBSN). Following lines of wheat were identified promising.

Nursery	Promising lines (disease reaction)
WDMN (TRAP)	HW 2021, C 306, DL 784-3, HPW 349, VL 892 against yellow rust (0 to 10S); Agra local-60S
SAARC	WH 1562, HD 2687, PBW 660, Punjab 85, Chorwal 86, and Bakhtawar 94 against yellow rust (0 to 10S); Susceptible check-40S
Loose smut expression nursery (LSEN-coordinated)	HS 664, HD 3086, DBW 88, WH 1124, DBW 90, GW 1339, HI 8713, HI 8737, MPO 1343, HI 8805, MACS 4058, MACS 4059, HI 8802, HW 1098, DDK 1054 (0-5%)
VL Loose smut Expression Nursery	VW 0716, VW 0739, VW 0770, VW 0920, VW 0933, VW 0965, VW 1519, VW 1540, VW 1564, VW 1713, VW 1747 (0%)
Hill Bunt Screening Nursery Coordinated (HBSN)	HS 562, HS 490, VL 3021 (0-10%)

2.4. Barley

Barley is being cultivated in some of the traditional areas of North-Western Hills. It has a coverage of 49.2 thousand ha with an average productivity of 1,189 kg/ha (2016-17). Barley improvement work is focussed mainly on the development of high yielding and disease resistant varieties suitable for rainfed conditions of NW hills.

2.4.1. Varietal Improvement

2.4.1.1. Elite Lines in All India Coordinated/ State/Station Trials

Eighty new barley strains were evaluated in 4 different trials, to identify high yielding disease resistant genotypes. In AVT timely sown rainfed trial BHS 475 (2,947 kg/ha) and VLB 162 (2,856 kg/ha) yielded significantly higher than the best check BHS 400 (2,560 kg/ha). In AVT dual purpose rainfed trial VLB 155 (2,260 kg/ha) ranked 2nd in terms of grain yield as compared to best check VLB 118 (2,310 kg/ha) which ranked 1st. As far as green forage yield is concerned it again ranked 2nd with 7,910 kg/ha green forage as compared to the best check BHS 380 (8,760 kg/ha). VLB 157 (2,299 kg/ha) and UPB 1078 (2,275 kg/ha) surpassed the best check VLB 118 (2,037 kg/ha) in SVT (organic) timely sown rainfed trial. Thirty-nine new bulks generated through institute breeding programme were evaluated in station trials under rainfed condition. Five promising strains having yield potential from 2,216 to 2,597 kg/ha were selected and nominated in to the All India Coordinated Trials of Northern Hill Zone.

Development of new strains

To develop high yielding disease resistant genotypes, 59 introduced materials were evaluated and 114 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

One hundred and fourteen advance lines were grown at the off-season facility at Lahaul Spiti, Himachal Pradesh for screening against yellow rust. Thirty lines having desirable rust reaction (<20S) were selected.

2.4.2. Agronomic Investigations

Performance of timely sown dual-purpose barley under rainfed condition

Five genotypes of dual-purpose barley were evaluated under rainfed condition. Among genotypes, VLB 118 (2,313 kg/ha) produced highest grain yield, which was significantly higher than rest of the genotypes, except VLB 155 (2,261 kg/ha). BHS 380 provided the highest green fodder yield (8,758 kg/ha), which was significantly higher than rest of the genotypes.

2.5. Small Millets & Potential Crops

Small millets and potential crops 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.

2.5.1. Varietal Improvement

2.5.1.1. 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 the Initial Varietal Trial, 3017 (3,223 kg/ha) and GPU 96 (2,453 kg/ha) were the top-ranking entries. Similarly, in Advanced Varietal Trial (AVT) (early and medium duration), 1004 (3,134 kg/ha) and 1008 (2, 996 kg/ha) recorded highest yield followed by 1011 (2,782 kg/ha) and local check VL *Mandua* 324 (2,570 kg/ha).

Barnyard millet

Barnyard millet Initial and Advanced Varietal Trial (BIAVT) comprising seventeen entries was conducted for evaluating yield and yield contributing traits. Entry 4017 recorded the highest grain yield (3,304 kg/ha) followed by 4008 (3,134 kg/ha), 4009 (3,028 kg/ha) and 4010 (2,798 kg/ha).

Elite Lines under State Varietal Improvement Programme

Finger millet

In the State Varietal Trial (SVT) under organic conditions, MH 1602 (2,225 kg/ha), MH 1603 (2,027 kg/ha) and MH 1601 (1,939kg/ha) were found superior to the check in terms of grain yield. Entry MH 1602 was found resistant to neck and finger blast disease and recorded lesser mean score (2.8%) and finger blast (3.4%) compared to check VL *Mandua* 352 (neck blast and finger blast - 5.0%).

Barnyard millet

In barnyard SVT trial, entry BY-1706 was top yielder (2,264 kg/ha) followed by BY-1704 (2,147kg/ha). Entry BY-1706 was found resistant to grain smut disease and recorded lesser mean score (2.5%) as compared to check VL *Madira* 207 (5.0%).

Breeding Materials/Development of New Strains

Finger millet

Yield evaluation of superior bulks in station trial

During the rainy season of 2019, 48 superior bulks identified in F_6 generation of different crosses were evaluated in Initial Station Trial (IST) for yield and yield attributing traits along with five checks (VL *Mandua* 352, VL *Mandua* 324, GPU 45, GPU 67, PR 202 and VL *Mandua* 324). Entry VR 18-4 (3873.6 kg/ha), VR 18-26 (3, 234 kg/ha) and VR 18-9 (3,089.3 kg/ha) were superior to the best check VL *Mandua* 376 (2,987.5 kg/ha) and VL *Mandua* 352 (2,416.4 kg/ha). These bulks were also evaluated for resistance to neck and finger blast disease under natural infestation conditions. Entry VR 18-4 was found resistant to neck (mean score 1.9 %) and finger blast (mean score 2.7%) while VR-18-9 and VR 18-26 were moderately resistant to both diseases.

Development of new strains

During *kharif* 2019, 40 new cross combinations were attempted involving high yielding blast resistant released varieties (IIMRF 823-17, VL *Mandua* 379, VL *Mandua* 387, VL *Mandua* 376, GPU 45, GPU 48 and GPU 28); early maturing locally adapted lines (VL *Mandua* 396, VL *Mandua* 340, VL *Mandua* 347, VL *Mandua* 315 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 genotypes picked from yield evaluation trials (IVT 9, IVT 22 and IVT 23) were also included in crossing program.

The breeding materials were handled following 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 (Table 2.5.1).

Table 2.5.1. Details of finger millet breeding material

Generation	Number of crosses	Number of progenies	Single Plant selections	Basis of selection
F_1	22	-	-	Early maturity (100 days), resistance to blast, ear head shape, number of fingers and grain yield
F_2	22	-	53	
F_3	14	93	110	
F_4	27	238	50	
F_5	10	49	86	
F_6	4	38	52	

Barnyard millet

Yield evaluation of superior bulks in station trial

Thirty superior bulks identified from F_6 generation 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 19-4 (3,106 kg/ha), VB 18-63 (3,028 kg/ha) and VB-19-10 (2,492 kg/ha) were superior to the best check VL *Madira* 207 (2,369 kg/ha).

Development of new strains and details of breeding material

During *kharif* 2019, 20 new cross combinations were attempted involving locally adapted genotypes (VL *Madira* 172, VL *Madira* 29, VL *Madira* 207, VL *Madira* 251, VL *Madira* 252 and VL *Madira* 137); high yielding genotypes 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 2.5.2.

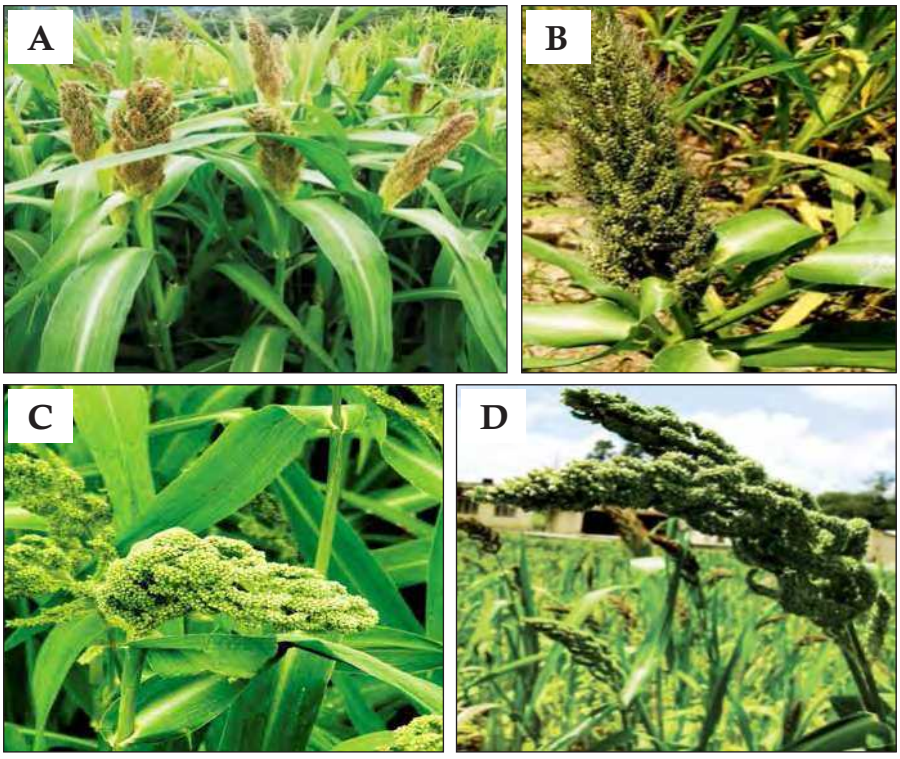
Table 2.5.2. Details of barnyard millet breeding material

Generation	Number of crosses	Number of progenies	Single Plant selections	selection criteria
F_1	13	-	-	Early maturity (> 100 days), resistance to grain smut, panicle length and width, grain yield
F_2	11	-		
F_3	15	52	76	
F_4	8	75	45	
F_5	11	89	47	
F_6	12	53	-	

New initiatives

Development of awnless and semi dwarf genotypes of Japanese barnyard millet (Echinocloa esculenta)

Inflorescence length and shape, disease resistance and plant vigor are the traits of high economic value but there is only little variation available in cultivated Indian barnyard millet (*E. frumentacea*). In addition, due to its taller habit lodging is a major production constraint of Indian barnyard millet. In general, Japanese barnyard millet (*E. esculenta*) possesses more diversity for agro-morphological traits compared to Indian species (*E. frumentacea*). However, interspecific hybrids between distant gene pools largely failed due to the presence of strong incompatibility barriers between the species. Therefore, inraspecific hybridization between the diverse genotypes of *E. esculenta* is one potential strategy to develop transgressive segregants for agronomic traits. Keeping this in view, both way intraspecific crosses were attempted between two genotypes (PRB 903 and PRJ 1) of *E. esculenta* at ICAR-VPKAS, Almora to exploit their high yield potential and agronomic superiority. The effort has resulted in obtaining F_6 progenies, characterized by large panicle size (27.5-35 cm), a greater number of panicle branches (>30) and medium plant height (120-148 cm) compared to the parents. In general, panicles of *E. esculenta* genotypes are characterized by large awns. Interestingly, the inraspecific hybridization attempt resulted in development of stable awnless segregants in the genetic background of PRJ 1, which are more vigorous than parental line. To the best of our knowledge, this is the first report of isolating awnless Japanese barnyard millet genotypes through hybridization. These awnless *E.*



Promising F_6 progenies of *E. esculenta* × E. *esculenta* cross. A: progenies with reduced height, larger and broader leaves and panicle size; B: panicle of parental genotype (PRJ 1) with large awns and C and D: Large awnless panicle of *E. esculenta* in the genetic background of PRJ-1

esculenta/*E. esculenta* derivatives with reduced plant height with uncompromised fodder potential are the positive developments towards generating dual purpose genetic material of barnyard millet. The successful attempt allows the consideration that hybridization between *E. esculenta* genotypes will be one of the directions of barnyard millet breeding to maximize its yield potential.

2.5.3. Crop Protection Investigations

Screening for disease resistance

During *Kharif* 2019, both finger millet and barnyard millet entries of both station and coordinated trials were evaluated for disease resistance to blast and grain smut diseases respectively. The resistant sources identified were summarized as follows (Table 2.5.3).

Table 2.5.3. The most prominent genotypes identified based on one season data are as follows

Crop	Nurseries	Entries	Disease	Highly resistant entries (0-3 % incidence for neck and finger blast)
Finger millet	Station trial-2019	30	Leaf, neck and finger blast	VR-19-13, VR-19-19, VR-19-20, VR-19-22, VR-19-26 and VR-19-28 these entries showed moderate reaction (4-5 score) for leaf blast
	Advanced Varietal Trial (North Zone)	13	Leaf, neck and finger blast	GPU 67, GPU 45, BR 14-27 and OEB 604 with moderate reaction to leaf blast
	Initial Varietal Trial (IVT)	32	Leaf, neck and finger blast	KWFM 4, KOPN 1112, GPU 100 and GPU 101with moderate reaction to leaf blast
Barnyard millet	Station trial	07	Grain smut disease	VB 19-3, VB19-4 and VB 19-6 with immune reaction (0 score)
	Barnyard advanced varietal trial (BAVT)	16	Grain smut disease	IIMR BM-2-17, IIMR BM-29-17, TNEF 318 and PRB-903 (R check) with immune reaction (0 score)
	National Screening Nursery (NSN)	12	Grain smut disease	LRB 10, LRB 13, LRB 14, LRB 15, LRB 17 and PRB-903 (R check) with immune reaction (0 score)

2.6. Pulses & Oilseeds

Pulses and oilseeds are the inseparable part of rainfed agriculture in marginal lands across the country. These valuable crops traditionally serve as crucial component in native food culture, crop rotations and cropping systems in North-Western Himalayan region because of their ability to ensure food and nutritional security even under harsh and stressed agro-climatic conditions. Pulses are cultivated in 110 thousand hectares with 122 thousand tonnes production whereas, the total oilseed production is 61 thousand tonnes from 91 thousand hectares in North-Western Himalayas (DAC 2017-18). Development of nutritionally superior high yielding, disease and insect-pest resistant varieties suitable for hill agro-ecosystem with matching production technologies are the thrust areas in research programme for improving pulse and oilseed production in hills.

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

Varietal Improvement

2.6.1.1. Variety Identified

VL150 Lentil entry VL 150 has been identified for timely sown rainfed organic condition of Uttarakhand hills. Small seeded lentil entry VL 150 (841 kg/ha) has shown significant yield superiority of 10.87% over the best check VL *Masoor* 125 (758 kg/ha) and 12.42% over the VL *Masoor* 133 (748 kg/ha) in SVT with 155-160 days maturity duration. It has moderate resistance against wilt, rust, pod damage and aphids.

VL 64 Field pea entry VL 64 has been identified for timely sown rainfed organic condition of Uttarakhand hills. VL 64 (990 kg/ha) has shown significant yield superiority of 9.93% over the best check *Pant* P14 (901 kg/ha), 10.85% over the VL *Matar* 42 (893 kg/ha) and 15.53% over VL *Matar* 47 (857 kg/ha) in State Varietal Trials with 140-145days maturity duration. It has moderate resistance against wilt and powdery mildew.

2.6.1.2. Elite Lines under All India Coordinated Programme

Yield evaluation trials were conducted to assess the adaptability of new strains with respect to grain yield, disease resistance and other desirable attributes under the rainfed condition. Under lentil AICRP trials, entries namely VL 531 (1,116 kg/ha) and VL 532 (979 kg/ha) were evaluated in IVT (large seed) whereas, VL 156 (979 kg/ha) and VL 157 (1,116 kg/ha) were evaluated in IVT (small seed) but none of the entry could surpass the best checks LH 84-8 (1,154 kg/ha) for IVT (large seed) and VL 126 (1,105 kg/ha) for IVT (small seed) trials with significant superiority. In AVT I (small seed), lentil entry VL 152 was tested which exhibited 1,255 kg/ha grain yield but not found significantly superior to the best check VL *Masoor* 126 (1,261 kg/ha).

In field pea AICRP trials, In IVT (Tall), field pea entry VL 68 (1,722 kg/ha]) was tested which yielded better than best check VL *Matar* 42 (1,481 kg/ha) and has been promoted to AVT I (NWPZ). In IVT (Dwarf), field pea entry VL 69 (1,278 kg/ha]) was tested which could not surpass the best check HFP 1446 (1,452 kg/ha). In AVT I (Tall), VL 66 was tested and it exhibited 1,450 kg/ha grain yield but could not surpass the best check HFP 1426 (1,496 kg/ha).

2.6.1.3. Elite Lines under State Varietal Trial (SVT)

In SVT, lentil entries VL 150, VL 152, VL 156, VL 531 & VL 527 were tested under organic condition. Small seeded entry VL 152 (817 kg/ha)

was promoted to III[rd] year of testing by surpassing the best check VL *Masoor* 133 (751 kg/ha). Large seeded entry VL 527 (913 kg/ha) surpassed the best large seeded check VL *Masoor* 514 (732 kg/ha) and was promoted to III[rd] year of testing under organic mode in SVT.

In SVT, field pea entries namely VL 64, VL 66 and VL 68 were tested and entry VL 64 was identified based on three years performance under organic conditions.

Breeding materials/Development of new strains

During *Rabi* 2018-19, 59 new cross combinations were obtained involving high yielding wilt resistant released varieties (PL 02, IPL 321, DPL 58, PL 117 & DKL 37); high biomass (LL 1203, LL 699 & LL 1122); earliness (ILWLS 118, L 4717 & L 4710) were included in the crossing program. Seventy cross combinations were advanced to F_2 generation. Different segregating generations were subjected to rigorous selection for traits, *viz*. yield components, biomass and wilt resistance and 260 crosses (F_2 to F_6 generation) were selected and advanced to subsequent generations following pedigree method. Twenty uniform bulks in both small and large seeded lentil were selected for further evaluation of yield, component traits, diseases, insect-pest reaction and quality characters.

In field pea, 33 new cross combinations were made involving 16 diverse parents with high grain yield (VL *Matar* 42, VL *Matar* 47, *Pant* pea 125), powdery mildew resistance (HFP 715, IPF 13-14, RFP 2009-2, Pant P 200 and RFPG 79) and semi leafless traits (HFP 4, Aman and VL *Matar* 47). Thirty five F_1 crosses were advanced to F_2 generation. Segregating generations were subjected to rigorous selection for yield and desirable yield components like pods per plant, pods per cluster, seeds per pod, semi-leaflessness, disease and insect pest resistance and 179 crosses were selected in F_2 to F_6 generations. Fourteen uniform bulks selected for further evaluation of yield, component traits, quality and quality characters.

Agronomic Investigations

Response of field pea varieties to different fertility levels

In a study on response of field pea varieties to different fertility levels, it was observed that VL *Matar* 64 showed highest seed yield (1,387 kg/ha), and was 6.0 and 13.5% higher than VL *Matar* 47 and VL *Matar* 42, respectively. Among fertility levels, 150% of recommended dose (30:90:60 kg NPK/ha) recorded highest seed yield (1,353 kg/ha) and fertility levels were statistically non-significant. Across the fertility levels, VL *Matar* 64 produced highest seed yield (1,445 kg/ha) at 150% of recommended dose.

Crop Protection Investigations

In *kharif* 2019, monitoring of different filed trials for pest incidences was done under field conditions at Hawalbag. Low incidence of *Spilosoma obliqua* and

Table 2.6.1. Pest parameters with respect to bruchid infestation in lentil lines

Accession No	No. of eggs/10 seed	No. of insects emerged	No. of damaged seeds	% wt. loss
EC223222	3	1	1	0.4
EC225476	4	0	1	7.0
EC267614	4	0	2	9.6
EC267620	13	3	3	1.9
EC78437	3	0	0	1.8
IC145280	17	7	6	4.8
JC201670	3	2	2	11
IC208337	11	4	4	18
IC316162	6	0	0	6.1
IC361296	11	4	4	9.1
IC393227	2	0	1	10.2
IC78505	4	1	1	5.0
IC98393	3	0	1	9.7
IC201669	3	0	1	10.6

Platypria hystrix aphid was noticed in all the trials. In this year, the sucking bug incidence started very early i.e. June and incidence was at medium level throughout the crop season. A total of 19 soybean and 10 black soybean varieties under station trials were screened for insect pest incidences (aphids and chauliops). All the entries showed resistance reaction against both the test insects which might be due to natural low incidences of pest.

A total of 735 lentil germplasms were screened for resistance against bruchid infestation. A preliminary screening of all the entries for adult emergence and percent weight loss of grains resulted in identification of 53 entries. In general, the adult emergence ranged between 0-48 adults/25 seeds and per cent weight loss over initial weight was between 0.11-79.21/25 seeds. Further screening of selected 53 entries showed promising parameters with respect to pest incidences in 14 entries (Table 2.6.1).

2.6.2. Kharif Legumes (Horsegram)

2.6.2.1. Elite Lines under All India Coordinated Programme

During the *Kharif* 2019, Yield evaluation trials were conducted to assess the adaptability of new strains with respect to grain yield, disease resistance and other desirable attributes under the rainfed condition. Under horsegram AICRP trials, entries namely VLG 49 (896 kg/ha) and VLG 50 (809 kg/ha) were tested which were nominated on the basis of their superior performance in station trails as compared to the best check VL *Gahat* 15 (763 kg/ha). In AVT II, out of 6 entries only code no. HG 1 and HG 2 were flowered with yield of 1,235 kg/ha and 1,6891 kg/ha, respectively.

2.6.2.2. Elite Lines under State Varietal Trial

During the *kharif* 2019, In SVT, four entries were tested and among them code HG1602 (770 kg/ha) and HG1603 (756 kg/ha) were top performers under organic rainfed condition at Almora.

2.6.2.3. Elite Lines under Station Trials

During the *kharif* 2019, a total of 2 station trials were conducted comprising Initial Station Trials, Advance Station Trials for horsegram, In Initial Station Trial, entries, *viz*. VS 2018-1 (963 kg/ha) and VS 2018-8 (741 kg/ha) were found superior to the best check VL *Gahat* 15 (704 kg/ha). In Advance Station Trial, entries, *viz*. VS 2016-13 (1,304 kg/ha), VS 2016-14 (1,294 kg/ha) and VS 2016-26 (1,259 kg/ha) were found superior to best check VL *Gahat* 15 (1,210 kg/ha).

Breeding materials/Development of new strains

During *kharif* 2019, 12 diverse parents were selected on the basis of high yield (VLG 19, VLG 15, VLG 8 and VLG 10), anthracnose resistance (HPK 2, HPK 4 and VLG 19) and earliness (VLG 19 and AK 42) for hybridization programme. Involving these parents 32 new cross combinations were attempted. From F_2 to F_5 generation, 99 crosses were selected for desirable phenotypic traits like yield and component traits, diseases (anthracnose) resistance. Forty-eight uniform bulks were selected from F_6 generation for their further evaluation in station trials.

2.6.3. Oilseed Crops – Soybean

2.6.3.1. Elite Lines under All India Coordinated Programme

A total of 83 soybean entries were evaluated for yield and yield contributing characters in three coordinated trials (IVT, IVT 2018 & AVT I) during *kharif* 2019. In IVT, entries namely VLS 98 (2,598 kg/ha) and VLS 99 (2,528 kg/ha) were tested which were nominated based on their superior performance in station trails as compared to the best check VL *Soya* 59 (2,267 kg/ha. In IVT, Code no. 1 (3,300 kg/ha), Code no. 20 (2,626 kg/ha) and Code no. 10 (2,288 kg/ha) were top performing entries at Almora. In AVT I only one entry NRC 142 (1,087 kg/ha) was tested along with 3 checks, which could not surpass the best check VL *Soya* 63 (2,217 kg/ha) at Almora.

2.6.3.2. Elite Lines under State Varietal Trial

In SVT, seven entries were evaluated and among them HS 501 (1,778 kg/ha), HS 503 (1,432 kg/ha) and HS 505 (1,383 kg/ha) were top performers under organic rainfed condition at Almora.

2.6.3.3. Elite Lines under Station Trials

During *kharif* 2019, a total of 3 station trials were conducted comprising Initial Station Trial, Advance Station Trials for soybean and Station Trial for black soybean. In Initial Station Trial, entries, *viz.* VS 2018-4 (3,333 kg/ha), VS 2018-8 (3,481 kg/ha) and VS 2018-2 (3,204 kg/ha) were found superior to the best check VL *Soya* 89 (2,407 kg/ha) and in

Station Trial *(Bhat)*, entries, *viz.* VS 2017-103 (2,272 kg/ha), VS 2016-101 (2,257 kg/ha) and VS 2017-101 (2,173 kg/ha) were top performing entries and found superior to the best check VL *Bhat* 201 (1,995 kg/ha). In Advance Station Trial of soybean, entries viz., VS 2015-12 (2,914 kg/ha), VS 2016-46 (2,914 kg/ha) and VS 2016-2 (2,889 kg/ha) were found superior to best check VL *Soya* 89 (2,469 kg/ha).

Breeding materials/Development of new strains

During *Kharif* 2019, 24 diverse parents were selected on the basis of high yield (VLS 47, VLS 63, VLS 59, VLS 77, PS 1556, PS 1092, PK 416 and Pusa 22), frog eye leaf spot resistance (VLS 47, RSC-10-17 and Himso 1685), earliness (JS 95-60 and VLS 73) determinate plant type in *Bhat* (VLS 65, *Birsa soya* 1 and VLB 201), wild parent (*G. soja*), promising local collection (VRPH 1444 and *Pauri Local*) and germplasm (EC 34057) for hybridization programme. Involving these parents 33 new cross combinations were attempted. From F_2 to F_5 generation, 106 crosses were selected for desirable traits phenotypic traits like yield and component traits, diseases (frog eye leaf spot and pod blight) and insect-pests (*Chauliops* and defoliators) resistance. Forty-six uniform bulks were selected from F_6 generation for their further evaluation in station trials.

Crop Protection Investigation

In *kharif* 2019, major diseases observed at experimental farm, Hawalbag and in farmers' villages in Almora district were frogeye leaf spot (FLS), bacterial pustules (BP) and pod blight (Ct). The first symptom of FLS was observed on 01.08.2019. The severity increased in September and reached up to 77.7% infection index in few entries. Bacterial pustule (BP) and pod blight (PB Ct) were observed with low to moderate intensity.

In soybean trap nursery for disease monitoring, out of 16 entries evaluated against frog eye leaf spot disease, JS 95-60 and VLS 58 showed resistant reaction (3 disease score). Out of the 72 soybean entries previously found resistant against FLS, 54 maintained their resistance (1-3 score on 0-9 scale). In experimental trial on evaluation of breeding materials for resistant donors, entries, *viz.* MACS 1566, MACS 1620, MACS NRC 1575, MACS NRC 1667, KDS 992, NRC 128 showed resistant reaction (1-3 score) against frog eye leaf spot disease.

2.7. Vegetable Crops

Vegetable cultivation, 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 90 thousand ha with an average productivity of 10.5 t/ha, which is much below the national productivity of 17.0 t/ha (NHB 2017). 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

2.7.1.1. Varietal Improvement

Two yield evaluation trials were conducted with 24 genotypes to evaluate their green pod yield against checks, *viz. Pant Anupama, Arka Suvidha, Swarn Priya* and VL *Bean* 2. Entry VLFB 1614 & 1615 (11,112 kg/ha), VLFB 1805 (17,130 kg/ha) and VLFB 1804 (16,230 kg/ha) recorded maximum green pod yield in SVT and AST II, respectively.

2.7.1.2. Development of New Strains

Emphasis was given to develop genotypes with high yield, stringless pod and resistance to rust. In this endeavour, 11 new F_1s were developed using diverse parents. Two hundred forty-five progenies derived from 62 crosses were advanced in F_2 to F_6 generations. Six new bulks were also made based on phenotypic uniformity in ensuing crop season.

2.7.2. Tomato

2.7.2.1. Varieties Identified in AICRP-Vegetable Crops

VL Cherry Tomato 1 (VT - 95)

VT 95 (VL Cherry Tomato 1) identified for Zone I (Jammu & Kashmir, Uttarakhand and Himachal Pradesh), Zone III (Sikkim, Meghalaya, Manipur,

Nagaland, Mizoram, Tripura, Arunachal Pradesh and Andaman & Nicobar Islands) & Zone VII (Madhya Pradesh, Maharashtra & Goa). It is an open- pollinated variety and can be grown both under polyhouse and open-field conditions. Fruits are small, attractive red colour with oval shape; better in nutritive traits (Vitamin C - 86 mg/100g and T.S.S - 7° Brix), good taste and being table type it can fetch high price to the growers. In the hills, it yields 25,000-30,000 kg/ha under open-field conditions and 40,000-50,000 kg/ha under polyhouse conditions.

VL Cherry Tomato 1 (VT - 95)

2.7.2.2. Varietal Improvement

Seven yield evaluation trials were conducted to evaluate 53 entries against suitable checks to identify high yielding genotype in determinate and indeterminate group. 2018/TODVAR-6 (26,636 kg/ha), 2017/TODVAR-10 (42,440 kg/ha), 2016/TODVAR-9 (50,513 kg/ha), 2018/TOINDVAR-5 (34,031 kg/ha), 2016/TODHYB-3 (67,549 kg/ha), 2018/TODVAR-2 (12,184 kg/ha) & 2016/TODVAR-3 (9,525 kg/ha) recorded maximum fruit yield in IET Det., AVT-I Det., AVT-II Det., IET Indet., AVT-II Det. Hyb., IET Cherry and AVT-II Cherry, respectively.

2.7.2.3. Development of New Strains

Emphasis was given to develop high yielding hybrids having market acceptability with regard to size, shape and pericarp thickness. Five F_1s were made using diverse parents with respect to desirable horticultural traits. Twenty-two progenies derived from 8 crosses were advanced in F_2 to F_6 generations.

2.7.3. Capsicum

2.7.3.1. Development of New Strains

In capsicum, emphasis was given to develop high yielding hybrids with medium dark green fruits, thick skin and other important traits, suitable for protected cultivation and open field, especially under organic conditions. Seven F_1s were developed involving diverse parents. Nine progenies derived from 8 crosses were advanced in F_2-F_6 generations for further selection.

2.7.4. Cowpea (Yard long bean)

2.7.4.1. Varietal Improvement

Two yield evaluation trials were conducted to evaluate 10 entries along with suitable checks to identify early maturing, high yielding genotype. 2016/COPVAR-4 (7,025 kg/ha) recorded maximum green pod yield in AVT I (Bush) whereas Lola (8,130 kg/ha) recorded maximum green pod yield in AVT II (Pole).

2.7.4.2. Development of New Strains

Four F_1s were developed involving diverse parents. Twenty F_6 progenies of a cross between *Vigna unguiculata*/*Vigna unguiculata sub* sp. *sesquipedalis* were advanced and selections for important horticultural traits were practiced.

2.7.5. Garden Pea

2.7.5.1. Varietal Improvement

Eight field yield evaluation trials were conducted to evaluate 84 entries with suitable checks to identify early and medium maturing, high yielding and powdery mildew resistant genotypes. 2018/PEDVAR-6 (13,923 kg/ha), 2018/PEVAR-6 (11,865 kg/ha), 2017/PEVAR-5 (11,957 kg/ha), 2016/PEVAR-7 (10,343 kg/ha), 2018/PEVAR-2 (11,457 kg/ha), 2017/PMVAR-4 (11,532 kg/ha) and 2016/PMVAR-9 (11,253 kg/ha) recorded maximum green pods yield in IET (Edible pod), IET (Early), AVT-I (Early), AVT-II (Early), IET (Medium) AVT-I (Medium) and AVT-II (Medium), respectively. VP 1018 (13,332 kg/ha) gave highest green pod yield in State Varietal trials. In pea AST I, VP 1601 (11,980 kg/ha) in AST was found to be promising line.

2.7.5.2. Development of New Strains

Emphasis was given to develop early and medium duration genotypes with high green pod yield and resistance to powdery mildew. In this endeavour, 51 new F_1s were made among selected parents to combine different horticultural traits like earliness,

high green pod yield, high shelling percent, attractive pod colour and shape as well as disease resistance *etc*. Better performing 40 F_1s were advanced for growing their F_2 generation in next season. Besides, selection was practiced in the segregating materials derived from 47 F_2s, 33 F_3s, 12 F_4s, 02 F_5s, 02 F_6s and 03 F_7s crosses. Based on desirable traits, 204 progenies derived from 52 crosses were advanced in F_3 to F_6 generations and three new bulks were made based on phenotypic uniformness evaluation in ensuing crop season in early and medium maturity group.

2.7.6. Onion

2.7.6.1. Varietal Improvement

Under four AINRP on long day onion, 61 genotypes were evaluated for their yield performance against checks. OA 18-33 (33,874 kg/ha), OB 18-72 (30,158 kg/ha), OC-18-59 (24,200 kg/ha) and VL *Piaz* 3 (24,592 kg/ha) recorded maximum bulb yield in IET, AVT I, AVT II and varietal, respectively.

2.7.6.2. Development of New Hybrids

Crosses were attempted in Male sterile line (VL In. 31-1A) as female and eight diverse lines as male for the development of F_1 hybrids. Male sterile line was maintained with the help of their maintainer line VL In. 31-1B by crossing, respectively.

2.7.7. Garlic

2.7.7.1. Varietal Improvement

Two AINRP trials on long day garlic were conducted with 19 genotypes to evaluate their yield performance against checks. GN 17-25 (16,379 kg/ha) in AVT and GN 15-78 (19,490 kg/ha) in AVT II recorded maximum bulb yield with big clove size.

2.7.8. Seed Multiplication of Released and Pre-released Varieties

A total of 950 kg/ha quality seeds were produced during the period in targeted vegetable (garden pea, onion, garlic, french bean and tomato).

2.7.9. Genetic Resources–Evaluation and Maintenance

Five hundred ninety three accessions of different vegetable crops were maintained during *rabi* 2018-19 and *kharif* 2019.

Crop	Accessions
Garlic	64
Zinger	06
Turmeric	24
French bean	125
Chilli	06
Capsicum	63
Tomato	115
Colocasia	33
Turmeric	23
Garden pea	130
Vegetable type mustard	04
Total	593

2.7.10. Agronomy

2.7.10.1. Response of Garden Pea Varieties to Different Fertility Levels

Three AVT-2 garden pea cultures (VP 1345, VP 1346, VP 1409 and VP 1422) were evaluated in comparison with high yielding checks (VL *Ageti Matar* 7, Vivek *Matar* 10 and Vivek *Matar* 11) for four fertility levels (F_1 - 20:40:40+10 t FYM/ha, F_2 - 20:60:40+10 t FYM/ha, F_3 - 20:80:40+10 t FYM/ha, and F_4 - 20 t FYM/ha) under field conditions. The highest pod yields were recorded with VP 1345 (13.63 t/ha) which was at par with 1346 (13.37 t/ha), VP 1409 (13.26 t/ha) and VP 1422 (12.72 t/ha). Among different fertility level the highest yield was recorded with N:P:K (20:40:40)+10 t FYM/ ha (13.07 t/ha).

2.7.11. Crop Protection Investigations

During the month of March and April, the major disease observed at Experimental farm, Hawalbag

Onion Disease Monitoring Nursery (Purple blotch)

was purple blotch of onion. The percent disease index (PDI) reached up to 55% in onion and 52% in garlic in few entries. The severity of stemphyllium blight of onion was low. Out of 51 IET, AVT I and II entries screened against purple blotch of onion, entries OA 18-31, OA 18-33, OA 18-34, OB 18-74, OB 18-76 and OC 18-58 (1.0-2.0 score) were found promising. In garlic, 17 entries were screened against purple blotch and entries GN 17-19, GN 17-27 and GN 15-71 (1-2 score) were promising.

2.7.12. Biochemistry

Total fifty-seven advance pea lines were screened for the Brix (%) and per cent total soluble sugars. Lines VM-11, VL-7, PMVAR-7 (AVT 2 early) and PMVAR-7 (IET medium) recorded Brix (%) >23.0. However, lines VP 1436, VP1437, VP1437, PMVAR-7 (IET medium), PMVAR-2, PMVAR-6, PMVAR-7 (AVT-2 Early) recorded total soluble sugars (%) >16.0 (Fig. 2.7.1).

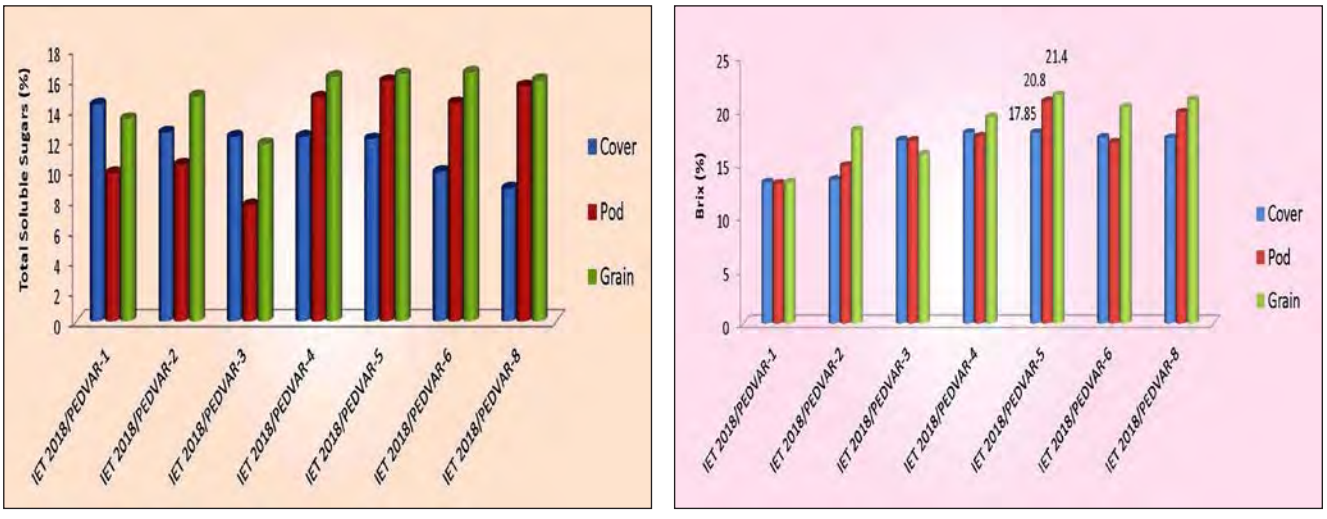


Fig. 2.7.1. Total soluble sugars and Brix per cent in garden pea advance lines

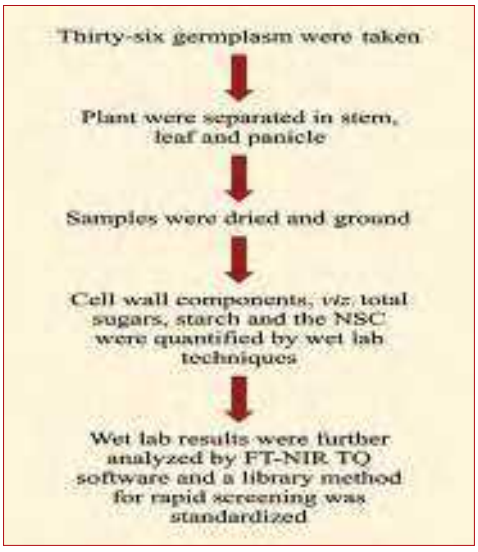
2.8. Germplasm Evaluation for Nutritional and Physiological Parameters

ICAR-VPKAS involve basic and applied research in relation to the crop productivity and quality for major hill crops like rice, maize, pulses oil seed and millets. There is a large pool of promising germplasm of many field crops available in different parts of North-Western hills with special reference to Uttarakhand state, which can be utilized to a great extent for nutritional and nutraceuticals security of the vulnerable population groups. An organized biochemical approach is essential to select nutritionally superior genotypes either to serve as parents or to identify well-established crop varieties with higher productivity and quality.

Standardization and calibration of the method for the rapid screening of non-structural carbohydrate (NSC) in wheat

The remobilization of non-structural carbohydrate (NSC) stored as reserve in the stem (sheath + culm) at pre-anthesis is important for the grain filling of cereal. However, the mechanism that regulates the NSC reserve in the stem pre-anthesis on grain filling of inferior grains of wheat remains unclear.

For the large no of sample screening for NSC a rapid screening method for the quantification of NSC in the stem (pre-anthesis and physiological maturity stage) through FT-NIR was standardized. In the present investigation, the FT-NIR spectroscopy spectrum of each dried sample of wheat was obtained by scanning with a Thermo-fisher FT-Near Infra Red spectroscopy system. The spectrum data range was 4000–10,000



Cm^{-1}, number of scans was 64, and the resolution was 4 Cm^{-1}.

The calibrated graph from FT-NIR TQ software (Fig. 2.8.1.) for Non-Structural Carbohydrates (NSC) showed a highly significant correlation (corr. coeff. 0.9051) at physiological maturity stage between the wet laboratory values (actual) and calculated values from FT-NIR. In summary, calibration models established by FT-NIR was found suitable for the rapid, accurate and non-destructive quantification of NSC in wheat. FT-NIR calibration models for stem NSC is worthy of further experimentation for breeding early maturing wheat.

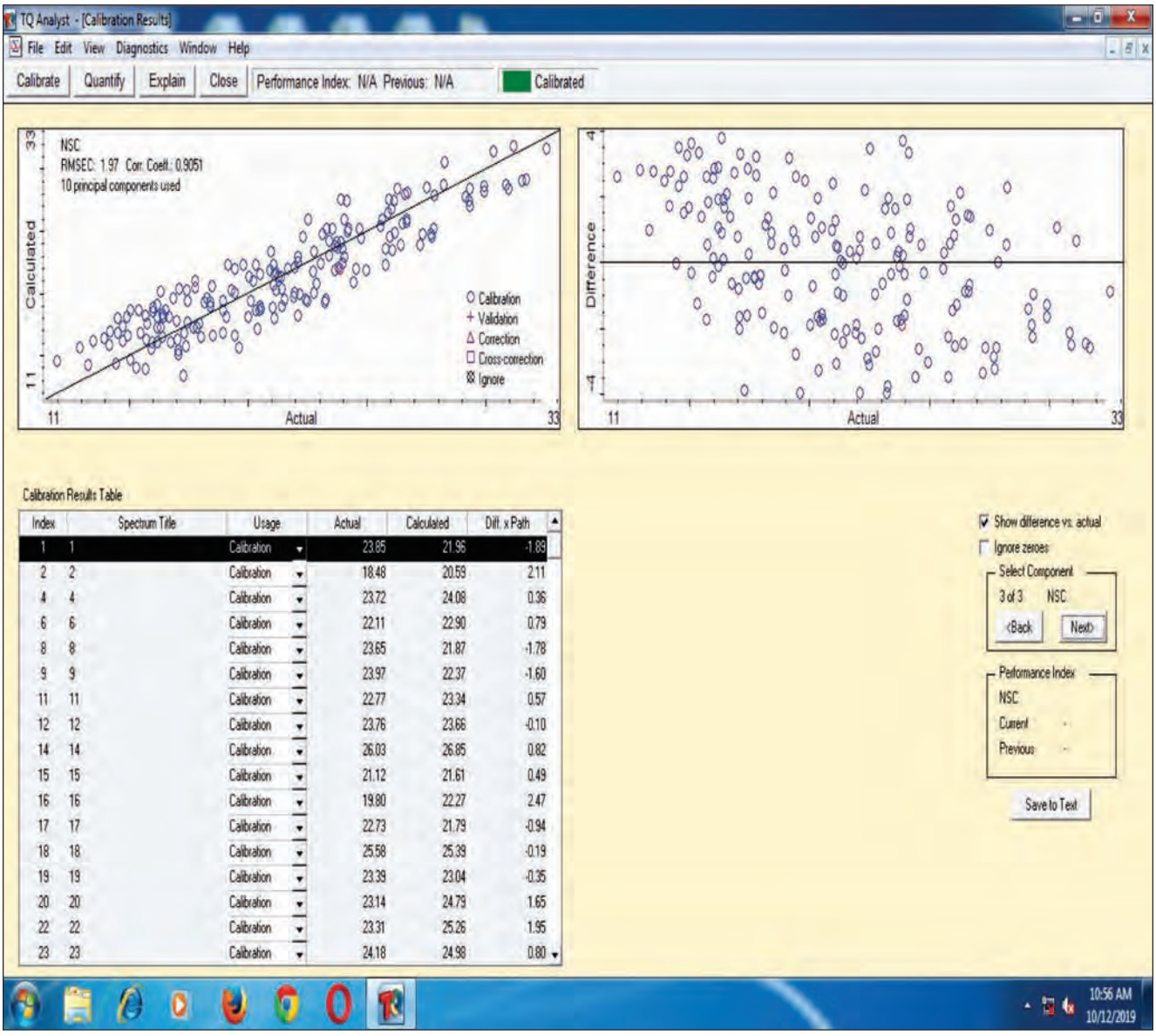


Fig. 2.8.1. Calibrated graph from FT-NIR TQ software for non-structural carbohydrates (NSC)

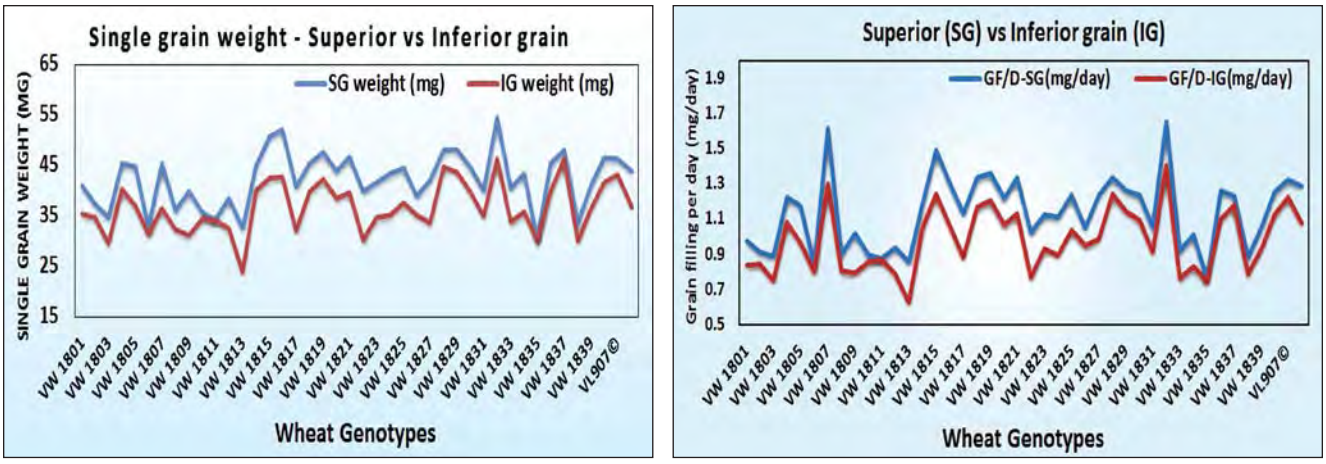


Fig. 2.8.2. Correlation of seed weight with non-structural carbohydrate

Data (superior grain and grain filling/day) showed that the 1000 seed weight showed a strong correlation with non-structural carbohydrate at anthesis state (Fig. 2.8.2.). Single grain weight found higher in case of superior grain compare to inferior grains and the grain filling per day was found higher in superior grains.

Screening of rice genotypes for nutritional and antinutritional parameters

In the present investigation, 43 advance genotypes of rice were analyzed for their nutritional, cooking and antinutritional attributes. Wide variations were observed in most of the traits under study such as total carbohydrate (24.94-38.46%), amylose (15.13–23.81%), protein (5.98–11.30%), amylopectin (76.19–84.87%), starch (31.77–43.67%), phytate P (2.38–6.50 mg/g) and cooking time (18–25 minutes). Most of the rice genotypes exhibited <20 per cent amylose (intermediate amylose). Similarly, considerable variations were observed in amylopectin and starch content. Rice with similar amylose content can be differentiated according to the tenderness. Cooked rice with softer gel consistency was more tender. Most of the rice genotypes exhibited soft gel consistency with intermediate gelatinization temperature (70-74^{0}C). Phytate P content is also on the lower side in studied genotypes. Among 43 cultivars, phytic acid content ranged 0.48 (VL-40480) to 1.30% (VL- 40540), with a mean of 1.08 per cent.

Evaluation of micronutrient content in maize genotypes

A total of 129 genotypes of maize were evaluated for grain Fe and Zn concentrations to identify those with improved Fe and Zn concentrations. Iron content ranged 25.70 (CS-16-2-1) to 47.40 (VLQC-8-1) ppm and Zn 17.50 (BS-24-3-1-1) to 32.10 (CS-16-2-1) ppm. Cultivar VLQC-8-1 had the highest iron content (47.40 ppm) in grain whereas the highest zinc content (32.10 ppm) was recorded in genotype CS-16-2-1.

Screening of soybean genotypic variability for phosphorus use efficiency

To assess the genotypic variability for phosphorus use efficiency, 42 soybean genotypes were grown under contrasting phosphorus levels *viz.*, P-deficit (20:0:20 kg/ha NPK) and high P (20:80:20 kg/ha NPK) under field conditions. The mean yield of soybean genotypes grown under P-deficit condition ranged 2.9 g/plant (SL 525) - 23.96 g/plant (MAUS 1), whereas, under high P condition it was 8.44 g/plant (MACS 13) - 34.74 g/plant (Birsa *Soya* 1) g/plant. Among the genotypes, MAUS 1 recorded grain yield of 23.96 and 28.55 g/plant under P-deficit condition and high phosphorus conditions, respectively.

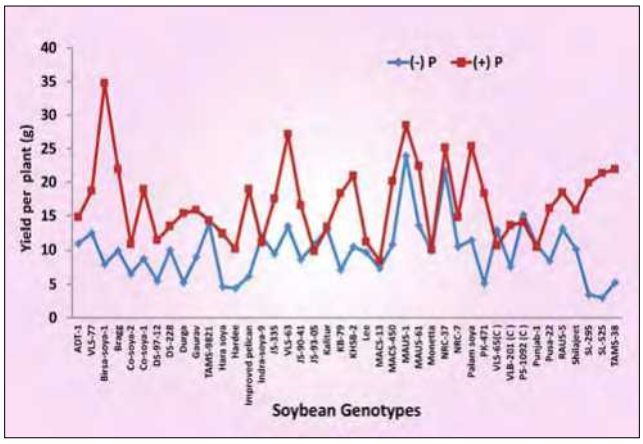


Fig. 2.8.3. Yield per plant in soyabean genotypes

Similarly, NRC 37 yielded 21.74 g/plant under P-deficit condition whereas, 25.11 g/plant under high phosphorus condition. Therefore, soybean varieties MAUS 1 and NRC 37 found tolerant to P-deficit and responsive under high phosphorus condition. Highest P uptake in (+P) genotypes was recorded in Birsa *Soya*-1 (15.80 kg/ha) whereas the highest uptake in (-P) genotypes was recorded in genotype MAUS-1 (11.23 kg/ha).

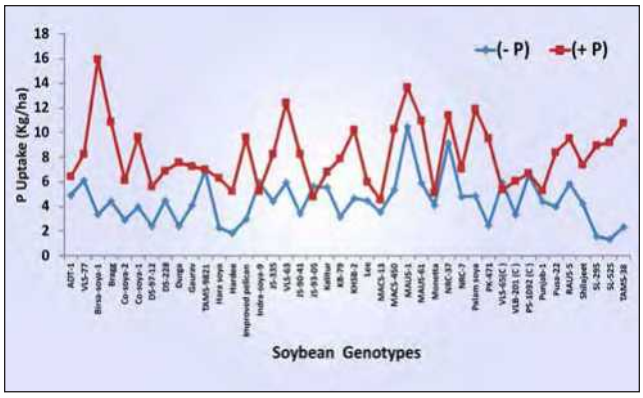


Fig. 2.8.4. P uptake in soyabean genotypes

2.9. Seed Production Programme

To cater to its clientele; the institute produces four types of seed, *viz*. Nucleus Seed, Breeder Seed, Truthfully Labelled 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 Truthfully Labelled (TL) and Nucleus seed of various hill crops.

Resource poor hilly areas face a major challenge; non-availability of the quality seed (improved varieties) to increase the crop production and productivity. ICAR-VPKAS, Almora a small institute from an operationally difficult area with its limited land and human resource produces four types of seed, *viz.* Nucleus Seed, Breeder Seed, Truthfully Labelled (TL) seed and Hybrid seeds of elite hybrids to caters to the quality seed requirements of its mandate area North-Western hill and additionally of the North-Eastern hill states.

During the period under report, 173.77 q breeder seed of 41 released varieties/inbreds of 15 crops were produced. A total of 134.26 q breeder seed was supplied to different seed producing agencies to take up further multiplication.

Around 12.98 q nucleus seed of 39 released varieties were also produced following standard methods of maintaining genetic purity.

In addition to this, 14.43 q Truthfully Labelled seed of 25 varieties of 16 crops was produced. Including the carry-over stock of TL seed; a total of 29.01 q TL seed was supplied to different stakeholders.

Under farmer participatory seed production programme, 135.32 q TL seed of wheat (VL *Gehun* 907, VL *Gehun* 829, VL *Gehun* 953), 0.75 TL seed of Lentil (VL *Masoor* 126 & 133), 2.30 q TL seed of rice (VL *Dhan* 68), 4.00 q of finger millet (VL *Mandua* 352) and 2.45 q TL seed of Horsegram (VL *Gahat* 19) were produced, and from it a total of 151.66 q TL seed was supplied back to different clientele.

Summer squash	Australian Green	0.00	0.00	0.02	0.0075	-
French bean	VL Bean 2	0.30	0.186	0.00	0.0803	0.05
Okra	VL *Bhindi* 2	0.00	0.00	0.08	0.0969	-
Total		55.35	51.4295	11.05	7.4782	2.97

SEED PRODUCTION

Production during *Kharif* 2018 and Supply in *Kharif* 2019

Crop	Variety	Breeder Seed (q)		TL Seed (q)		Nucleus Seed (q) Production
		Production	Supply	Production	Supply	
Rice	VL *Dhan157*	0.20	0.10	0.00	0.05	0.40
	VL *Dhan* 68	6.50	4.30	0.00	0.00	0.15
	VL *Dhan* 86	1.00	0.00	0.20	0.01	0.10
	VL *Dhan* 85	0.90	1.00	0.10	0.28	0.10
	VL *Dhan* 65	1.60	0.50	0.10	0.00	0.10
	VL *Dhan* 208**	0.00	0.50	0.00	0.00	-
Maize	Vivek Sankul Makka 31**	2.50	2.90	0.25	0.13	0.20
	VL Amber Popcorn	0.00	0.1725	0.00	0.014	0.05
	V 373	0.30	0.35	0.00	0.00	0.02
	V 390	1.00	0.175	0.00	0.00	0.02
	V 407	0.90	0.39	0.00	0.00	0.02
	V 409	0.50	0.195	0.00	0.00	0.02
	VMH 53	0.00	0.00	1.50	0.9725	-
	VMH 45	0.00	0.00	6.25	3.732	-
Finger Millet	VL *Mandua* 379	2.00	1.955	0.00	0.00	-
	VL *Mandua* 352	15.40	15.40	1.90	1.627	0.02
	VL *Mandua* 315**	0.75	0.90	0.00	0.00	0.02
	VL *Mandua* 376	5.50	5.65	0.00	0.00	0.02
	VL *Mandua* 347**	0.75	1.075	0.00	0.0375	-
	VL *Mandua* 348	0.90	0.85	0.00	0.00	-
Barnyard Millet	VL *Madira* 207	3.00	2.76	0.05	0.315	0.02
Soybean	VL *Soya* 65	5.00	4.00	0.20	0.031	0.80
	VL *Soya* 63	3.00	3.54	0.20	0.0325	0.50
Horsegram	VL *Gahat* 19	1.80	1.41	0.00	0.00	0.15
Pigeon pea	VL *Arhar* 1**	1.10	2.60	0.15	0.027	0.15
Buckwheat	VL *Ugal* 7	0.10	0.12	0.00	0.02	0.05
Amaranth	VL *Chua* 44	0.35	0.401	0.05	0.015	0.01
Summer squash	Australian Green	0.00	0.00	0.02	0.0075	-
French bean	VL *Bean* 2	0.30	0.186	0.00	0.0803	0.05
Okra	VL *Bhindi* 2	0.00	0.00	0.08	0.0969	-
Total		**55.35**	**51.4295**	**11.05**	**7.4782**	**2.97**

Production during *Rabi* 2018-19 and Supply in *Rabi* 2019-20

Crop	Variety	Breeder Seed (q)		TL Seed (q)		Nucleus Seed Production (q)
		Production	Supply	Production	Supply	
Wheat	VL *Gehun* 829	5.50	4.74	0.30	0.60	1.00
	VL *Gehun* 892	13.00	15.35	0.50	2.56	1.50
	VL *Gehun* 907	41.00	25.94	0.00	0.00	2.00
	VL *Gehun* 953**	27.00	23.30	0.70	12.17	1.50
	VL *Gehun* 967**	2.30	2.20	0.00	5.12	1.00
	VL *Gehun* 832	2.00	0.00	0.00	0.00	-
	VL *Gehun* 3004	2.00	2.00	0.00	0.17	1.50
Barley	VL *Jau* 130	-	-	-	-	0.20
Lentil	VL *Masoor* 126	2.30	1.40	0.05	0.05	0.10
	VL *Masoor* 133	8.90	4.40	0.50	0.00	0.10
	VL *Masoor* 514	0.17	0.00	0.00	0.00	-
	VL *Masoor* 129	2.00	0.00	0.15	0.00	0.10
Field Pea	VL *Matar* 42**	0.00	0.10	0.00	0.00	-
Garden Pea	Vivek *Matar* 10	1.40	0.30	0.00	0.05	0.10
	Vivek *Matar* 11**	0.00	0.235	0.00	0.328	0.10
	Vivek *Matar* 12	1.00	0.325	0.00	0.00	0.10
	VL *Sabji Matar* 13	0.90	0.58	0.00	0.00	0.10
	VL *Sabji Matar* 15	0.63	0.58	0.00	0.00	0.10
Toria	VL *Toria* 3**	0.00	0.052	0.00	0.035	-
	TS 67**	0.00	0.05	0.00	0.00	-
Garlic	VL *Lahsun* 2	8.00	1.05	0.00	0.00	0.50
Piaz	VL *Piaz* 3	0.32	0.2326	0.00	0.00	0.01
Radish	Dunagiri Local**	0.00	0.00	0.13	0.21	-
Coriander	*Dhania* PD 1	0.00	0.00	0.23	0.06	-
Lahi	*Hathikaan*	0.00	0.00	0.10	0.014	-
Methi	PEB 1	0.00	0.00	0.70	0.093	-
Palak	All Green	0.00	0.00	0.02	0.089	-
Total		**118.42**	**82.8346**	**3.38**	**21.549**	**10.01**

** Carry over seed

Crops	Farmers Participatory Seed Production (q)		
	Varieties	Production *Kharif* 2018	Supply *Kharif* 2019
Rice	VL *Dhan* 68	6.30*	2.30
Finger millet	VL *Mandua* 352	4.00	1.32
Horsegram	VL *Gahat* 19	2.45	1.74
Total		**12.75**	**5.36**

* TL seed (4 q) produced by rice breeder

Crops	Farmers Participatory Seed Production (q)		
	Varieties	Production *Rabi* 2018-19	Supply *Rabi* 2019-20
Wheat	VL *Gehun* 829	21.60	21.60
	VL *Gehun* 907	23.20	23.24
	VL *Gehun* 953	90.52	90.50
	VL 804**	0.00	10.48
Total		135.32	145.82
Lentil	VL *Masoor* 126	0.40	0.486
	VL *Masoor* 133	0.35	0.00
Total		**0.75**	**0.486**

** Carry over seed

3. Natural Resource Management for Sustainable Productivity

Research Projects

- Crop Management for Higher Soil Quality and Sustainability *[Drs. Dibakar Mahanta, P.K. Mishra, V.S. Meena, Manoj Parihar, R.P. Meena & Priyanka Khati (w.e.f., 11 July 2019)]*
- Enhancing Productivity and Profitability of Major Hill Crops through Efficient Resource Utilization *[Drs. Sher Singh, J.K. Bisht, P.K. Mishra, B.M. Pandey, Dibakar Mahanta, V.S. Meena & Er. Utkarsh Kumar (w.e.f., 11 July 2019)]*
  - ➤ Identification of Micro Watershed (Natural Spring) Using Remote Sensing and GIS Technique and Its Run off Estimation for Potential Water Harvesting *[Er. Utkarsh Kumar-PI]*
- Farm Mechanization and Post-harvest Management for Mountain Regions *[Er. Shyam Nath, Drs. B.M. Pandey, Sher Singh, Kushagra Joshi, R.P. Yadav, Jitendra Kumar & J.K. Bisht]*
- Agro-forestry and Fodder Production Management with Emphasis on Utilization of Marginal Lands in Hills *[Drs. J.K. Bisht, R.P. Yadav, P.K. Mishra, B.M. Pandey, V.S. Meena, Er. Shyam Nath, Jitendra Kumar & Manoj Parihar]*
  - ➤ Evaluation and Refinement of Suitable Agro-forestry Practices for Hills *[Dr. R.P. Yadav-PI]*
- Water Harvesting and Effective Utilization of Water for Enhancing Crop Productivity and Input Use Efficiency *[Drs. S.C. Panday, Mahipal Chaudhary (on study leave), Er. Shyam Nath, R.P. Yadav, Jitendra Kumar, Manoj Parihar, R.P. Meena, Priyanka Khati (w.e.f., 18 October 2019) & Ashish Kumar (w.e.f., 18 October 2019]*

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 & grassland and agroforestry management, farm machinery and post-harvest technology, plasticulture engineering and technology in hilly regions.

3.1. Crop Management for Higher Soil Quality and Sustainability

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

The farmyard manure (FYM) and vermicompost (VC) were evaluated against the recommended NPK (60-30-20 and 20-80-40 kg N-P_2O_5-K_2O/ha) under rainfed wheat (VL *Gehun* 829)–soybean (VL *Soya* 47) cropping system. The highest wheat equivalent grain yield of 10,908 and 11,494 kg/ha from wheat-soybean cropping system with favourable rainfall (102 mm) during the reproductive phase of wheat growing season through FYM and VC were produced with application of 133 and 136 kg P/ha/year, which were 12 and 18% higher than the recommended NPK, respectively (Fig. 3.1.1). The levels of P required from FYM and VC to achieve the same yield level as recommended NPK for wheat-soybean cropping system were only 67 and 58 kg P/ha/year, respectively.

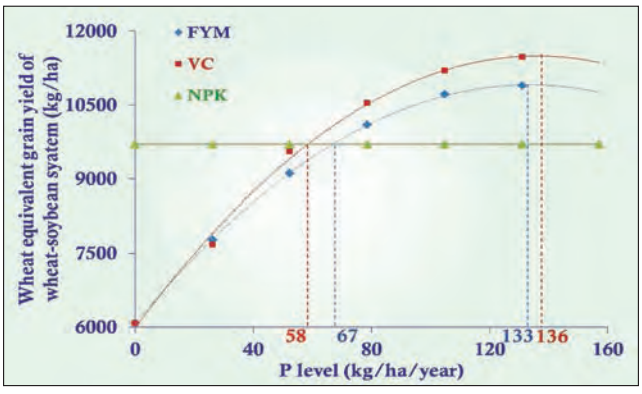


Fig. 3.1.1. Response of wheat equivalent grain yield of rainfed wheat-soybean cropping system to P application through farmyard manure and vermicompost

Comparative evaluation of P-enriched compost with biofertilizer and single superphosphate on mcrobial biomass carbon and soil respiration in soybean-based cropping systems

Application of P-enriched compost (PEC) @125% of the recommended P with seed inoculation of *Pseudomonas fragi* CS11RHI provided 50% higher microbial biomass carbon (MBC) (552 µg g^{-1} soil) than the recommended SSP treated plot (368 µg g^{-1} soil). The highest MBC was recorded under soybean-*toria* (513 µg g^{-1} soil) followed by soybean-wheat (485 µg g^{-1} soil) and lowest under soybean-lentil (477 µg g^{-1} soil) cropping system. The highest soil respiration was recorded under soybean-lentil (1370 µg CO_2 g^{-1} soil) followed by soybean-wheat (1348 µg CO_2 g^{-1} soil) and the lowest under soybean-*toria* (1200 µg CO_2 g^{-1} soil) cropping system. Application of P-enriched compost (PEC) @125% of the recommended P with inoculation of *Pseudomonas fragi* CS11RHI provided 53% higher soil respiration (1603 µg CO_2 g^{-1} soil) than the recommended SSP treated plot (1046 µg CO_2 g^{-1} soil). The higher values of MBC and soil respiration were finally reflected in higher grain yield of different crops.

Comparative influence of organic and chemical amendments on irrigated wheat-maize cropping system

Farmyard manure (FYM) and vermicompost (VC) were evaluated against recommended NPK (NPK) (150-60-60 and 120-60-40 kg N-P_2O_5-K_2O/ha) under irrigated wheat (VL *Gehun* 907) - maize (*Vivek* Maize Hybrid 45) cropping system. The highest wheat equivalent grain yield of 12,830 kg/ha was produced with application of FYM @ 300 kg N/ha, which was 12% higher than the NPK plot.

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

The analysis of grain yield data after 46 years of experimentation under rainfed soybean (cultivar: 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) cropping system confirmed that the wheat equivalent grain yield of inorganic fertilized plots of the system

provided reduced yield compared to the first year (1973-74). But, the application of FYM along with inorganic fertilizer provided an increase in the wheat equivalent grain yield than the first year (Fig. 3.1.2). The average wheat equivalent grain yield from the system with the application of 10 t/ha FYM along with the recommended NPK (6,737 kg/ha) recorded 105% higher compared to the recommended NPK (3,289 kg/ha), which confirmed that the application of chemical fertilizer only is not sustainable.

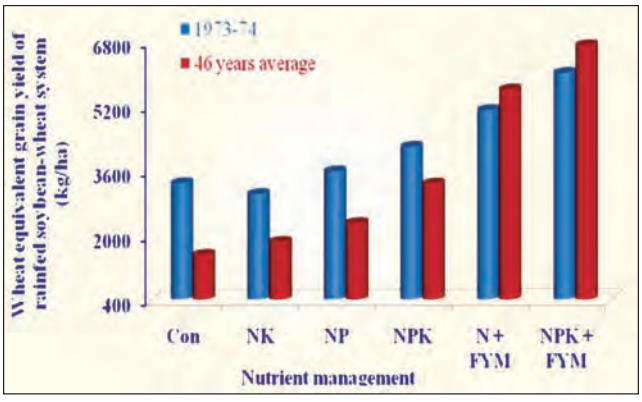


Fig. 3.1.2. Comparative wheat equivalent grain yield of rainfed soybean-wheat system

Photosynthetic rate of wheat under long term fertility management

The highest photosynthetic rate during peak vegetative growth (12.64 µmol $CO_2/m^2/s$) and reproductive stage (10.98 µmol $CO_2/m^2/s$) of wheat were recorded with application of FYM @ 10 t/ha along with recommended level of NPK (NPK + FYM), which were 12 and 13% higher than NPK only, respectively (Fig. 3.1.3). This was ultimately reflected in the grain yield of the crop.

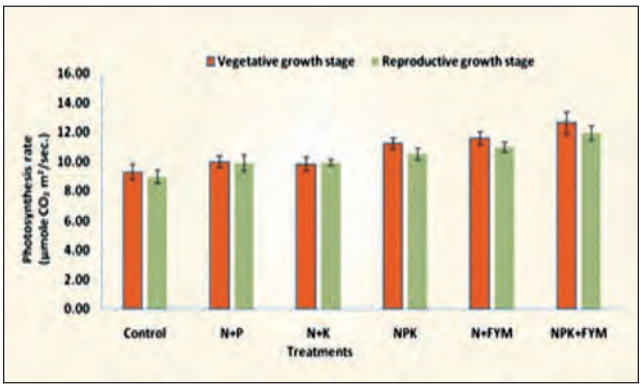


Fig. 3.1.3. Photosynthetic rate at vegetative and reproductive growth stages of wheat under long term fertility management

Response of cold tolerant 'P' solubilizing Pseudomonas strains on yield of lentil

Two elite cold tolerant 'P' solubilizing *Pseudomonas* strains (*Pseudomonas* sp. RT5RP(2) and *Pseudomonas fragi* CS11RH1) along with uninoculated control were used for seed inoculation of three lentil varieties (VL *Masoor* 126, VL *Masoor* 507 & VL *Masoor* 514) to study their response on grain yield of lentil under field conditions. A two-way analysis of variance was conducted on the influence of two independent variables (varieties and *Pseudomonas* strains) on grain yield. All effects were statistically significant at the 0.05 significance level. Bacterization with cold tolerant P solubilizing *Pseudomonas* sp. RT5RP(2) recorded higher lentil grain yield of 607 and 476 kg/ha for VL *Masoor* 514 and VL *Masoor* 507, respectively. However, VL *Masoor* 126 provided higher yield (730 kg/ha) with *Pseudomonas fragi* CS11RH1 (Fig. 3.1.4).

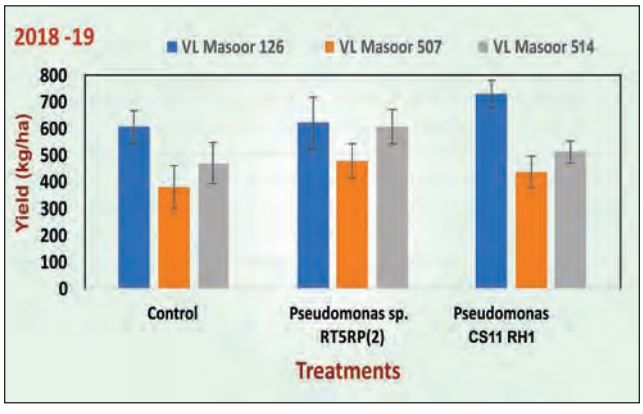


Fig. 3.1.4. Effect of cold tolerant P solubilizing *Pseudomonas* strains on yield of lentil varieties

Response of cold tolerant 'P' solubilizing consortium on yield of lentil

Two elite cold tolerant 'P' solubilizing consortium {C2 (PB2RP1 (2), NS12RH2 (1), CS11RP1) and C3 (PB2RP1 (2), NS12RH2 (1), CS11RH4)} along with uninoculated control were used for seed inoculation of three lentil varieties (VL *Masoor* 126, VL *Masoor* 507 & VL *Masoor* 514) to study their response on yield of lentil under field conditions. A two-way analysis of variance was conducted on the influence of two independent variables (varieties and cold tolerant PGP consortium) on grain yield. All effects were statistically significant at the 0.05 significance level. The interaction effect was significant $F(4,18) = 173.3$, $p<0.05$ (Fig. 3.1.5). Bacterization with cold tolerant P solubilizing bacterial consortium C2

recorded higher lentil grain yield of 1,322 and 1,257 kg/ha for VL *Masooor* 514 and VL *Masooor* 507, respectively. However, VL *Masooor* 126 provided higher yield (1,290 kg/ha) with consortium C3.

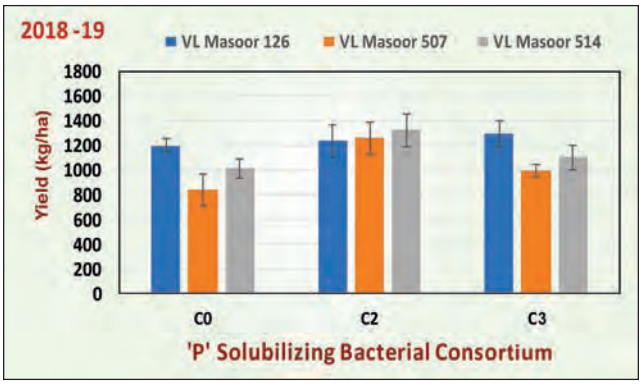


Fig. 3.1.5. Effect of cold tolerant P solubilizing bacterial consortium on yield of lentil varieties

Foliar spray of zinc helps in harvesting the potential grain yield of irrigated wheat

The maximum grain yield of 4,060 kg/ha was recorded with the double spray of 0.5% $ZnSO_4.7H_2O$ at active tillering and dough stage, which was significantly higher than rest of Zn scheduling, except spraying either at tillering or at booting stage. Spraying of Zn at tillering and dough stages provided 25% higher grain yield than no spraying.

3.2. Enhancing Productivity and Profitability of Major Hill Crops through Efficient Resource Utilization

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

Short duration variety "VL *Mandua* 347" of finger millet and timely sown wheat variety "VL *Gehun* 907" of wheat were assessed for different conservation agriculture practices under rainfed condition. Seed drill sowing improved wheat yield by 8.9 and 25.0% compared to manual line sowing (2,405 kg/ha) and broadcasting (2,096 kg/ha), respectively. Under conservation agriculture practice, the mulch used in finger millet crop conserved soil moisture for the succeeding wheat crop, where one hoeing after winter rains in the mulched plots resulted 7.6% higher wheat grain yield compared to no mulch (2,420 kg/ha). In wheat, zero tillage provided 3.1% more grain yield than conventional tillage (2,474 kg/ha). Seed drill sowing of wheat under zero tillage conditions in mulched plots fetched net returns of Rs 35,427/- per ha with B:C ratio of 2.50.

Management of heat stress during grain filling stage of wheat through muriate of potash (MOP) spray

There was no significant effect of MOP spray on grain yield of different wheat varieties (VL *Gehun* 953 and VL *Gehun* 892) in different sowing dates. The spraying of MOP (0.2%) provided 12% higher grain yield of VL *Gehun* 953 during normal sowing date, which was non-significant.

Comparative performance of heat stress damage ameliorating substances in wheat

There was no effect of different heat stress amendments (MOP, KNO_3 and salicylic acid) on grain yield of late sown wheat (VL *Gehun* 892).

Evaluation of herbicides for control of weeds in maize

The post-emergence spraying of tembotrione @ 120 g/ha (10,864 kg/ha) at 25 days after sowing provided 6% higher grain yield of maize compared to the recommended pre-emergence spraying of atrazine (1500 g a.i./ha) followed by post-emergence spraying of 2,4-D amine (400 g a.i./ha). The weed competition index of tembotrione was 11, which was 33% less than the recommended herbicide application of atrazine + 2,4-D amine. It indicates that application of tembotrione @ 120 g/ha at 25 DAS is significantly better than the spraying of both atrazine 1.5 kg/ha as pre-emergence and 2,4-D amine 0.4 kg/ha as post-emergence for higher grain yield and better control of weeds under maize crop. Hence, tembotrione can substitute the recommended atrazine + 2,4-D amine for weed control in maize.

Response of cold tolerant PGP Pseudomonas strains on yield of wheat

Two elite Pseudomonad strains (*Pseudomonas* sp. PPERs23 and *Pseudomonas* sp. NARs9) along with uninoculated control were used for seed inoculation of three wheat varieties (VL *Gehun* 804, VL *Gehun* 907 & VL *Gehun* 953) to study their response on yield of wheat under field condition. A two-way analysis of variance was conducted on the influence of two independent variables (varieties and *Pseudomonas* strains) on grain yield. All effects were statistically significant at the 0.05 significance level. Bacterization with cold tolerant PGP *Pseudomonas* sp. PPERs23 recorded higher wheat grain yield

of 2,129 and 2,110 kg/ha for VL *Gehun* 804 and VL *Gehun* 907, respectively. However, VL *Gehun* 953 provided higher yield (1,773 kg/ha) with *Pseudomonas* sp. NARs9 (Fig. 3.2.1).

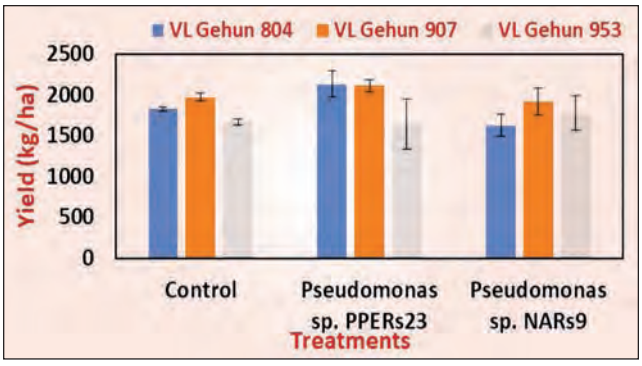


Fig. 3.2.1. Effect of cold tolerant PGP *Pseudomonas* strains on yield of wheat varieties

Response of cold tolerant PGP consortium on yield of wheat

Two elite cold tolerant PGP consortium {Consor -tium C2 (PGRs4, PPERs23, PCRs4) and Consortium C4 (PPRs4, PCRs4, PGRs1)} along with uninoculated control were used for seed inoculation of three wheat varieties (VL *Gehun* 804, VL *Gehun* 907 & VL *Gehun* 953) to study their response on yield of wheat under field conditions. A two-way analysis of variance was conducted on the influence of two independent variables (varieties and cold tolerant PGP consortium) on grain yield. All effects were statistically significant at the 0.05 significance level. The interaction effect was significant. Bacterization with cold tolerant PGP consortium C2 recorded higher grain yield of 2,418 and 2,090 kg/ha for VL *Gehun* 804 and VL *Gehun* 953, respectively. However, VL *Gehun* 907 recorded higher yield (2,130 kg/ha) with the consortium C4 (Fig. 3.2.2).

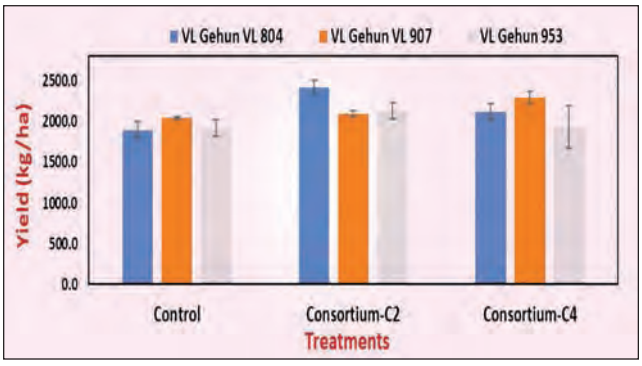


Fig. 3.2.2. Effect of cold tolerant PGP *Pseudomonas* strains on yield of wheat varieties

Tillage and phosphorus management in wheat-soybean cropping system

Different levels of 'P' along with phosphate solubilizing bacteria (PSB) provided 17 to 31% higher wheat grain yield compared to control (Fig. 3.2.3). The tillage effect was non-significant with zero tillage having 5.9% higher yield than conventional tillage (3,920 kg/ha). The application of NK + 150% P + PSB under zero tillage recorded highest grain yield of wheat (4,980 kg/ha).

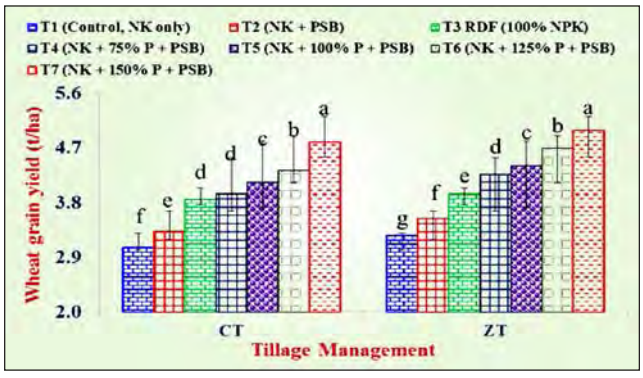


Fig. 3.2.3. Effect of tillage and phosphorus management on wheat grain yield

Identification of micro watershed (Natural Spring) using remote sensing & GIS techniques and its runoff estimation for potential water harvesting

Digital Elevation Models (DEMs) are important source of elevation data required for watershed development. Moreover, DEMs (Fig. 3.2.4) are more often used in Geographic Information Systems (GIS), and form the basis for digitally produced relief map. In this study, elevation data was extracted for experimental farm, Hawalbag. The accuracy statistics [root mean square error (RMSE), correlation coefficient (R) and coefficient of determination (R^2)] were computed using the ground point of 42 reference points in the study

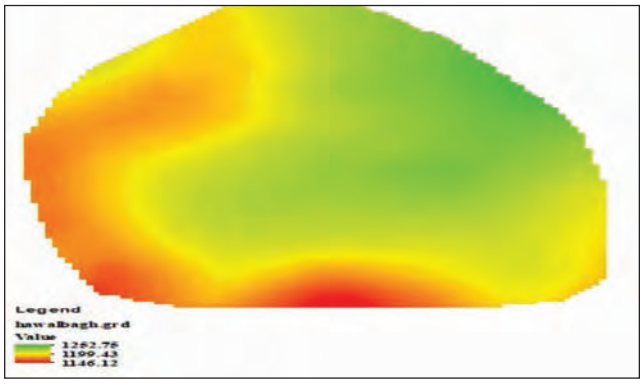


Fig. 3.2.4. Digital Elevation Model (DEM) of study area

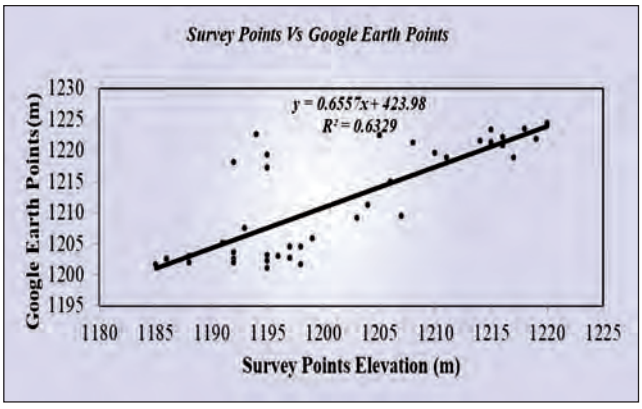


Fig. 3.2.5. Scatter plot showing correlation between survey points and Google Earth points

area (Fig. 3.2.5). The reference data was collected using GPS mp 76CSx. The value of R was 0.79, the coefficient of determination (R^2) was 0.63 and root mean square error (RMSE) was 11 m. The result showed the accuracies for the prepared DEM are suitable for hydrological and other water resources modelling. In general Google earth derived DEM can only be used for investigation and preliminary analysis with low initial investment.

Response of finger millet varieties to increasing nitrogen levels under rainfed condition

Two finger millet varieties, *viz*. VL *Mandua* 352 and VL *Mandua* 379 were evaluated with five different nitrogen levels, *viz*. 0, 20, 40 (recommended dose), 60 and 80 kg N/ha under rainfed condition. The grain yield of VL *Mandua* 379 (2,814 kg/ha) was found significantly higher than VL *Mandua* 352 (2,412 kg/ha). Among various nitrogen levels, 60 kg N/ha recorded the maximum grain yield (2,855 kg/ha), which was at par with 40 kg N/ha (2,780 kg/ha). The highest grain yield was recorded by VL *Mandua* 379 with 40 kg N/ha (3,073 kg/ha) which was at par with 20 kg N/ha (2,979 kg/ha) and 60 kg N/ha (2,962 kg/ha).

3.3. Farm Mechanization and Post-Harvest Management in Mountain Region

Development and evaluation of Vivek iron plough

Present VL *Syahi hal* is very popular among famers. But at the same time, it also needs to be improved for its robustness and easy fabrication. To overcome the existing limitations, VL *Syahi hal* (specially for upland conditions) has been modified as "VL Metallic Plough" for upland as well as irrigated valley conditions.

Development of animal feed block machine

Animal feed block machine was improved for a block of 250×250×150 mm instead of 300×300×150 mm and a trapezoid shape instead of ractagle shape. The benefit of trapezoid shape feed block was that it was very easy to take out after compressing. It was also tried to make block of vermicompost and for compressing wheat straw to grow oyster mushroom. Screw pressing was done manually.

Development of small tools

The small farm tools and implements are being developed as per location specific requirement. VL hand fork and VL line maker was modified for better penetration and soil coverage. Manufacturing of small tools like VL *Kutla*, VL Hand fork, VL Garden Rake, VL Hand Hoe, VL Line Maker, VL *Khurpi* and VL *Darati* was carried out at institute workshop. A MoA was signed for VL small tools kit with M/s Himalayan High-tech Nursery, Haldwani.

Design and development of VL Maize Sheller

Design for the development of VL Maize sheller was accomplished using Creo Parametric 4.00 (CAD Software). Rotor was the main component for the sheller. The rotor with reverse slanted square bar provided better result. The dimension of the square bar was 560×10×10 mm. Nine number of square bars were used. The diameter of the rotor was 100 mm. The overall dimension of the machine was 1000×450×1000 mm. The main components of the sheller were frame, half hp electric motor, rotor,

Final Prototype of VL Maize sheller under operation

threshing drum, feeding chute (hopper). Power from electrical motor was transmitted to shelling rotor through "V" belt and pulley. The shelling rotor was rotated from 1000 to 1200 rpm approximately. The overall weight of the machine was 52 kg.

The average shelling capacity and efficiency was 115 kg grains/h and 93%, respectively at 14% moisture content and 18 degree working slope (Table 3.3.1). The speciality of this sheller is no breaking of the cob wood. Farmers use this whole cob in their traditional fire places and hearths and the sheller is specially designed for this.

Table 3.3.1. Performance of VL Maize Sheller during preliminary testing

Shelling slope (degree)	18
Average moisture content (%)	13.7
Average threshing efficiency (%)	93.2
capacity (kg grains/h)	114.8

3.4. Agroforestry and Fodder Production Management with Emphasis on Utilization of Marginal Lands in Hills

Identification of forage material for hills

Two varieties of forage grass, *i.e.* Setaria-25 (*Setaria anceps*) and Palam perennial rye-1 (*Lolium perenne*) were identified for Himachal Pradesh and Uttarakhand hills during *rabi* and *kharif* group meet of All India Coordinated Research Project (AICRP) on forage crops in collaboration with CSKHPKV, Palampur, HP.

Evaluation of grasses

Bajra Napier Hybrid: Out of sixteen entries, the entry VTBN-2019-8 produced significantly higher green fodder (19,153 kg/ha) and dry fodder (5,793 kg/ha) than rest of the entries, except the entry VTBN-2019-10 for green fodder.

Rye Grass: In advance varietal trial on rye grass, out of four entries, the entry AVT2-RG-2 and AVT2-RG-1 produced maximum green forage (38,287 kg/ha) and dry fodder (10,573 kg/ha), respectively.

White Clover: Out of six entries of white clover, significantly higher green fodder (11,883 kg/ha) was obtained from entry VTWC-1 compared to VTWC-3 and VTWC-6. Likewise, entry VTWC-1 also produced significantly higher dry fodder (2,733 kg/ha) than rest of the entries, except VTWC-2 and VTWC-5.

Red Clover: Out of seven entries of red clover, entry VTRC-7 produced significantly higher green fodder (3,150 kg/ha) and dry fodder (567 kg/ha) than VTRC-2 and VTRC-5 only for green fodder and VTRC-5, VTRC-1 and VTRC-2 for dry fodder.

Evaluation of cultivated fodder

Oat: In initial varietal trial on oat, out of eleven entries, entry IVTO MC-9 and IVTO MC-2 produced significantly higher green fodder (30,016 kg/ha) and dry fodder (13,424 kg/ha), respectively than rest of the entries. In first advance varietal trial in oat multicut, entry AVTOMC-2 produced significantly higher green fodder (37,900 kg/ha) and dry fodder (6,064 kg/ha) than rest of the entries, except AVTO MC-1 for green fodder.

Berseem: Out of eight entries in initial varietal trial of berseem, significantly higher green fodder (18,975 kg/ha) was obtained from the entry IVTB-1 than rest of the entries, except IVTB-6 & IVTB-8. Maximum dry fodder (4,008 kg/ha) was also recorded from the entry IVTB-1.

Maize: In advance varietal trial on forage maize, out of nineteen entries, maximum green forage was obtained from entry AVTM-1-1 (41,152 kg/ha). Entry AVTM-1-1 also produced significantly higher dry matter (7,853 kg/ha) than entries AVTM-1-4 to 7 and AVTM-1-12 to 15. Out of fifteen entries of maize initial varietal trial, significantly higher green forage (44,522 kg/ha) and dry fodder (12, 253 kg/ha) was obtained from the entry IVTM-15 than rest of the entries, except IVTM-16 for green fodder.

Cowpea: In cowpea advance varietal trial, entry AVTC-2-3 produced significantly higher green forage (24, 200 kg/ha) than rest of the entries except AVTC-2-1. However, dry fodder (4, 419 kg/ha) was significantly higher in the entry AVTC-2-1 than rest of the entries except AVTC-2-3.

Agroforestry

Agri-horti system

Fruit-based

In fruit based agri-horti system, four fruit crops, *viz.* hill lemon, pear, plum and apricot were planted with the soybean in *kharif* and dual-purpose wheat during *rabi* season. During initial years, no significant effect on green fodder and grain yield of wheat was observed with the presence of different fruit trees in *rabi* crop, however, during *kharif,* presence of tree affected significantly the grain yield of soybean. In both *rabi* and *kharif,* maximum grain and straw yield was recorded under open condition followed by lemon (*Citrus limon).* Green fodder yield of wheat varied between 2,378 and 3,795 kg/ha.

Peach-based

In peach-based agri-horti system, four varieties each of wheat (VL *Gehun* 804, VL *Gehun* 892, VL *Gehun* 829 and VL *Gehun* 907) and finger millet (VL *Mandua* 149, VL *Mandua* 324, VL *Mandua* 315 and VL *Mandua* 347) were evaluated. In *rabi* season, wheat grain and straw yield significantly reduced by 16.9 and 15.2%, respectively under peach than without peach (open). In case of varieties, the highest grain yield was recorded from VL *Gehun* 804 followed by VL *Gehun* 892, VL *Gehun* 829 and VL *Gehun* 907 (Fig. 3.4.1). In *kharif* season, irrespective of the varieties, the open condition (without peach) produced significantly higher (6.1%) yield of finger millet compared to peach-based system. Among verieties, significantly higher grain yield (1.8 t/ha) was recorded by VL *Mandua* 149 than rest of the varieties.

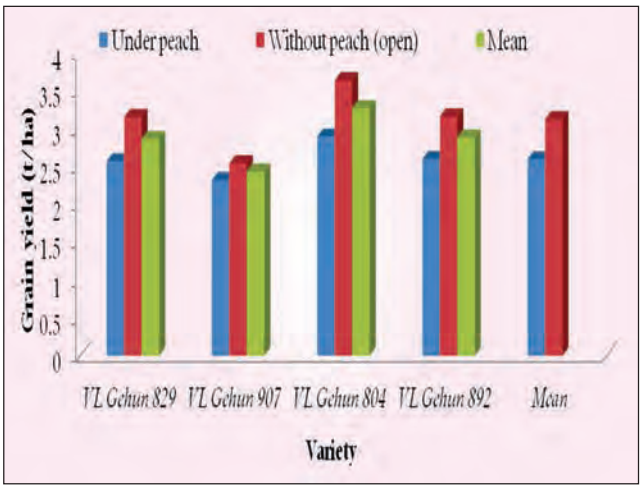


Fig. 3.4.1 Grain yield of wheat varieties under peach-based agri-horti system

Pecan nut-based

In pecan nut based agri-horti system irrespective of growing situation, significantly higher turmeric yield was obtained from RCT-1 (15.09 t/ha) compared to *Pant pithab* and *Swarna* and was statistically at par with local (Fig. 3.4.2). However, the turmeric yield was more under pecan nut (5.89%) than without pecan nut.

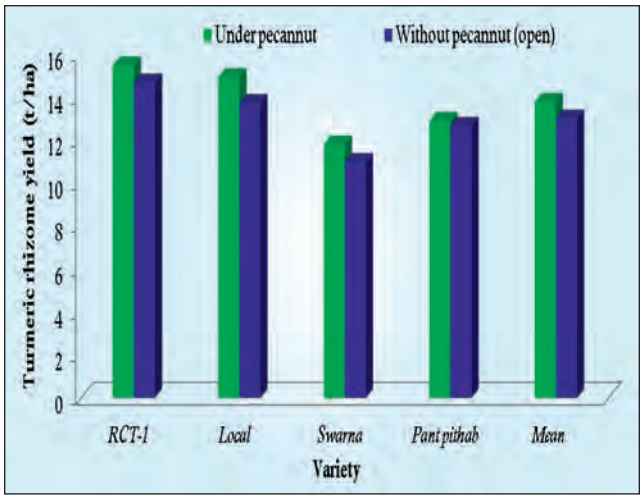


Fig. 3.4.2. Rhizome yield of different turmeric varieties under pecan nut based agri-horti system

Soil enzyme activity under pecan nut based agri-horti system

The initial soil enzyme activity was estimated under open (without tree) and pecan nut based agri-horti system. In comparison to open condition, tree-based cropping system provided higher enzyme activity. Data revealed that under tree-based cropping system (0-15cm), alkaline phosphatase activity ranged from 278.4 to 331.1 µg p-NPg^{-1}soil h^{-1}, which was ~9 to 30% higher than open condition. Among different varieties of turmeric, mostly *Pant Pitabh* and RCT-1 provided higher enzyme activity but were adjudged at par with other varieties. The similar trend was observed for dehydrogenase and urease activity but β-glucosidase activity was highest in local variety grown under both tree (46.7 µg p-NP produced g^{-1}soil h^{-1}) and open condition (34.4 µg p-NP produced g^{-1}soil h^{-1}). All the enzyme activities reduced at sub-surface soil layer (15-30 cm) compared to surface soil layer (Fig. 3.4.3).

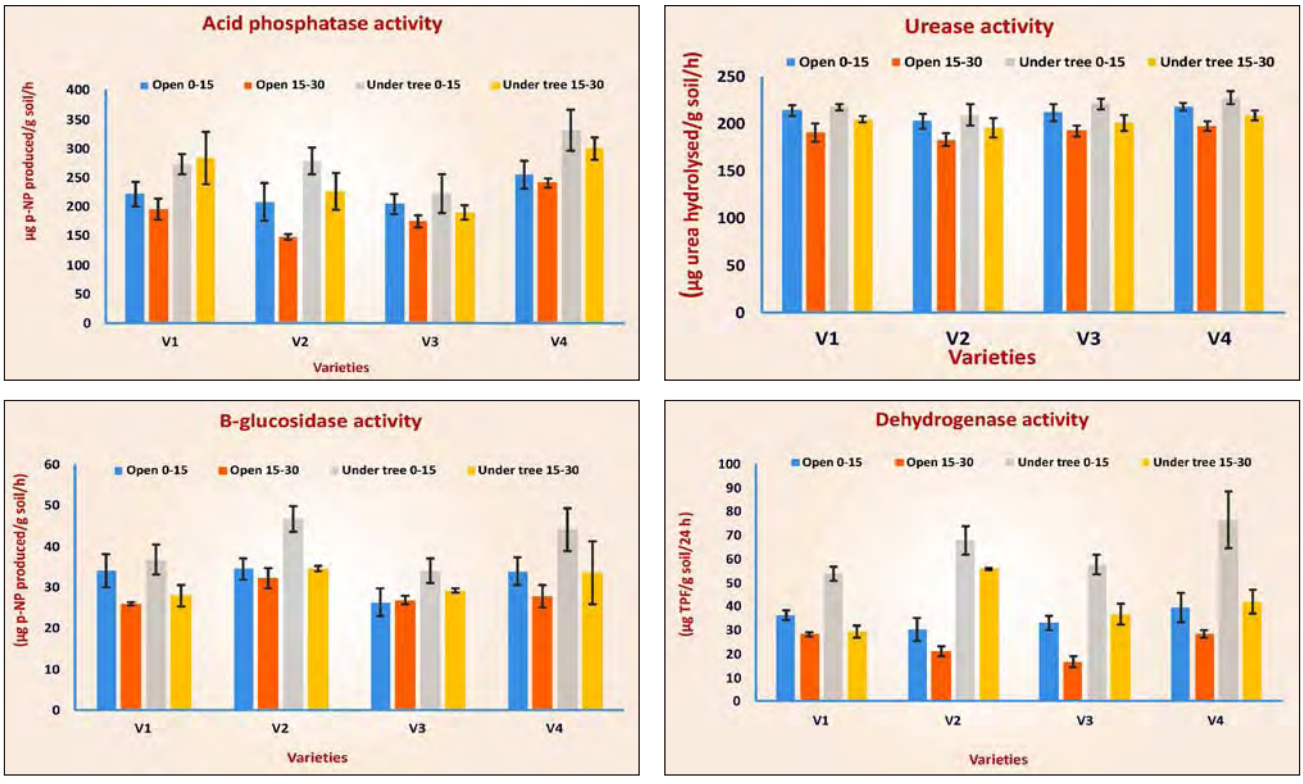


Fig. 3.4.3. Soil enzyme activity under pecan nut based agri-horti system

Silvi-horti system

Oak-based

Different cutting management of oak and open (without oak) influenced significantly turmeric yield of *Pant pithab* and *Swarna* variety. Average yield of *Pant pithab* and *Swarna* was 8.46 and 8.78 t/ha, respectively (Fig. 3.4.4). Turmeric yield ranged from 7.0 to 11.6 t/ha for different cutting management and open (without oak). Significantly higher green fodder (20.7 t/ha) and wood yield (11.3 t/ha) was recorded in cutting at 3 m height than other, except in cutting at 2 m height for wood yield.

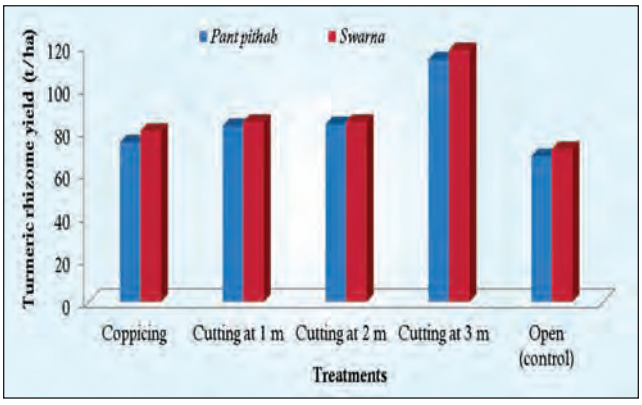


Fig. 3.4.4. Turmeric rhizome yield under different cutting management of oak tree and without oak (open)

Silvipasture System

Fodder trees *Quercus leucotrichophora, Grewia optiva, Morus alba, Bauhinia retusa* and *Melia azedarach* along with four cutting management, *viz*. coppicing, pollarding at 1-meter height, pollarding at 2-meter height and pollarding at 3 meter height with *Setaria kazungula* under these trees were tested under silvi-pastoral system. During winter season, the highest green fodder leaf biomass (3,067 kg/ha) was yielded by *Quercus lecuotrichophora*, however, in case of cutting management, pollarding at 3-meter height produced the highest green fodder leaf biomass (2,591 kg/ha). During *kharif* season, *Setaria sphacelata* (cv. Kajungula) grass produced the highest green fodder (5,583 kg/ha) under *Quercus lecuotrichophora*. Whereas, under lopping management the highest green forage yield was obtained with cutting at 1 m height (4,759 kg/ha) followed by cutting at 2 m, 3 m and coppicing.

Carbon Sequestration

The biomass C stock for peach and pecan nut was 22.3 and 65.9 Mg/ha under agrihorti system, respectively. Under silvihorti system, on sloping land, the highest C stock was recorded in *Quercus glauca* (109.4 Mg/ha), followed by *Alnus nepalensis*

(99.4 Mg/ha), *Melia azedarach* (89.7 Mg/ha) and least in *Bauhinia retusa* (3.8 Mg/ha). Whereas, on flat land the highest biomass C was accumulated in *Celtis australis* (281.6 Mg/ha) followed by *Quercus leucotrichophora* (179.2 Mg/ha), *Bauhinia retusa* (44.5 Mg/ha) and *Grewia optiva* (6.2 Mg/ha).

3.5. Water Harvesting and Effective Utilization of Water for Enhancing Crop Productivity and Input Use Efficiency

Irrigation requirement of wheat-rice rotation in relation to tillage alteration

The direct sown rice-wheat rotation was evaluated with limited irrigation under zero and conventional tillage. The higher wheat yield (3,223 kg/ha) was recorded under zero tillage in comparison to conventional tillage (2,646 kg/ha) (Fig. 3.5.1). However, higher rice yield (1,893 kg/ha) was recorded under conventional tillage than the zero tillage (1,567 kg/ha) (Fig. 3.5.3). Significant increase in wheat yield was recorded with increasing level of irrigations. The highest yield of wheat (3,061 kg/ha) and rice (1,920 kg/ha) was recorded with four irrigations (Fig. 3.5.2 & 3.5.4). The applied water productivity was higher under zero tillage. The highest water productivity was recorded with one irrigation

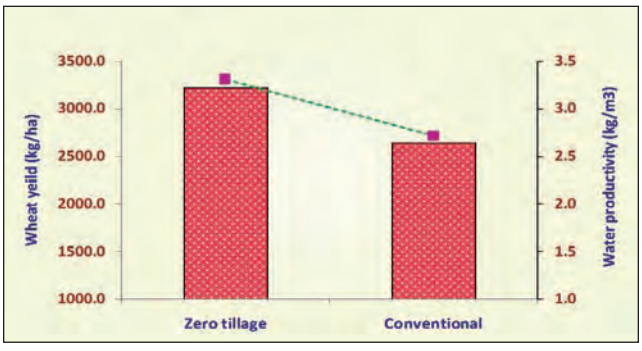


Fig 3.5.1. Influence of tillage on grain yield and water productivity of wheat

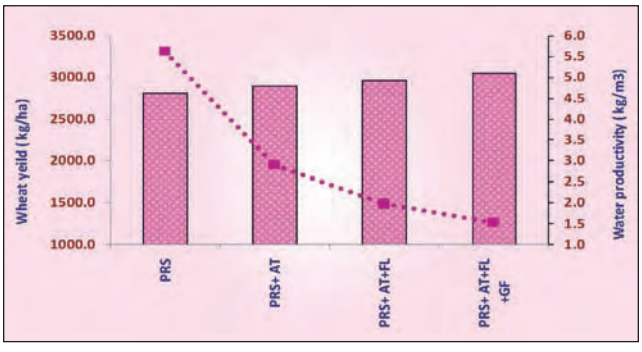


Fig. 3.5.2. Influence of irrigation on grain yield and water productivity of wheat

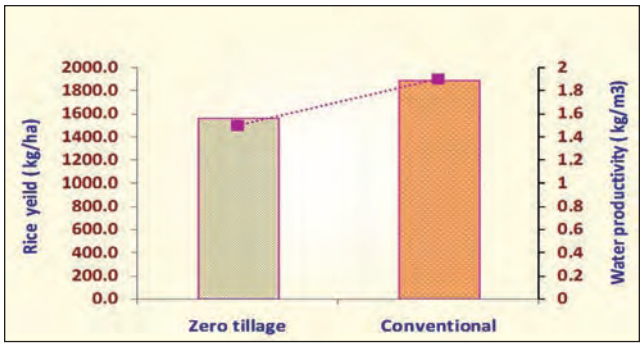


Fig 3.5.3. Influence of tillage on grain yield and water productivity of rice

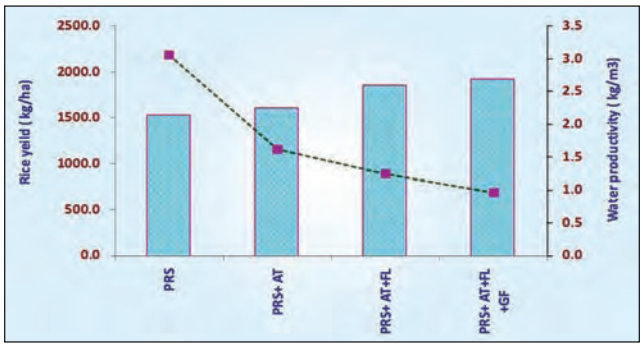


Fig. 3.5.4. Influence of irrigation on grain yield and water productivity of rice

followed by two and three irrigations. Lowest water productivity was recorded with four irrigations.

Weed dynamics in wheat under different tillage and irrigation system

Weed is a major problem under zero tillage system, hence, the weed density and weed biomass were recorded in different treatments (Fig. 3.5.5). The highest weed density (1132/m^2) and weed dry biomass (370 g/m^2) were observed under zero tillage which were 67 and 47% higher than the

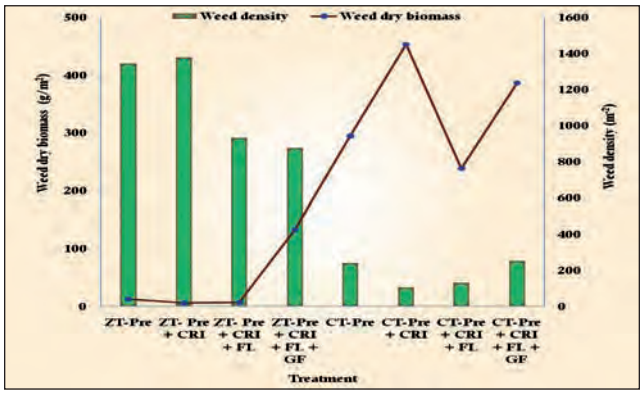


Fig. 3.5.5. Influence of different tillage and irrigation system on weed density and dry biomass under wheat (ZT- zero tillage; CT-conventional tillage; Pre- pre-sowing irrigation; CRI- irrigation at CRI stage; FL- irrigation at flowering; GF-irrigation at grain filling stage)

conventional tillage (183/m^2, 96 g/m^2), respectively. The highest weed density (792/m^2) was recorded by the application of irrigation at pre-sowing (Pre) and highest weed dry biomass was recorded with application of irrigation at pre-sowing, Crown Root Initiation (CRI), flowering stage and at grain filling stage (Pre+CRI+FL+GF) (360 g/m^2). The results showed that proper weed management is required in zero tillage in order to reduce weed infestation and its negative impact on crop.

Soil moisture and nutrient dynamics in wheat-soybean rotation under irrigated condition

Wheat was grown under fertilized condition and soybean was grown on the residual fertility, except one treatment where it was grown with recommended NPK. The application of recommended NPK+10t FYM/ha recorded higher wheat grain yield (3,625 kg/ha) followed by N+FYM (3,132 kg/ha). The FYM application provided higher yield (3,197 kg/ha) in comparison to N alone (2,025 kg/ha). The lowest grain yield was obtained under control (1,111 kg/ha) (Fig. 3.5.6). The water productivity followed the same trend as in the case of grain yield.

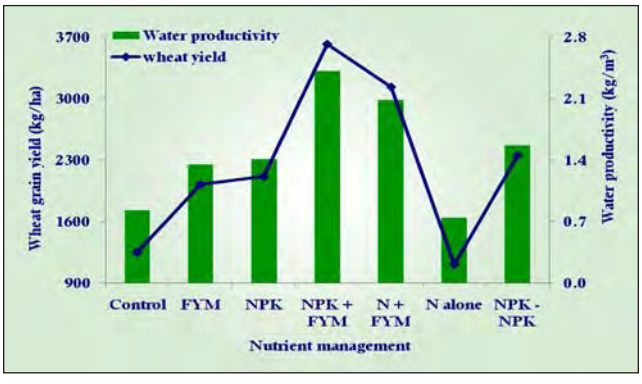


Fig. 3.5.6. Wheat yield and productivity under different level of nutrients

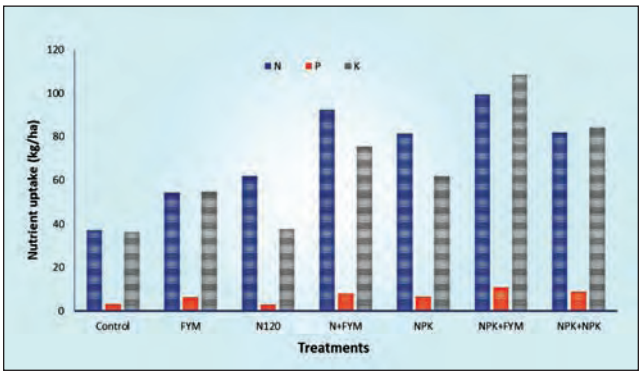


Fig. 3.5.7. Nutrient uptake (N, P and K) by wheat crop under different level of nutrients

The highest nitrogen uptake was recorded in NPK+FYM (99.6 kg/ha) which was 22, 84 and 168% higher than the NPK, FYM and control plots, respectively (Fig 3.5.7). Almost similar trend was recorded for P and K uptake which ranged from 3.1 to 10.8 and 36.4 to 108.6 kg/ha, respectively.

The soil pH is an important chemical parameter which regulates nutrient availability and subsequently their uptake by crop plants. The continuous application of only nitrogenous fertilizer (N_{120}) and by the application recommended NPK dose in both season (NPK+NPK) reduced the pH value (5.79) in comparsion to other treatments (Fig 3.5.8). The highest yield of soybean was recorded by the direct application of recommended NPK fertilizer followed by the application of NPK+FYM in *rabi* season, N+FYM and FYM (Fig. 3.5.9).

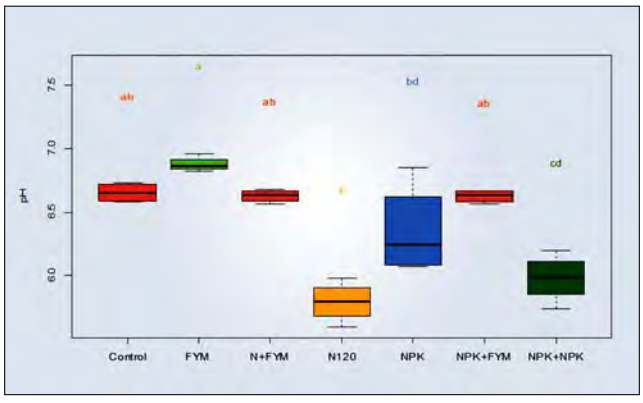


Fig. 3.5.8. Effect of long-term fertilization on soil pH

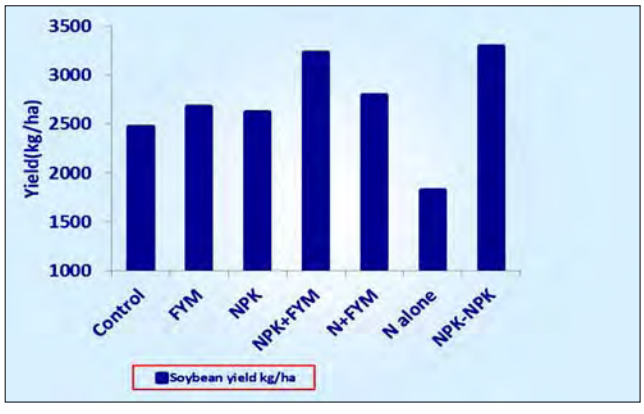


Fig. 3.5.9. Effect of residual and direct application of NPK on soybean yield

The microbial count revealed that the highest bacteria and actinomycete population was recorded by the application of NPK + FYM treated plots followed by the application of 10 t FYM/ha and the lowest was recorded under control (Fig. 3.5.10).

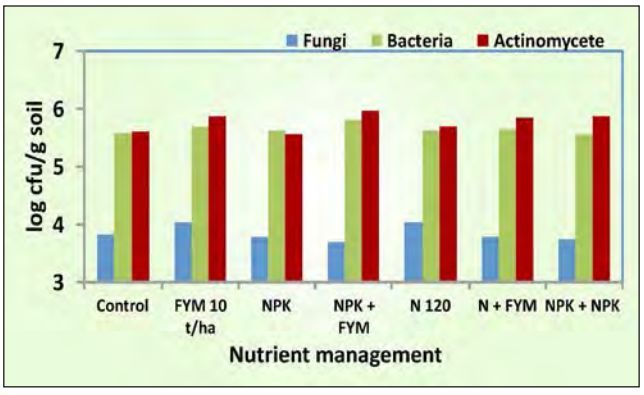


Fig. 3.5.10. Microbial population under different treatments.

Artificial recharging techniques for hill springs

The main purpose of artificial spring recharge technology is to store excess surface runoff to make sure the water availability during winter and post-monsoon season. One of the spring located at ICAR-VPKAS, Hawalbag farm was selected to revive because its discharge was greatly reduced due to heavy construction on its catchments. The roof water as well as surface water was harvested in trenches along with plantation on trenches to avoid evaporation and to enhance time of the water infiltration in aquifer recharging zone.

The comparative study revealed that the five year mean annual discharge of the spring was 73.2, 100.7, 114.2, 135.9, 148.8, 145.8, 138.4, 142.6, 136.4 and 140.1 per cent higher during 2006-2010, 2007-2011, 2008-2012, 2009-2013, 2010-2014, 2011-2015, 2012-2016, 2013-2017, 2014-2018 and 2015-2019, respectively in comparison to annual discharge recorded during 2000 before the inception of treatments (Fig. 3.5.11). Although the five-yearly mean annual rainfall was -19.4, 13.5, -15.5, -13.6, -12.5, -24.2, -26.5, -27.1, -32.5 and 34.7 per cent lower during 2006-2010, 2007-2011, 2008-2012, 2009-2013, 2010-2014, 2011-2015, 2012-2016, 2013-2017, 2014-2018 and 2015-2019, respectively in comparison to year 2000. The annual discharge was 146.5 per cent higher during 2018 in comparison to discharge recorded before treatment inception in 2000. The discharge and rainfall relationship was worked out including the data before the treatment inception and after the treatment inception. (Fig. 3.5.12). It shows that the treatments enhanced water percolation in soil. Therefore, the correlation between discharge and rainfall increased. The discharge of spring greatly increased during lean period compared to discharge recorded in 2000 (Fig. 3.5.13).

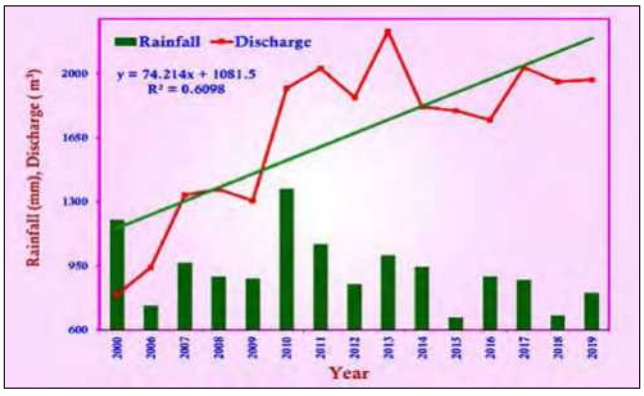


Fig. 3.5.11. Annual rainfall and discharge in different years from spring before and after treatments

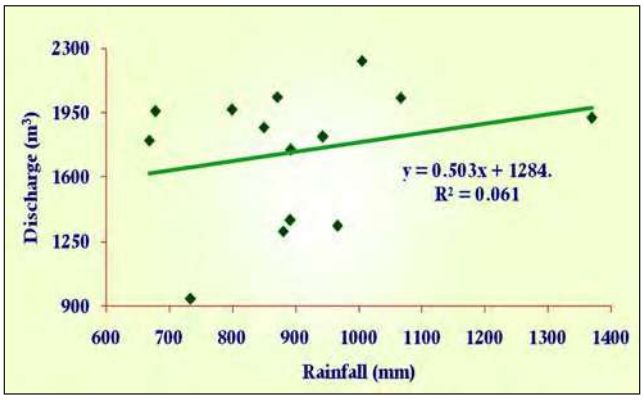


Fig. 3.5.12. Rainfall and spring discharge relationship after the treatment inception

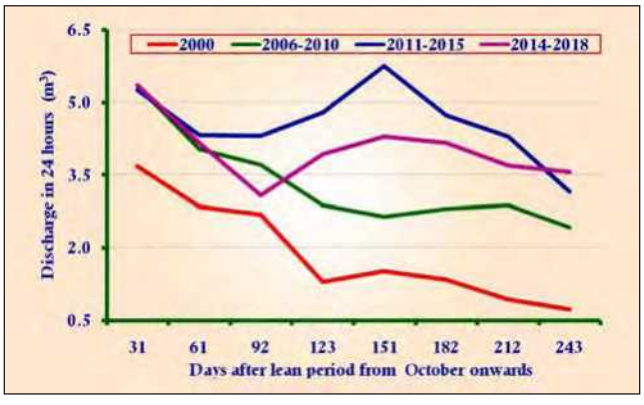


Fig. 3.5.13. Spring discharge during lean period before and after the treatment inception during different years

Studies on the suitability of locally available covering material to protect pond lining material from UV radiation and physical damages

The study indicates that four treatments were found suitable to protect LDPE film from the damage. LDPE film covered with cement and stone/gravel

blocks (made locally)+soil found very suitable and economical with long shelf life. The special block was designed to cover vertical ponds without slope. It was found suitable, but required to carry out observation for more period. This is observed that covering LDPE lining with locally block not only protect film but also create favourable condition for fish farming. The LDPE film can also be covered with round stone, bricks+soil. LDPE covered with soils also found suitable.

Estimation of water requirement of major crops

CROPWAT is a decision support tool developed by the Land and Water Development Division of FAO. CROPWAT model is extensively tested, widely accepted for calculation of crop water requirements based on soil, climate and crop data. In addition, the programme allows the development of irrigation schedules for different management and the calculation of scheme of water supply for varying crop patterns. CROPWAT ver. 8.0 model used weather data and employs the modified Penman-Monteith approach used to estimate reference evapotranspiration on a daily basis. The meteorological data was taken from Agromet Observatory, ICAR-VPKAS, Experimental farm Hawalbag, Almora. The general soil properties of the experimental field were used in CROPWAT model. Based on the details of soil characteristics, total available water was taken 135 mm m^{-1} depth of soil. Infiltration rate was measured using double ring infiltrometer and the basic rate was 6.8 mm hr^{-1} and the unsaturated hydraulic conductivity was 0.77 cm h^{-1}. The irrigation water requirement was estimated and the values were (346-376, 131-189, 1.4, 1.3, 78.6, 93.5, 104.1, 176, 96.9 and 16.2 mm for rice, wheat, maize, soybean, vegetable pea, kidney bean, barley, tomato, french bean and chilli crop, respectively (Table 3.5.1).

Table 3.5.1. Estimation of irrigation water requirement of major crops

Crop	Crop water requirement (mm)	Effective rainfall (mm)	Irrigation water requirement (mm)
Vegetable pea	209.8	131.7	78.6
Barley	250	147.9	104.1
Kidney bean	123.3	29.7	93.5
Tomato	262.4	84.3	176
French Bean	166.9	70.1	96.9
Chilli	310.6	370.7	16.2
Rice	434-505.9	464-491	346-376
Wheat	269.2-375.1	163-194.6	131-189
Maize	247.9	395	1.4
Soybean	350.6	494.4	1.3

Effect of irrigation schedule on onion and garlic

The mean onion yield (11.58 t/ha) under drip irrigation was almost same in comparison to check basin irrigation (11.47 t/ha). The highest yield (12.32 t/ha) was obtained under drip irrigation scheduled at 1.2 IW:CPE ratio (Fig. 3.5.14). In case of garlic, the yield (7.56 t/ha) under drip irrigation and farmers practice (7.75 t/ha) was higher in comparison to check basin irrigation (6.13 t/ha). The highest yield (8.58 t/ha) was obtained under drip irrigation scheduled at 1.0 (CPE-R) followed by drip irrigation scheduled at 0.8 (CPE-R) (Fig. 3.5.14).

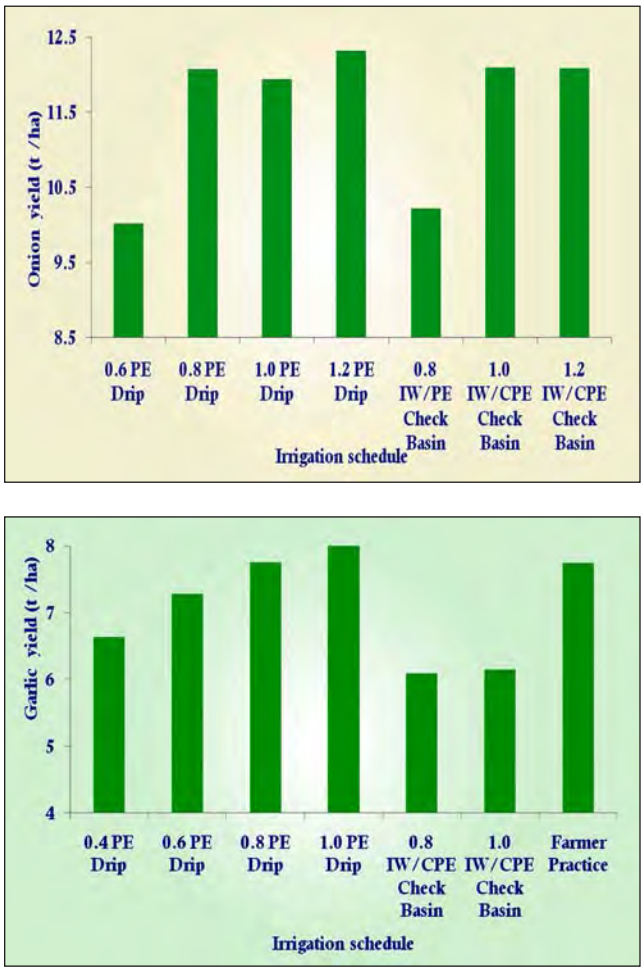


Fig. 3.5.14. Influence of irrigation level on bulb yield and water use of onion and garlic

4. Integrated Pest Management

Research Projects

- Race Pofiling, Variability and Management of Major Plant Pathogens of Hill Crops *[Drs. Rajashekara, H., K.K. Mishra, A.R.N.S. Subbanna, Jeevan B (w.e.f., 11 July 2019) & Ashish Kumar Singh (w.e.f., 11 July 2019)]*
- Biointensive Management of Major Polyphagous Pests of Uttarakhand Hills *[Drs. A.R.N.S. Subbanna, J. Stanley, Rajashekara H & Amit Umesh Paschapur (w.e.f. 11 July 2019)]*
- 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*) *[Drs. K.K. Mishra, P.K. Mishra & V.S. Meena]*

4. Integrated Management of Diseases and Pests of Hill Crops

Crop protection measures play a 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 has been given on the 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

During the months of February and March, surveys were conducted at Naukulia and Jhankat wheat growing areas of Sitarganj, district Udham Singh Nagar. Around 80% area was covered with VL *Gehun* 829, VL *Gehun* 907 and VL *Gehun* 953 and no rust disease was observed. However, symptoms of yellow rust were noticed at Experimental Farm, ICAR-VPKAS, Hawalbag, Almora. The disease was observed up to 20S in few lines in February 2019.

Yellow rust symptoms in wheat crop at Experimental farm, Hawalbag

During February, severe incidence of rust symptoms in garlic was observed at Mukteshwar, Uttarakhand. The symptoms included orange

Field view of rust infested garlic crop

Field view of rust infested garlic crop

coloured pustules on the leaf and leaf sheath. Only uredinial pustules which contain numerous uredospores were observed. These pustules were orange in colour, spherical to ellipsoidal, echinulate and crowded in mass.

The major diseases observed in soybean at Hawalbag and farmers' fields of Almora district were Frogeye Leaf Spot (FLS), bacterial pustules and pod blight (Ct). The first symptom of FLS was observed during August 2019. However, the severity of the disease was increased in September and reached up to 77.7% infection index in some entries. Low to moderate intensity of bacterial pustule (BP) and pod blight (Ct) were observed. Leaf and neck blast diseases of rice were moderate to severe (30-50%) with 5-7 score on 0-9 scale. False smut of rice incidence was severe (>40%). It occurred naturally in all experiments conducted at Experimental farm, Hawalbag as well as in farmers' field. In maize, turcicum leaf blight and maydis leaf blight were moderate. The incidence of banded leaf and sheath blight was moderate in all experiments. The incidence of brown spot caused by *Physoderma maydis* was observed in experimental trials. In finger millet the severity of leaf, neck and finger blast was moderate to severe. In garden pea, very low severity of wilt (2%) was observed. In onion and garlic,

medium to high severity of purple blotch (20-30%) was noticed during the months of March and April. Medium severity (15-20%) of rust was observed in french bean.

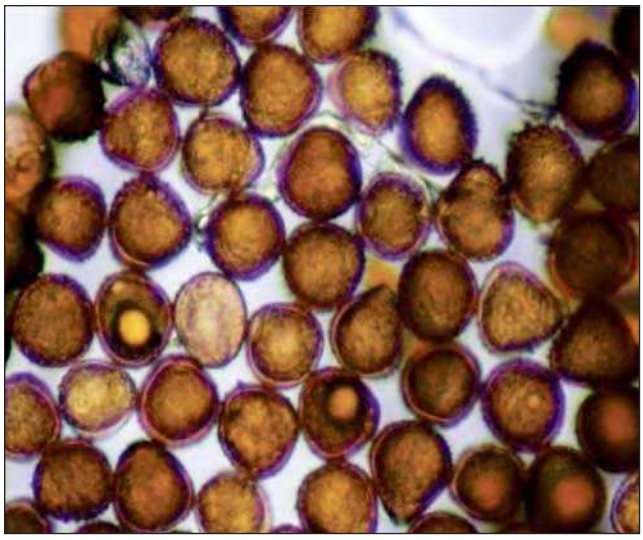
High infestation of aphids in mustard and red pumpkin beetle in cucurbits was observed during March. Medium infestation of pea leaf miner was noticed during March-April. Soybean was infested with bug, *Chauliops choprai* during July-August. In polyhouse, medium infestation of whiteflies in tomato was recorded during May. In capsicum, medium infestation of aphids and high infestation of mites were found during June to August and September, respectively. *Spodoptera* damage was found during July to September in capsicum grown in polyhouses. Low to medium incidence of root-knot nematode in rice, tomato, chilli and brinjal was recorded.

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

Report of Parthenium rust disease

Parthenium (*Parthenium hysterophorus* L.) is an obnoxious and one of the most invasive weed species in India. During February 2019, severe incidence (60-70%) of rust in Parthenium caused by *Puccinia abrupt* var. *partheniicola* was observed at ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Experimental Farm, Hawalbag (29°56'N, 79°40'E, and 1250m MSL), Almora, Uttarakhand. The typical rust symptoms included reddish brown colour pustules on leaf, stem, and subsequently the entire foliage showed burnt appearance and complete

(A) Rust on *Parthenium hysterophorus L.*



(B) Uredospores of *Puccinia abrupt var. partheniicola*

drying (A). Samples were collected and slides were prepared for microscopic spore observation. Only uredospores were observed on the infected weed (B), which were light reddish brown in colour, obovoid to almost triangular, scattered or occasionally crowded in tight circular groups but, without discernible pycnia.

Cross infectivity of Magnaporthe sp. infecting rice and finger millet on different cereal host under artificial inoculation conditions

Pathogenicity assay

The young seedlings of rice (Tetep, VLK 39 and Bala), wheat (VL *Gehun* 907, VL *Gehun* 892, VL *Gehun* 829 and Agra local), barley (BL-2) and finger millet (Udarmallige, VL *Mandua* 324, VL *Mandua* 352 and VL *Mandua* 149) genotypes were inoculated with rice blast isolate LB-VLD 209. The disease reaction was observed five days after inoculation. It was observed that rice, wheat and barley seedlings showed typical blast symptoms and no symptoms were observed in finger millet (Table 4.2.1).

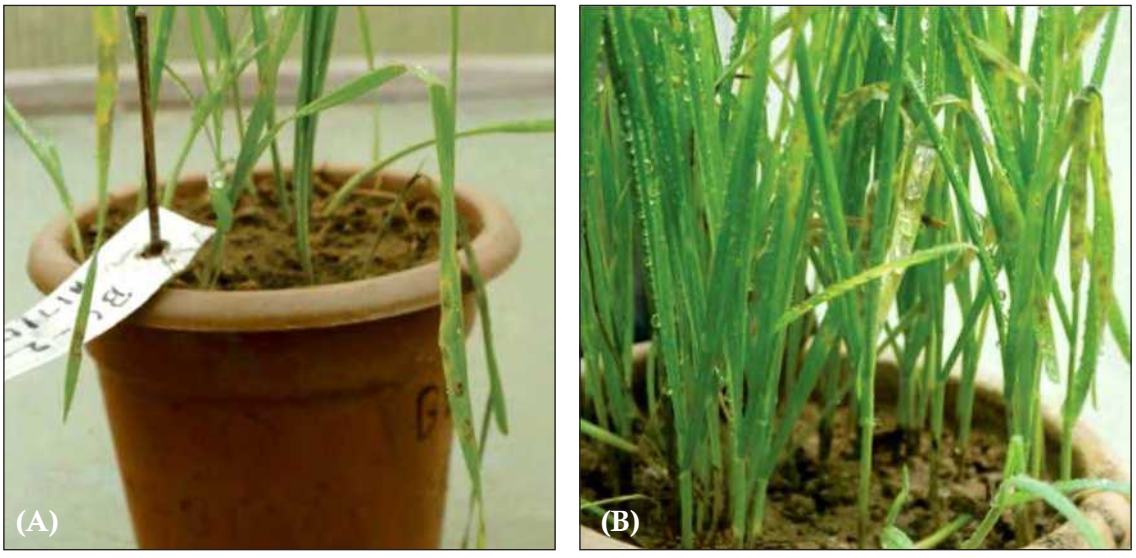
Re-isolation of pathogen and pathogenicity from infected wheat and barley blast samples

Pure cultures of wheat blast and barley blast pathogen were established and inoculated on young seedlings of rice, wheat, barley and finger millet. The disease reactions were observed on seedlings of rice, wheat and barley but no symptoms were observed on finger millet.

Table 4.2.1. Blast pathogen reaction on different cereal host seedlings

Host type	Varieties	Isolates		
		LB-VLD 209	Wheat blast	Barley blast
Rice	Tetep	-	-	-
	Bala	+	+	-
	VLK-39	+	+	+
Wheat	VL *Gehun* 907	+	+	+
	VL *Gehun* 892	+	+	+
	VL *Gehun* 829	+	+	+
	Agra local	+	+	+
Barley	BL-2	+	+	+
Finger millet	Udarmallige	-	-	-
	VL 324	-	-	-
	VL 352	-	-	-
	VL 149	-	-	-

(+) blast symptom development, (-) no blast symptom development



Blast symptoms development on (A) barley seedlings and (B) wheat seedlings

Management of Banded Leaf and Sheath Blight (BLSB) of maize using integrated approaches

Different bioagents and chemical fungicides were tested for management of BLSB in maize. The effect of different treatments on germination, disease reduction, sclerotial development and yield parameters were analyzed. Germination among treatments ranged from 74 to 88%. Seed treatment with commercial bioagent *Pseudomonas fluorescens* (*Pant* Bioagent 2) provided maximum germination (88%), while seed treatment and spraying with bacterial strain (CH83) recorded minimum germination (74%). Plant Disease Index (PDI) ranged from 39.7 to 46.8%. Seed treatment with *Pseudomonas* sp. PCRP7(2) + Spraying @4g/l at the time of disease appearance provided minimum disease index of 39.7 and control recorded maximum disease index of 46.8%. The sclerotial number was also recorded among different treatments. The maximum sclerotial development was observed under soil incorporation of *Trichoderma harzianum* (Tr-28) @10g/kg FYM+spraying @4g/l at the time of disease appearance (11 sclerotia per plant) and least was recorded in seed treatment with Carbendazim @2g/kg+spraying @2g/l at the time of disease appearance (6 sclerotia per plant) (Fig. 4.2.1).

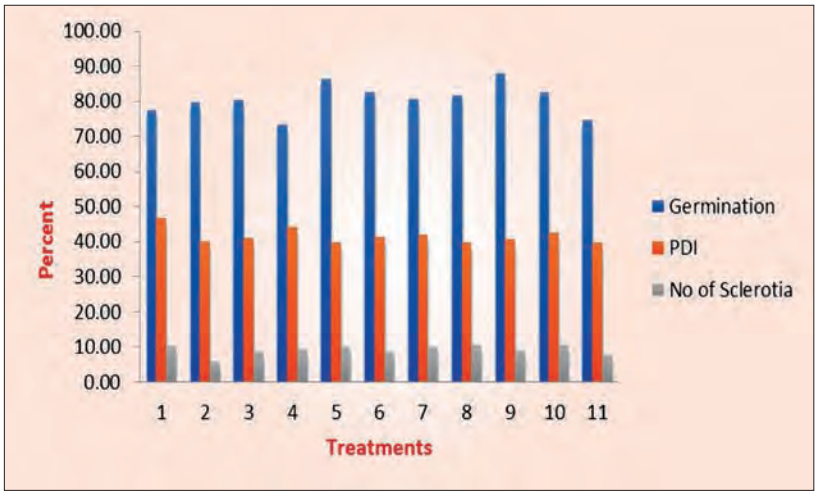


Fig. 4.2.1. Effect of different treatments on banded leaf and sheath blight of maize

T1-Control; **T2** - Soil incorporation of *Trichoderma harzianum* strain (Tr-28) @ 10g/kg FYM + spraying at time of disease appearance @4g/l;**T3**-Seed treatment with *Trichoderma harzianum* strain (Tr-28) @ 10g/kg seed + spraying at the time of disease appearance @4g/l;**T4**-Soil incorporation of *Pseudomonas* sp. PCRP7(2) @10g/kg FYM + spraying at the time of disease appearance @4g/l.;**T5**-Seed treatment with *Pseudomonas* sp. PCRP7(2) @10g/kg spraying @4g/l at the time of disease appearance;**T6**- Soil incorporation of commercial bioagent (Pant bioagent 1) *Trichoderma* sp. @ 10g/kg FYM + spraying at the time of disease appearance @4g/l;**T7**-Seed treatment with (Pant bioagent 1) *Trichoderma* sp. @ 10g/kg seeds + spraying at the time of disease appearance @4g/l; T8-Soil incorporation of (Pant bioagent 2) *Pseudomonas fluorescens* @10g/kg FYM + spraying at the time of disease appearance @4g/l;**T9**-Seed treatment with commercial bioagent (Pant bioagent 2) *Pseudomonas fluorescens* @ 10g/kg seeds + spraying @4g/l at the time of disease appearance;**T10**-seed treatment with carbendazim 2g/kg seed and spray @ 2 g/l at the time of disease appearance with carbendazim; **T11**-seed treatment with and spraying bacterial strain (CH 83).

Identification of resistant sources to rice blast disease

A total of 51 rice genotypes were evaluated for leaf and neck blast resistance under Uniform Blast Nursery (UBN). Based on three replication data, it was found that four (VL 8654, A 57, GSR-125 and GSR-142) and five genotypes (VL 31817, VL 31851, VL 31916, VL 31997 and GSR-132) were highly resistant to leaf and neck blast with 1 score disease severity, respectively. None of the entries showed a highly susceptible reaction for both leaf and neck blast disease (Fig. 4.2.2).

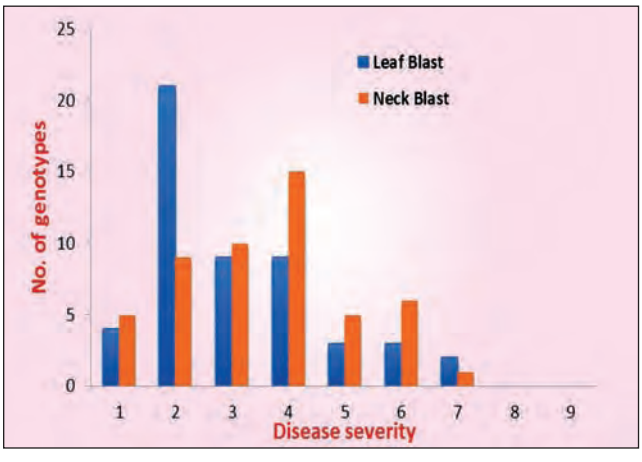


Fig. 4.2.2. Distribution of different rice genotypes based on disease severity for blast disease

Screening of finger millet hill germplasm collections against blast disease

A total of 162 hill germplasm collections of finger millet were evaluated for their spectrum of reaction against the leaf, neck and finger blast diseases under natural field conditions. Based on the disease screening scores, it was observed that none of the germplasms were highly resistant to leaf blast disease; however, 24 germplasms (14.81%) were found moderately resistant. The average disease score varied from 5 to 8 with the mean value of 6.54. The frequency distribution of neck blast and finger blast was 0 to 31.5 and 0 to 32.4, respectively (Fig. 4.2.3). The identified resistant sources include GPU45, VL347, VHC 4171, VHC 4180 and VHC 4200. These entries were highly resistant to neck blast and moderately resistant to leaf blast. The entries, *viz.* GPU45, VRB-MF-859, VRB-MF-1816, VHC 3595, VHC 3607, VL 324 and VL 3796 showed highly resistant reaction to finger blast (<1% incidence).

Incidence of plant parasitic nematodes in major hill crops of Uttarakhand

During *kharif* season, a survey was conducted to assess the plant parasitic nematode incidence

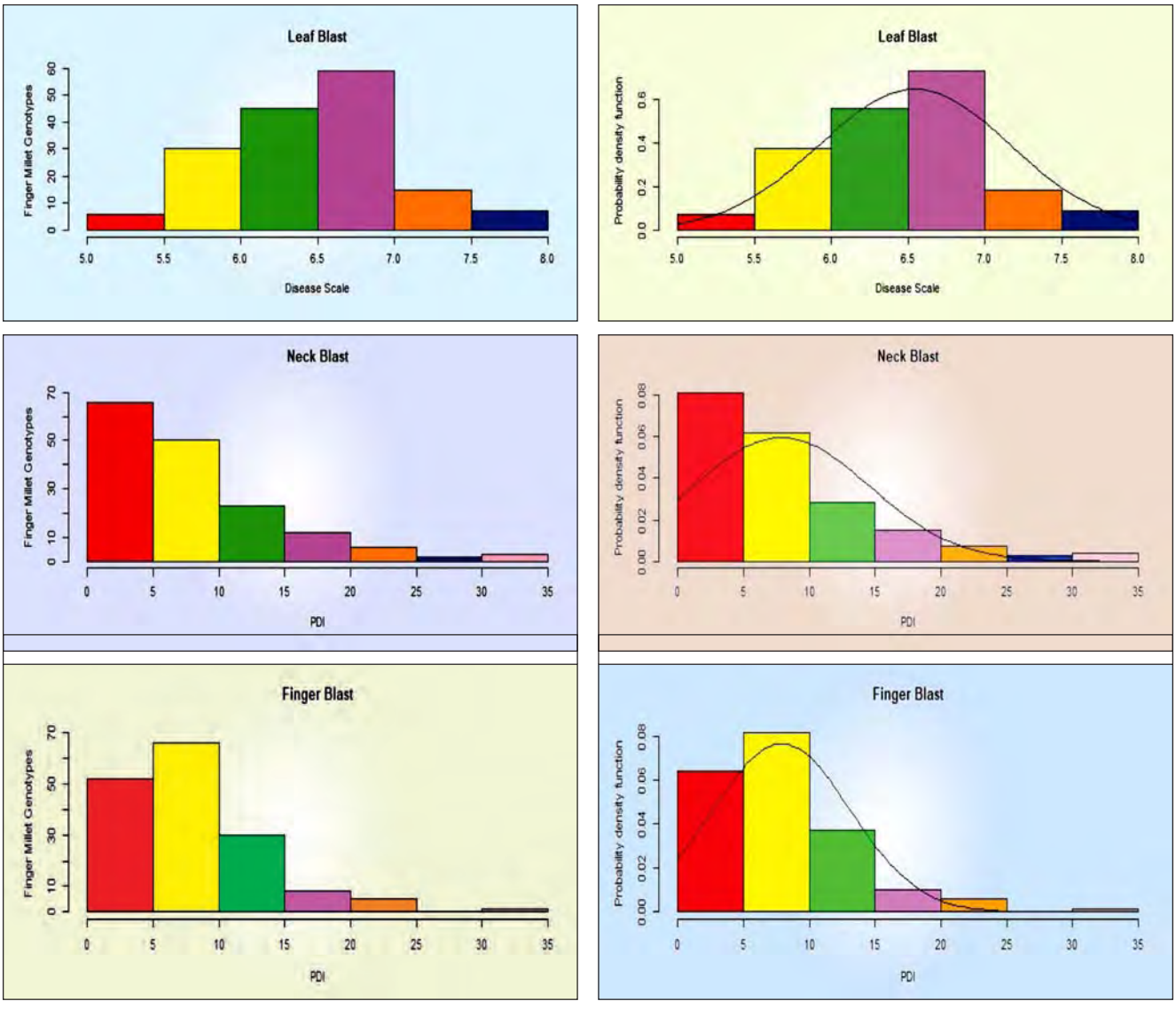


Fig. 4.2.3. Frequency distribution of leaf, neck and finger blast in hill germplasms of finger millet

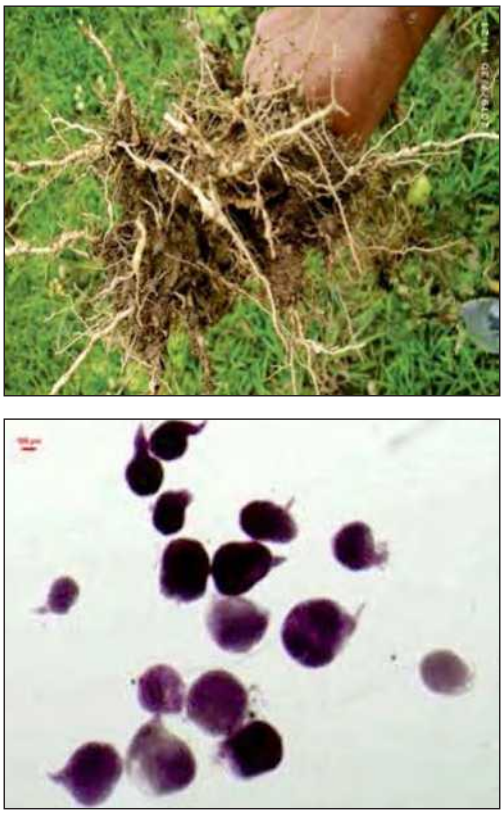
in different districts (Almora, Bageshwar and Nainital) of Uttarakhand. The population of root-knot nematode (RKN) (*Meloidogyne graminicola*) infecting paddy crop was diagnosed. The typical symptoms include hook shaped terminal gall on root, yellowing and stunting on above ground plant parts.

Yellowing and stunting

Hook shaped galls

Microscopic observation of root tip

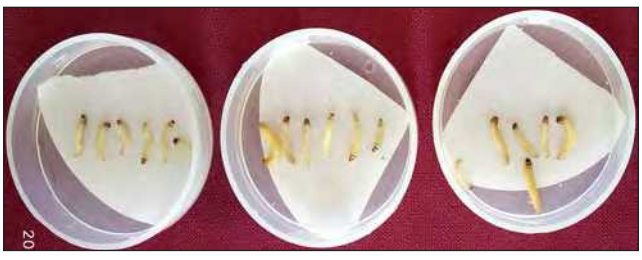
The incidence of RKN was also observed in tomato, chilli and brinjal grown in open field as well as polyhouse conditions. Symptoms include root knots on infected plant, yellowing of the leaves, stunting, wilting and reduced fruit size. Mature female and juveniles (J2) were isolated and characterized using morphological features.



RKN infected tomato plants and isolated matured females

Entomo-pathogenic nematode (EPN) and its pathogenicity test

During *kharif* season, a survey was conducted, and soil samples were collected from orchards, field crops, river sides and forest land from Nainital, Bageshwar and Almora districts of Uttarakhand. The soil samples were subjected to larval baiting technique and infective juveniles of *Steinernema* was isolated and pathogenicity was tested against larvae of *Corcyra* and *Spodoptera*.



Dead cadaver of *Corcyra*

Dead cadaver of *Spodoptera*

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

Light trap catches of different species of whitegrubs

A total of 8,062 beetles were trapped in 10 light traps installed at the experimental farm, Hawalbag during May to October 2019. A maximum of 75.11% of total catch was recorded during June-July. Diversity of the beetles comprised of 33 species, of which 13.09 and 12.12% was of the predominant species, *Anomala* sp., and *A. dimidiata*, respectively. The catches of *A. dimidiata* were found to get decreased over previous years and have become the second species in predominance. Other species, *viz. Hemiserica nasuta*, *Anomala rugosa*, *Aphodius* sp. and *Maladera similana* were 9.08, 8.71, 7.86 and 7.68% of the total catch, respectively. The species composition of light trap catches is given in Fig. 4.3.1.

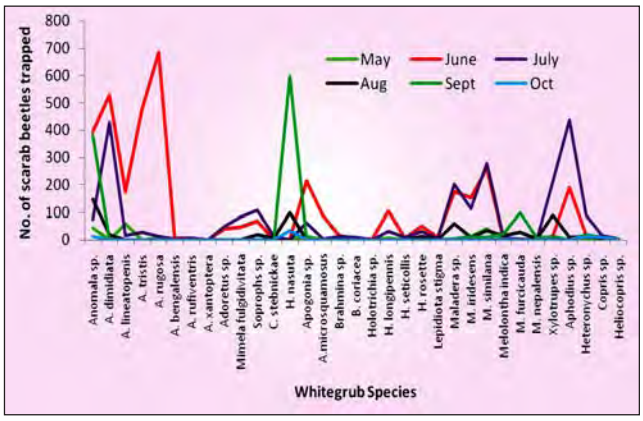
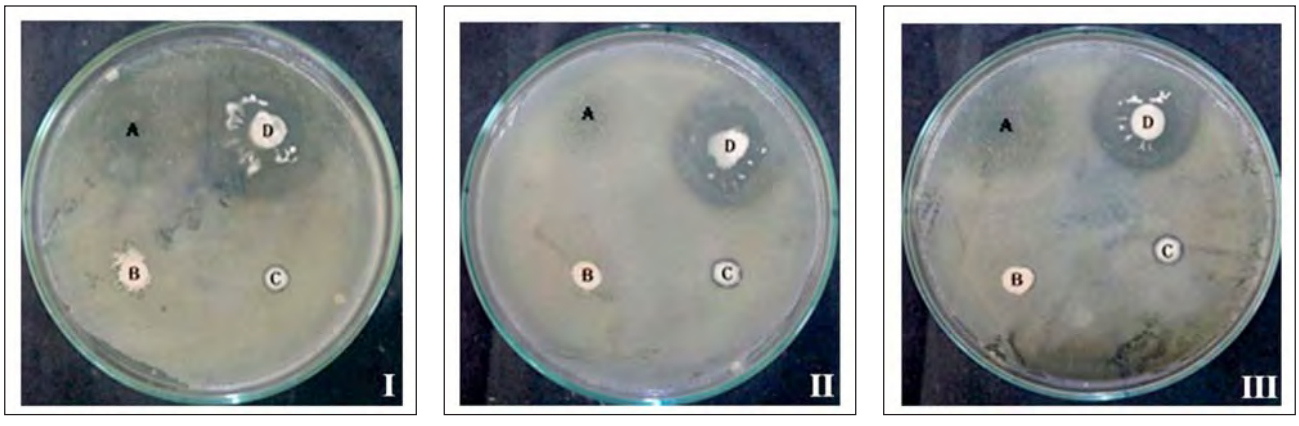


Fig. 4.3.1. Scarab beetle species composition caught in light traps in different months

Compatibility of insecticides with potent B. thuringiensis isolates

A simple, effective and rapid *in-vitro* methodology for qualitative identification of compatibility of chemical pesticides with entomopathogenic bacteria was standardized. In this method the insecticide solution is placed as drop on a culture plate which is already inoculated (using L spreader) with bacteria suspension (10^6cfu/ml). After incubation for required time, the inhibition in the growth of bacteria in and around the pesticide spot signifies their compatibility. Using this plate assay compatibility of selected insecticides with four potent *B. thuringiensis* (VLBt27, VLBt38, VLBt109 and VLBt135) isolates was done. The results on the compatibility of insecticides at both commercial and recommended doses are presented in table 4.3.1. With an exception of nimbecidine and spinosad, all the tested insecticides were found to be toxic to *B. thuringiensis* isolates. All the tested insecticides showed very clear halo with no growth of bacteria around the insecticide spot, except cartap hydrochloride, where partial growth of bacterium was observed within halo. The formulations of organophosphate insecticides, profenophos and chlorpyriphos were found highly toxic with more than 3 mm halo. However, profenophos was found to be safe in its recommended dose whereas, chlorpyriphos showed no growth of bacterium within the spot. Remaining all the insecticides were found to be safe in their recommended doses. With respect to *B. thuringiensis* isolates, VLBt27 showed exceptional compatibility with chlorpyriphos at its recommended dose where all other isolates failed.



Compatibility of VLBt27 (I), VLBt38 (II) and VLBt109 (III) with commercial formulations of cartap hydrochloride (A), nimbicidine (B) indoxacarb (C) and profenophos (D)

Table. 4.3.1. *In vitro* compatibility of insecticides with potent *B. thuringiensis* isolates

Insecticide/Formulation	Group	Recommended dose		VLBt27		VLBt38		VLBt109		VLBt135	
		(g or ml/l)	Conc (%)	F	R	F	R	F	R	F	R
Cartap Hydrochloride 50SP	Thiocarbamates	1	0.050	--	+	--	+	--	+	--	+
Spinosad 45SC	Bacteria origin	0.4	0.018	+	+	+	+	+	+	+	+
Indoxacarb 14.5 SC	Oxadiazine	1	0.015	-	+	-	+	-	+	-	+
Acetamiprid 20SP	Neonicotinoid	0.3	0.006	--	+	--	+	-	+	-	+
Thiomethoxam 25WG	Neonicotinoid	0.5	0.013	--	+	--	+	-	+	--	+
Imidacloprid 17.8 SL	Neonicotinoid	0.3	0.005	-	+	-	+	-	+	-	+
Chlorpyriphos 20EC	Organophosphates	2	0.040	---	+	---	-	--	-	---	-
Profenophos 50EC	Organophosphates	2	0.100	---	+	---	+	---	+	---	+
Nimbecidine 0.03	Limonoids	3	0.0001	+	+	+	+	+	+	+	+

R: Recommended dose; F: formulation; -: Less than 1 mm halo around; -- halo between 1 to 3 mm ; ---: More than 3 mm halo; +: No halo and bacterial growth observed inside the insecticide spot

Protein electrophoresis and identification of chitinases from potent B. thuringiensis isolates

An outgel assay after native polyacrylamide gel electrophoresis (PAGE) is standardized for identification of molecular masses of chitinases from crude protein samples or culture supernatant proteins from any entomopathogen and for that matter any enzyme with soluble or colloidal substrate. Crude extracellular supernatant proteins from chitin detection media of four potent isolates (VLBt27, VLBt38, VLBt109 and VLBt135) were fractionated by electrophoresis under non-denaturing conditions (Fig.4.3.2.). The major protein bands observed were around 130, 110, 92, 70 and 40 kDa. The protein banding patterns were almost similar with a difference of around 5-10 kDa between the isolates. The out-gel identification of chitinases using substrate gel showed chitinase activity at around 130 kDa in all the four tested isolates. To the best of our knowledge no previous study reported this high molecular weight chitinases in *B. thuringiensis* and thus unique. Our previous studies on chitinolytic *Bacillus* species native to Uttarakhand Himalayas also showed existence of this high molecular weight chitinases.

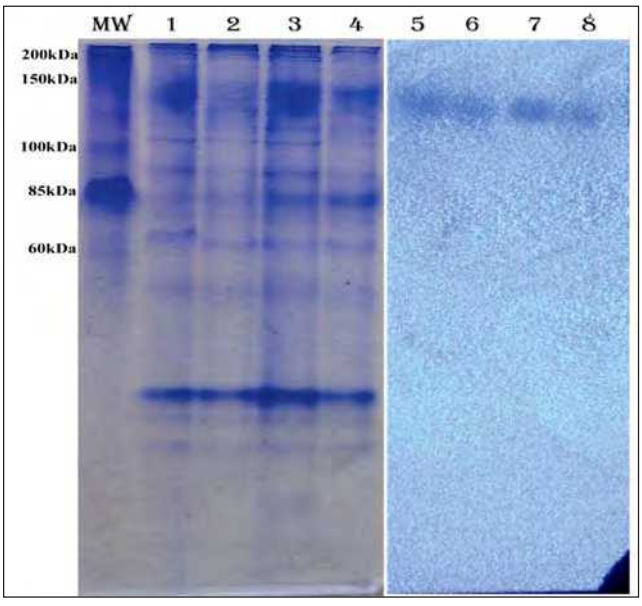
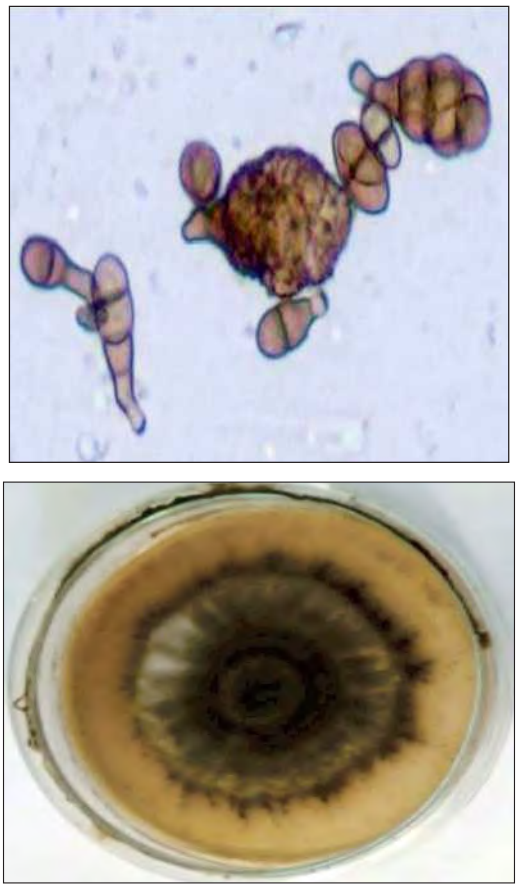


Fig. 4.3.2. PAGE analysis of culture supernatant proteins and identification of chitinases from potent *B. thuringiensis* isolates (MW, Molecular weight marker, Lanes 1 to 4: CHD culture supernatant proteins from *B. thuringiensis* isolates VLBt27, VLBt38, VLBt109 and VLBt135, Lanes 5-6: substrate gel showing enzyme activity of *B. thuringiensis* isolates VLBt27, VLBt38, VLBt109 and VLBt135).

Efficacy of novel entomopathogenic fungi (Alternaria alternata) against major insect pests

Isolation and identification of the fungi

An entomopathogenic fungi, was isolated from the infected insect cadavers of greenhouse whitefly (*Trialeurodes vaporariorum*) infecting ornamental plant *Salvia divinorum* from experimental farm, Hawalbag. The spore and colony characters showed that the fungi belonged to *Alternaria* sp. and molecular characterization (ITS sequences) confirmed that the fungi was *Alternaria alternata* and the sequence was submitted to NCBI gene bank with accession number MN704636 *Alternaria alternata* strain VLH1



Spores and colony characters of *A. alternata* strain VLH1

Acute toxicity test and calculation of lethal concentrations of entomopathogenic fungus, A. alternata strain VLH1

Laboratory bioassays were carried out against 12 insect pests, which showed varying degrees of reaction to fungal infection. Median lethal concentrations were calculated (Table 4.3.2) manually against five sucking pests, *viz.* greenhouse whitefly (nymphs and adults), cabbage aphid

(*Brevicoryne brassicae*), green peach aphid (*Myzus persicae*), soybean seed bug (*Chauliops choprai*) and pulse aphid (*Aphis craccivora*). Lepidopteran larvae showed varying degrees of reaction to fungal infection like cessation in feeding, delayed mortality and adult deformation.

The results showed that LC_{50} values for all the insects ranged between 10^4 to 10^6 spores/ml. LC_{50} for green peach aphid (*Myzus persicae*) was as low as $4.8x10^4$ spores/ml, whereas, soybean seed bug (*Chauliops choprai*) recorded the highest LC_{50} concentration of $2.5x10^6$ spores/ml.

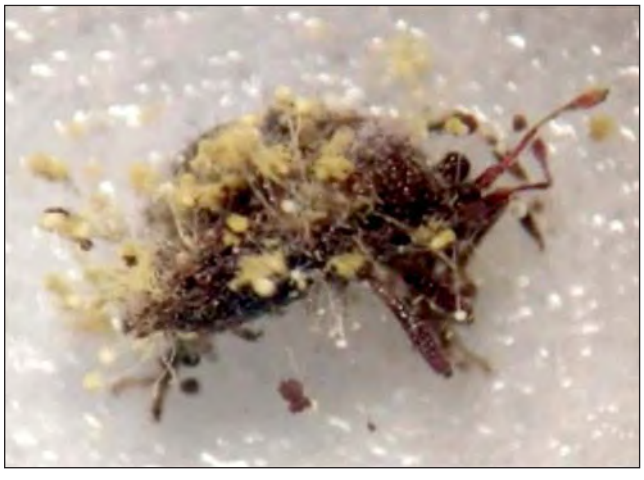
Table 4.3.2. Median lethal concentrations against major insect pests

Insect species	Linear equation (Y=ax+c)	LC_{50} (Spores/ml)	LC_{90} (Spores/ml)	χ^2 value
Brevicoryne brassicae	Y=0.31x+3.37	$1.2x10^5$	$1.3x10^9$	0.88
Trialeurodes vaporariorum (Adults)	Y=0.48x+3.01	$1.4x10^5$	$6.4x10^9$	0.96
Trialeurodes vaporariorum (Nymphs)	Y=0.18x+3.72	$1.3x10^6$	$1.7x10^{12}$	0.98
Myzus persicae	Y=0.47x+3.27	$4.8x10^4$	$2.5x10^6$	0.94
Aphis craccivora	Y=0.42x+3.35	$8.5x10^4$	$9.6x10^6$	0.97
Chauliops choprai	Y=0.3x+3.38	$2.5x10^6$	$4.6x10^{11}$	0.98

Infected adult of *Trialeurodes* sp.

Infected *Brevicoryne brassicae*

Infected *Myzus persicae*



Infected *Chauliops choprai*

Infected *Pieris brassicae* larvae

Pupal and adult deformation in *H. armigera*

Pathogenicity symptoms of *A. alternata* strain VLH1

4.4. Studies on Physico-Chemical Properties of Compost and Casing Soil in Relation to Fructification and Yield of White Button Mushroom (*Agaricus bisporus*)

Evaluation of siderophore producing Pseudomonas strains on yield of Macrocybe gigantea

A total of 12 siderophore producing Pseudomonad were applied at the time of casing along with untreated check. Out of these, casing application of strain NARs9, NPRs3, NARs1 resulted in 116.1, 54.6 and 46.4% higher yield of *Macrocybe* in comparison to untreated control, respectively (Fig. 4.4.1).

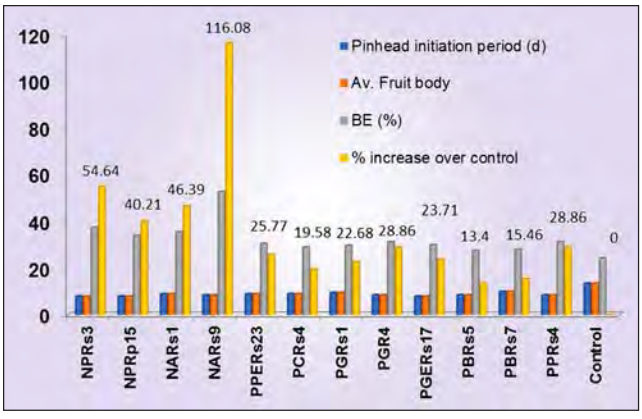


Fig. 4.4.1. Effect of siderophore producing *Psudomonas* strains on yield of *M. gigantea*

experimental farm, Hawalbag, was demonstrated at farmers' field by applying in casing soil for enhanced yield of *Macrocybe gigantea*. The strain was applied in 20 bags (4 kg wet substrate) at the time of casing soil application. The average yield obtained was 850 g per bag (85% biological efficiency).

Crop of *M. gigantea* at farmers' field

Evaluation of siderophore producing Pseudomonas sp. *NARs9 on yield of Macrocybe gigantea at farmers' field*

The promising *Pseudomonas* sp. NARs9, which gave 52.4% biological efficiency (116% increased yield over control) in experimental trials conducted at

Evaluation of siderophore producing Pseudomonas strains on yield of Agaricus bisporus

Twelve different siderophore producing *Pseudomonas* strains were tested for enhanced yield of *A. bisporus*. The average yield of *A. bisporus* was found to be

positively correlated with application of siderophore producing strains except for strain *P. putida* PBRs5. The casing incorporation of strains *Pseudomonas* PPERs23, PGRs1 and NARs1 gave 39.6, 36.9 and 36.4% higher yield as compared to uninoculated control (Fig. 4.4.2).

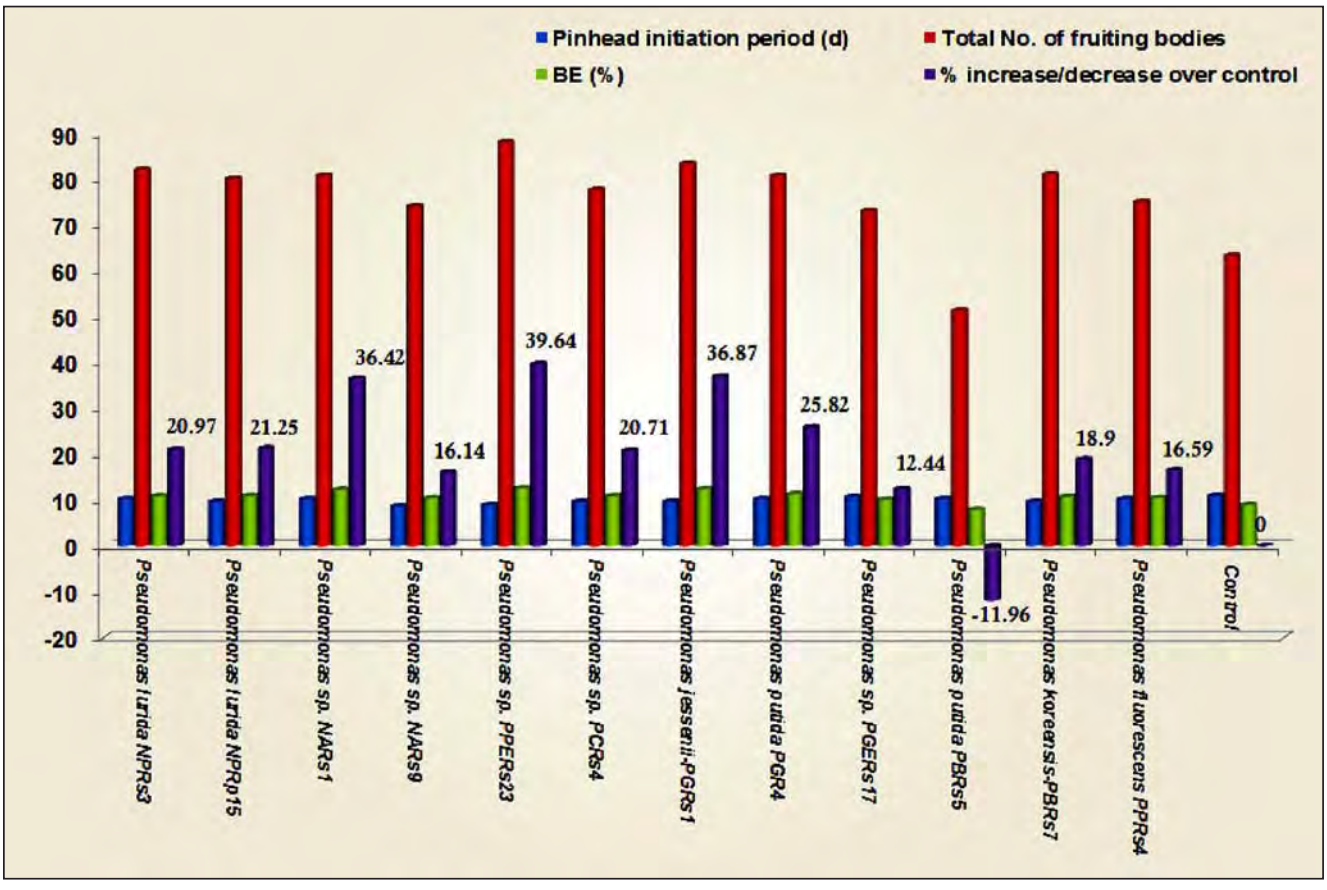


Fig. 4.4.2. Effect of siderophore producing *Pseudomonas* strains on yield of *A. bisporus*

5. Socio-Economic Studies, Transfer of Technology and Information Technology

Research Projects

- Socio-Economic Issues of Hill Farming and Extension Methods *[Drs. Nirmal Chandra, Kushagra Joshi, Ankita Kandpal (up to December 27, 2019) & Sushil Kumar (up to August 23, 2019)]*
- Impact of Constrained and Unconstrained Choices on Adoption of Improved Agricultural Practices by Farmers *[Drs. Renu Jethi, Kushagra Joshi & Ankita Kandpal (up to December 27, 2019)]*
- Technological Interventions for Mitigating Drudgery and Improving Nutritional Status of Hill Farmwomen *[Drs. Kushagra Joshi, Renu Jethi, Nirmal Chandra & Sushil Kumar (up to August 23, 2019)]*

5. Socio-Economic Studies, Transfer of Technology and Information Technology

Socio-Economic survey and analysis are important aspects 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 agro-technologies.

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

Impact of mobile SMS advisory service in uptake of agriculture extension information: a case study in valley area of Almora district

The widespread use of mobile phones in rural areas, offer new possibilities for introducing new ICT based approaches for uptake of agricultural extension information.

In the present study, ex-post-facto research design was followed. Basulisera and Binta villages in Dwarahat block of Almora district were selected for providing advisory on rice disease, as the farmers in this area follow rice-wheat cropping sequence. A group of 100 farmers were selected randomly (50 from each village) owning mobile phones. Benchmark data were collected on socio-personal and economic aspects. Selected farmers were trained in identification of crop diseases in rice. Advisories were sent through mKisan SMS portal regularly for two years and farmer's queries were responded.

Field training provided to the farmers

Identification of crop diseases

It was found that farmers were very selective in choosing the ICT. In general, TV, radio and video were used for awareness creation and transfer of technology. Mobile phones were found most suitable for collecting and disseminating advisory and market information.

Information Needs Assessment of Farmers: The farmers were asked to rank the areas based on the urgency of need for information. It was found that seeds/planting materials, credit facilities and manure/fertilizer used were the areas, where more information was needed (Table 5.1.1).

Table 5.1.1. Information Needs Assessment of Farmers (N=80)

Aspects on which information needed	Frequency	Percentage
Seeds and planting materials	78.0	97.5
Credit facilities	77.0	96.3
Manure and fertilizer use	74.0	92.5
Grain Storage	71.0	88.8
Intercultural operations	68.0	85.0
Weather information	66.0	82.5
Market information	64.0	80.0
Diseases and pest control	60.0	75.0
Soil and water conservation	50.0	62.5

Perceived role of ICT in development of various areas of agriculture

Ten possible roles that the ICT can play in the area of agriculture were presented and farmers were asked to rank each role in a four-point continuum of Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD). According to the farmers

of the area, the most important roles played by use of ICT were ranked as monitoring of pest/diseases outbreak (I); provides information on agricultural inputs (II), helps increase productivity of farmers (III) and reduces social isolation (IV).

Effectiveness of mKisan SMS advisory services in addressing the information need of the stakeholders

mKisan SMS advisory service was provided to the selected group of farmers for a period of three years and thereafter effectiveness of the ICT project (Table 5.1.2) was estimated as per the following formula –

$$\text{Effectiveness} = \frac{T1xW1+Q1xW2+U1xW3+SFxW4+EUxW5}{W1+W2+W3+W4+W5} X\ 100$$

Where, TI=Timeliness of information; QI=Quality of information; UI=Utility of information; SF=Satisfaction of farmers; EU= Ease of understanding; W_i are respective weight as per mean of experts rating to the above components.

Table 5.1.2. Overall Effectiveness of mKisan SMS Advisory Services

Category of effectiveness	Class Score	f	%
Very low	63.06 - 66.62	4	5.00
Low	66.62 - 70.16	8	10.00
Medium	70.16 - 73.72	17	21.25
High	73.72 - 77.27	33	41.25
Very high	77.27 - 80.82	18	22.50
Mean	73.97 (High)		
Standard Deviation	3.47		

f-frequency

The aspects which were considered for estimating the overall impact of the project are (i) satisfaction with the services provided by the project, trainings provided in identification of disease and use of mobile phone, technical support, the quality of the information, and the service and the cost of the service (ii) awareness created among the users on the potential use of ICTs (iii) empowerment of the users in terms of increase in skills, social status, self-confidence and influence on decision-making and (iv) economic impact in terms of increased income levels of users. The overall impact of the project was maximally reflected with the level of satisfaction (82%) followed by awareness created among the users for the potential use of ICTs (60%) (Fig. 5.1.1).

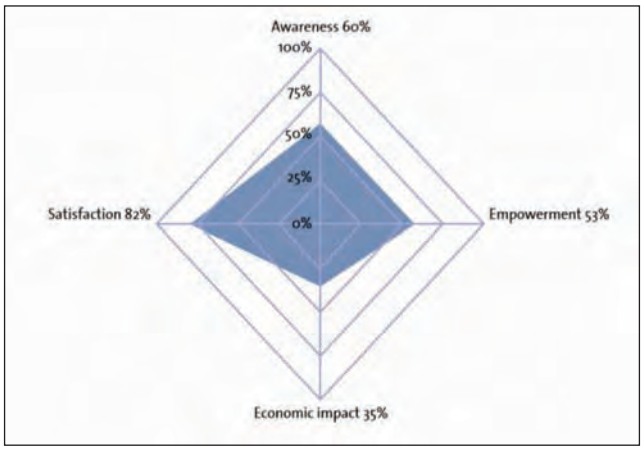


Fig. 5.1.1. Impact of project on satisfaction level of farmers

Study of the vegetable value chain in Nainital district of Uttarakhand

Four blocks (Ramgarh, Dhari, Bhimtal and Okhalkanda) of Nainital district were selected for SWOT analysis of vegetable production in hill areas.

Existing vegetable marketing channels

The major marketing channels operating in the selected blocks were

Channel I: Producer—Consumer

Channel II: Producer—Retailer—Consumer

Strength (S)	Weakness (W)
1. Vegetable farming in hill areas is profitable as off-season cultivation is possible 2. Organic vegetable farming is more profitable than conventional farming 3. Better employment opportunities	1. Lack of appropriate crop varieties 2. Poor quality seeds 3. High margins retained by middlemen
Opportunity (O)	**Threat (T)**
1. Shifting from subsistence to commercial vegetable production 2. Conventional vegetable farming can be transformed to organic vegetable farming	1. More incidences of disease and pest and high use of pesticides leading to high production cost 2. Fluctuation in market prices of inputs and vegetable produce

Channel III: Producer—Wholesaler/Commission agent (local market)—Retailer—Consumer

Channel IV: Producer—Commission agent—Wholesaler (distant market)—Retailer— Consumer

The most expensive channel was IV followed by III, II and I. However, maximum business of about 80% was being done through channel-III (Fig. 5.1.2).

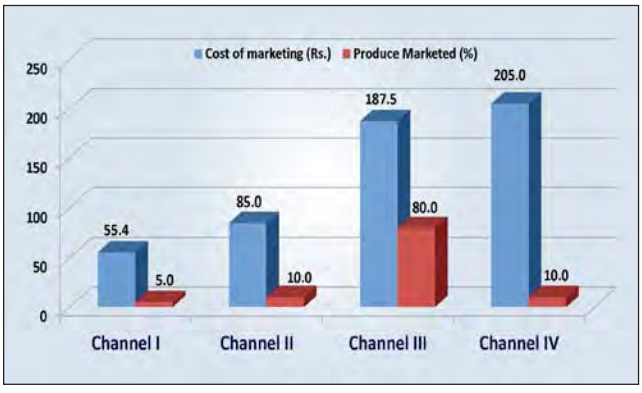


Fig. 5.1.2. Cost of marketing and produce sold through various marketing channels (Tomato)

Seasonal variations in arrival and market price of vegetables

Seasonality is the phenomenon that causes crop prices to behave in a relatively predictable manner, year in and year out. Seasonality index for pea and tomato for their arrival and prices was worked out.

In case of pea, market arrival is the highest in April and lowest between June to September whereas its market prices are highest in November and lowest during July-September. For tomato, peak season for arrival and price is December & January and July-August, respectively and slack season is May-October and December (Fig. 5.1.3).

Similarly, for potato and cabbage, the peak arrival was in March and October while lowest arrival was observed in September and May, respectively. In potato, peak prices were attained in August and lowest price were observed in February. In cabbage, highest price was observed in August and lowest price month was February.

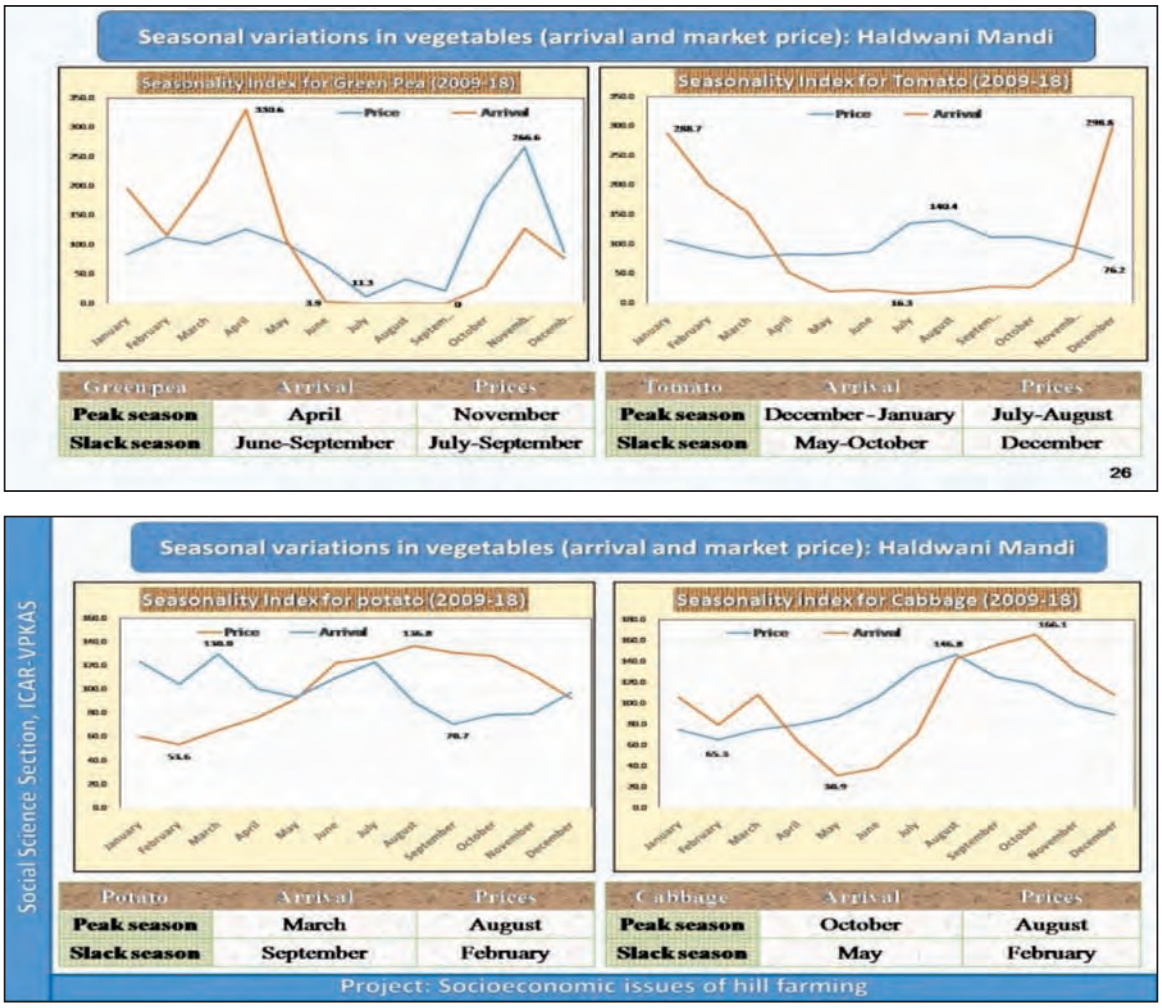


Fig. 5.1.3. Seasonal variations in arrival and market price of vegetables

5.2. Impact of Constrained and Unconstrained Choices on Adoption of Improved Agricultural Practices by Farmers

Extent of adoption of recommended agricultural practices in finger millet cropping system

Samples were selected from two types of village areas with distance of 40 km in between to estimate the extent of adoption of recommended agricultural practices in finger millet based cropping system. From area I (Malgalta village, Almora) those farmers were selected who are exposed to some technological interventions related to finger millet, whereas in area II (Kiroli village, Pithoragarh) those farmers were selected, who had not received any intervention. Finger millet and lentil crops were selected for both the areas. Random sampling technique were employed to select a total of 70 sample farmers with 35 farmers from each area during 2018-19.

Constrained Choices: Farmers choice for recommended agricultural practices under different socioeconomic, technological and other constraints.

Un-constrained Choices: farmers choices for recommended agricultural practices in absence of constraints/or in the situation where these constraints are addressed.

Therefore, an effort was made to study their present actual farming practices (constrained choices) and their choice to adopt improved practices if these constraints are addressed (unconstrained choices).

Extent of adoption of recommended agricultural practices in lentil crop under constrained condition

Adoption was estimated on three-point continuum, *viz*. full, partial and nil with numerical score of 3, 2 and 1, respectively for extent of adoption of each technology. For each respondent, a total score was obtained by adding the numerical scores of technology adoption. Finally, the total score of each respondent was used for calculating the adoption index.

$$\text{Adoption Index} = \frac{\text{Respondent's Score}}{\text{Total Possible Score}} \times 100$$

The obtained final score was categorized into three groups namely, 'Low', 'Medium' and 'High', considering the mean and standard deviation.

It could be inferred that 26% farmers of area I and only 3% farmers of area II had high adoption. Technology intervention resulted in higher adoption of recommended agricultural practices in lentil (Fig. 5.2.1).

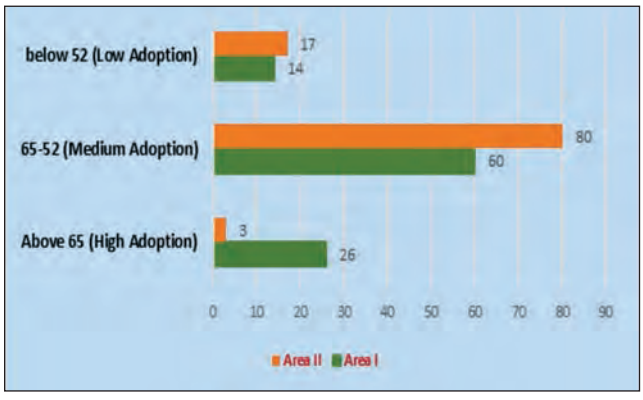


Fig 5.2.1. Adoption level of recommended agricultural practices in lentil crop

Farmers' constrained and unconstrained choices of recommended agricultural practices in lentil crop

This study compares the differences between choices made by farmers under unconstrained condition and farmers actual (constrained) practices and attempts to identify the source of differences in both

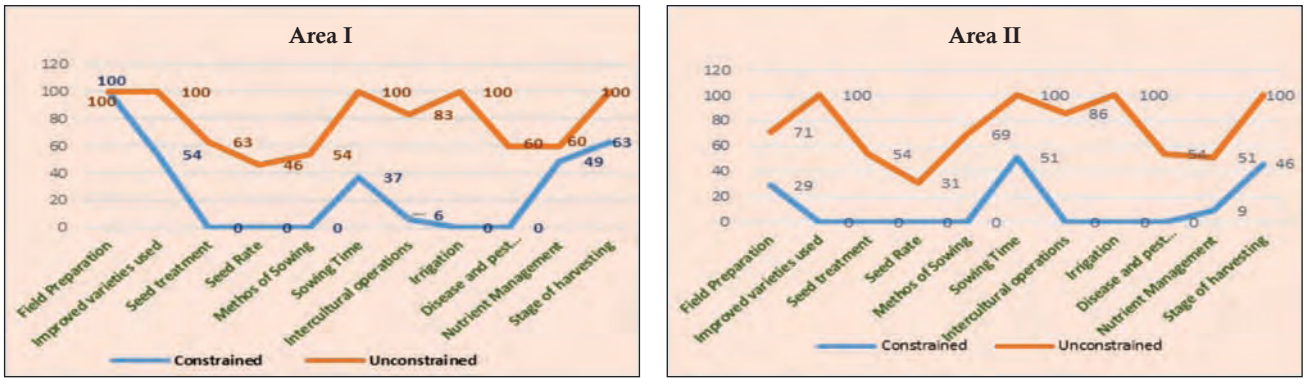


Fig 5.2.2. Farmers' choices of recommended agricultural practices in lentil under constrained and unconstrained conditions

types of areas selected (Fig. 5.2.2). Farmers in area I were following recommended agricultural practices in field preparation (100%), improved varieties (54%), sowing time (37%), intercultural operations (6%), nutrient management (49%) and stage of harvesting (63%) under constrained condition. In area II, in the absence of any intervention, farmers were following recommended agricultural practices in field preparation (29%), sowing time (51%), nutrient management (9%) and stage of harvesting (46%) under constrained condition. None of the respondents from both the areas were following seed treatment, recommended seed rate, method of sowing, irrigation and disease & pest management.

In unconstrained condition, almost all farmers chose to use improved varieties, right sowing time, proper irrigation and right stage of harvesting. The data showed that in case of seed treatment, seed rate, method of sowing, disease and pest management still some farmers are hesitant to adopt recommended agricultural practices in both the area I and area II.

Adoption level of recommended agricultural practices in finger millet crop under constrained condition

It could be inferred that 37 and 63% farmers of area I had high and medium level of adoption, respectively, whereas 91% farmers of area II had medium level of adoption of recommended agricultural practices in finger millet crop (Fig. 5.2.3).

Farmers' constrained and unconstrained choices of recommended agricultural practices in finger millet crop

Farmers in area I were following recommended agricultural practices like improved varieties (91%), seed rate (11%), method of sowing (49%), thinning

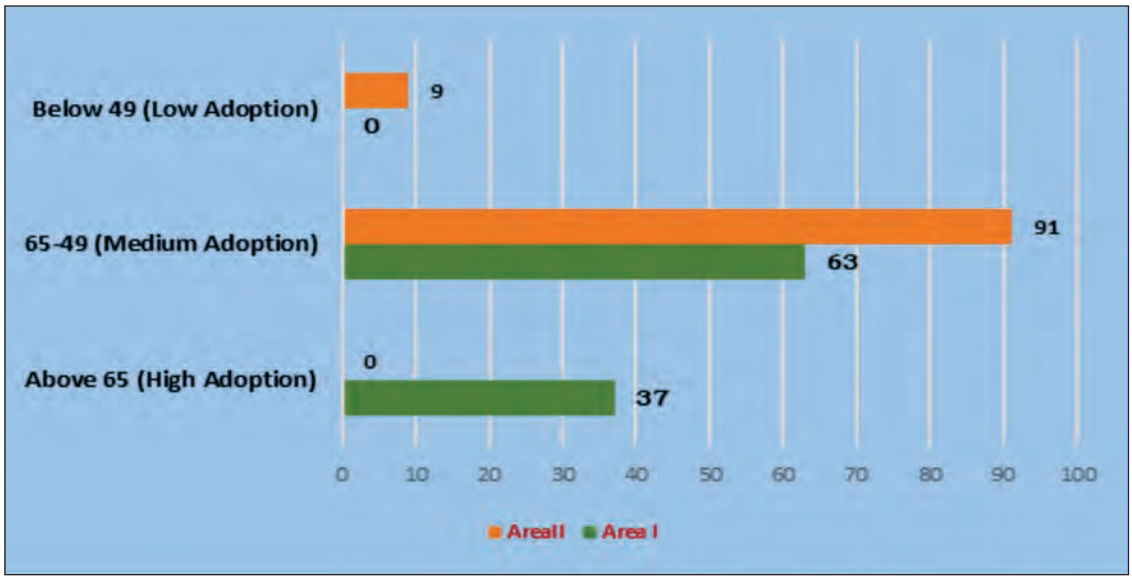
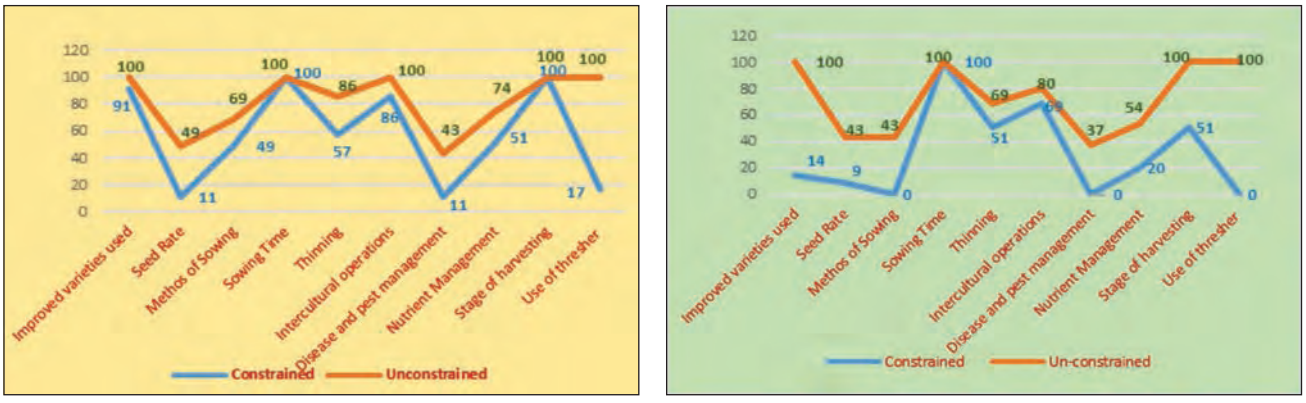


Fig 5.2.3. Adoption level of recommended agricultural practices in finger millet



Area I **Area II**

Fig 5.2.4. Farmers' choices of recommended agricultural practices in finger millet under constrained and unconstrained conditions

(57%), intercultural operations (86%), disease and pest management (11%), nutrient management (51%) and use of thresher (17%) under constrained condition. In area II in the absence of any intervention farmer were following recommended agricultural practices like improved varieties (14%), seed rate (9%), sowing time (100%), thinning (51%), intercultural operations (69%) and nutrient management (20%) (Fig. 5.2.4).

It was found that in the absence of constraints; almost all farmers chose to use improved varieties, right sowing time, intercultural operations, right stage of harvesting and use of thresher. The data showed that some farmers are still hesitant to adopt the recommended agricultural practices for seed rate, method of sowing, thinning, disease and pest management and nutrient management.

Demonstration of improved agricultural technology in finger millet and its impact on farmers choices

During *kharif* 2019, demonstrations were conducted to study the impact on farmers choices of recommended agricultural practices in finger millet. In area II, interventions introduced in the form of improved finger millet variety VL *mandua* 352 and line sowing as an improved method of sowing.

Data in table 5.2.1 revelaed that there was increase in number of farmers who chose to adopt improved agricultural practices like improved varieties, seed rate, thinning, intercultural operations and stage of harvesting. Only 29% farmers adopted line sowing as mixed cropping of finger millet with pulses like horse gram and black gram is prevalent in the area. There were no signs of major diseases in finger millet in the area during *kharif* 2019.

Table 5.2.1. Farmers constrained choices for improved agricultural practices before and after intervention

Farmers' constrained choices	Before intervention (% farmers followed improved practices)	After intervention (% farmers followed improved practices)
Improved varieties	14	100
Seed rate	9	51
Method of sowing	0	29
Thinning	51	60
Intercultural operations	68	80
Disease management	0	0
Nutrient management	20	40
Stage of harvesting	51	63


Mixed cropping in finger millet


Demonstration plots at farmers' field with improved practices in finger millet

5.3. Technological Interventions for Mitigating Drudgery and Improving Nutritional Status of Hill Farm Women

Drudgery for cultivation of wheat, finger millet and paddy under finger millet based cropping system (finger millet-wheat-finger millet) and paddy based cropping system (paddy-wheat-paddy) was studied. Data was collected from farm women of villages practising finger millet cultivation at Tunakot, Tipola in Tarikhet block, Daal and Kafun in Hawalbag block and Patiya and Kotyura in Takula block in Almora district. Data for paddy cultivation was collected from Binta-Basulisera villages of Dwarahat block.

Assessment of drudgery and women's workload

Drudgery involved in paddy cultivation was derived based on certain parameters, namely physical load, time spent, exertion, musculo-skeletal discomfort and posture involved. Focused group discussions were held with farm women. On the basis of their responses, weightage was assigned to the variables. The drudgery scores derived for various activities in paddy cultivation indicate highest drudgery for transplanting activity closely followed by weeding, harvesting and uprooting tasks (Fig. 5.3.1).

Uprooting task of rice seedlings

Transplanting of rice seedlings

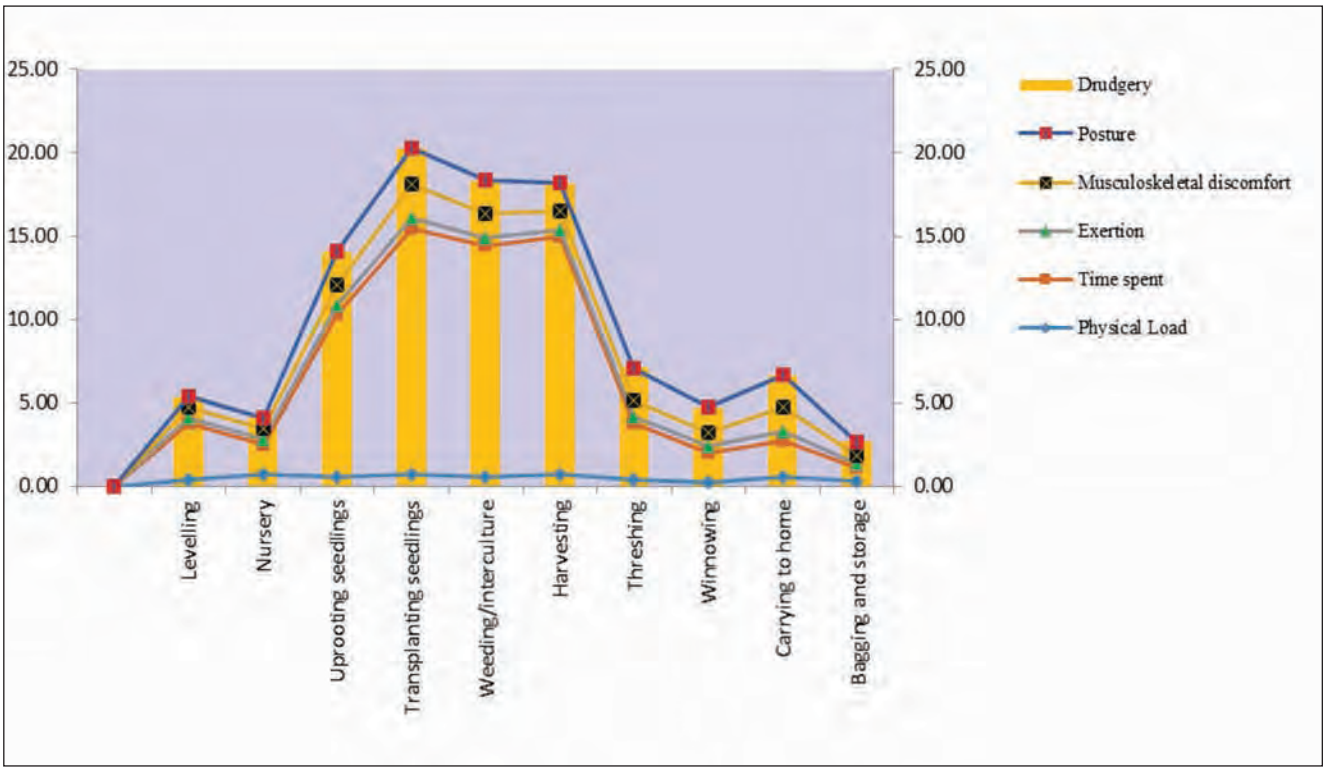


Fig 5.3.1. Drudgery scores of various activities in paddy cultivation

Energy expenditure rate of farm women practising various activities in paddy cultivation was assessed. Transplanting can be categorised as heavy activity (energy expenditure rate: 10.55 kJ/min), uprooting seedlings (energy expenditure rate: 9.91 kJ/min) and manual weeding (energy expenditure rate: 8.73 kJ/min) were found as moderately heavy activities (Table 5.3.1). This corroborates with drudgery index for these activities.

Participatory evaluation of technologies for drudgery reduction among farm women

For wheat harvesting, improved VL Sickle with small bent and wide bent were tested for their feasibility and drudgery reduction over local sickle. Sickle wide bent and local sickle were almost at par in area covered and energy expenditure rate. VL Sickle with small bent performed better in terms of area covered (10.40% more) and energy expenditure rate (22.69% less) in comparison to local sickle (Fig. 5.3.2).

Participatory evaluation of VL Line Maker for line sowing in finger millet

Use of VL Line Maker for line sowing of finger millet was demonstrated for participatory testing among farm women. Use of VL Line Maker decreased the Body Part Discomfort by 60%. With VL Line Maker, more area was covered (59.63 m^2 in 15 minutes) in comparison to local *Kutla* (43.16 m^2) (Fig. 5.3.3).

Table 5.3.1. Ergonomic evaluation of sub activities in paddy cultivation

Activity	Heart Rate Working (beats/min)	Energy Expenditure (kJ/min)	Overall Discomfort Rating
Uprooting seedlings (squatting)	117.2	9.91	5.2
Transplanting	121.20	10.55	6.3
Manual weeding (squatting/bending)	109.8	8.73	5.8

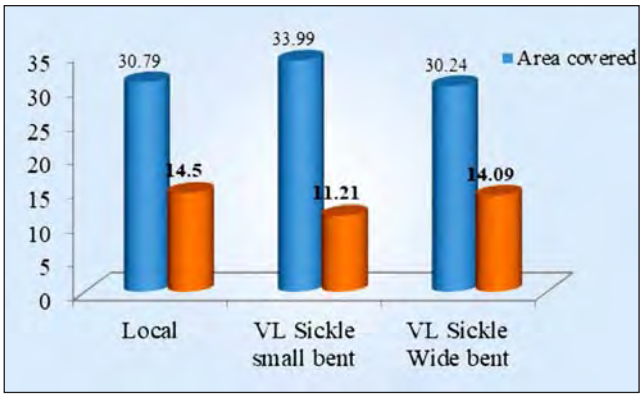


Fig 5.3.2. Reduction in drudgery by VL Sickle in wheat harvesting

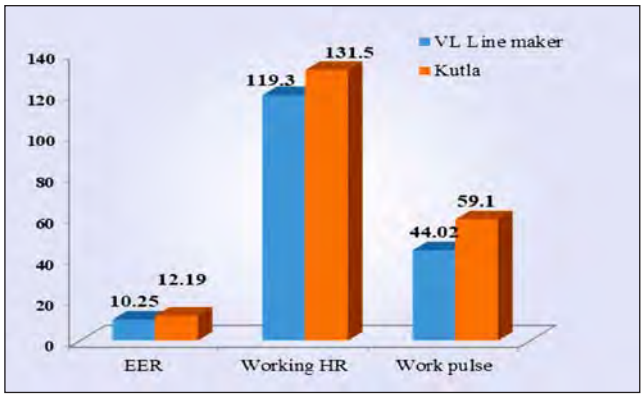


Fig. 5.3.3. Participatory ergonomic evaluation of VL Line Maker with farm women

Food based and educational approaches for nutritional improvement

Data on nutritional status of farm women were collected from villages Bhadkot, Jogath and Dunda in Uttarakashi and Patiya, Kotyura and Daal village in Almora. As body mass index (BMI) of women showed significant positive (at 95% confidence level) relation with Dietary Diversity scores of women, nutrition gardens were promoted to enhance dietary diversity. Nutrition gardens (25) were developed in Almora district at Kotyura in Takula block and Daal village in Hawalbag block. Women with low dietary diversity scores (Minimum Dietary Diversity score< 5) were provided seed kits (8 types of vegetables in each season) for ensuring round the year supply of vegetable for family of five members. After the intervention, the MDDW scores for women increased significantly, resulting in 54% women achieving minimum dietary diversity score in first season.

Educational interventions on good occupational health and safety

An objective of the project is to plan educational interventions to bring behavioural changes in farm women towards occupational health and safety issues. Demonstrations on improved tools and work simplification techniques were planned for women along with knowledge on good nutrition and safety issues.

Demonstration of nutrition gardens in Daal and Kotyura village

Educating women on good ergonomic practices and improved implements

6. Other Research Projects

6.1. ICAR-NASF Funded

- Utilization and Refinement of Haploid/Doubled Haploid Induction Systems in Rice, Wheat and Maize Using *in-vitro* and Molecular Strategies *[Drs. R.K. Khulbe & A. Pattanayak]*
- Information Dissemination System(s) for Empowering Farming Community of Uttarakhand *[Dr. Kushagra Joshi]*

6.2. Consortium Research Platform (CRP) Projects

- ICAR-CRP on Biofortification in Selected Crops for Nutritional Security *[Drs. R.K. Khulbe, R.S. Pal & Rakesh Bhowmick]*
- ICAR-CRP on Molecular Breeding in Maize *[Drs. R.K. Khulbe, R.S. Pal, Rajasekara H & Rakesh Bhowmick]*
- CRP on agrobiodiversity, PGR management, Component II – Wheat *[Drs. Lakshmi Kant & K.K. Mishra]*
- CRP on Molecular Breeding Wheat *[Drs. Lakshmi Kant, K.K. Mishra & Rakesh Bhowmick]*

6.3. UN Environment-GEF Funded Project

- Mainstreaming Agricultural Biodiversity Conservation and Utilization in Agricultural Sector to Ensure Ecosystem Services and Reduce Vulnerability *[Drs. A. Bhartiya (on maternity leave w.e.f., Nov 30, 2018 to May 28, 2019), Nirmal Chandra & Jitendra Kumar]*

6.4. PVP & DUS Test through ICAR-SAU System

- DUS/GOT trials in kidney bean *[Dr. Anuradha Bhartiya (on maternity leave w.e.f., Nov 30, 2018 to May 28, 2019)]*

6.5. AICRP/ Network Projects

- Post Harvest Technology for Value Addition and Marketing of Agricultural Produce *[Drs. Sher Singh, Shyam Nath, Kushagra Joshi & Jitendra Kumar]*
- Use of Plastics in Agriculture Particularly in Protected Cultivation, Water Harvesting and Packaging *[Drs. Sher Singh, Shyam Nath & Jitendra Kumar]*
- All India Network Project on Soil Arthropod Pests *[Drs. J. Stanley & A.R.N.S. Subbanna]*
- Network Programme on Organic Farming (NPOF) *[Drs. Dibakar Mahanta, P.K. Mishra, K.K. Mishra, J. Stanley, V.S. Meena, Manoj Parihar & Priyanka Khati]*

6.6. Network Project on AMAAS

- Developing PGP Consortia for Enhanced Micronutrient (iron and zinc) Uptake and Yield of Finger Millet (*Eleusine coracana*) in Hilly Areas *[Drs. Pankaj K. Mishra & V.S. Meena]*

6.7. NICRA Project under Competitive Grants Component (CGS)

- Design and Development of Protective Structures for High Values Crops to Reduce Damage from Hail and Frost *[Dr. Sher Singh]*

6.8. NMHS Project

- Strategies to Improve Health and Nutriotional Status of Hill Farm Women through Technological Interventions *[Drs. Renu Jethi, Nirmal Chandra, Pankaj Nautiyal & Manisha Arya* (on study leave *w.e.f.* 08.01.2019)*]*

6.9. NMHSE Project

- National Mission for Sustaining the Himalayan Ecosystem *[Drs. A. Pattanayak, S.C. Panday, Kushagra Joshi, V.S. Meena & J. Stanley]*

6.10. NABARD Funded Project

- Formation and Promotion of farmers' Producer Organization *[Dr. Renu Jethi]*

6.11. High Altitude Testing Site (HATS), Mukteshwar

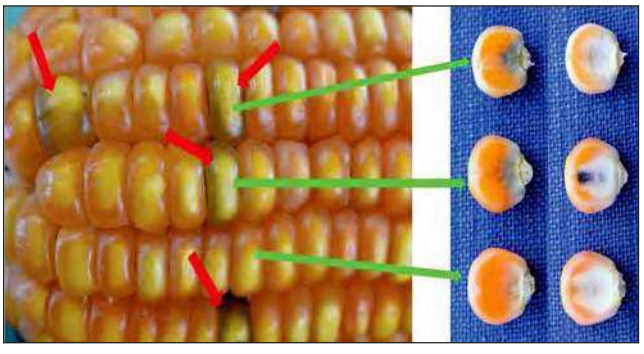
- High Altitude Testing Site, Mukteshwar *[Drs. N.K. Hedau & Sher Singh]*

6.1. ICAR-NASF Funded

6.1.1. Utilization and Refinement of Haploid/Doubled Haploid Induction Systems in Rice, Wheat and Maize Using *In-Vitro* and Molecular Strategies

Enhancing chromosome doubling potential of haploid plants through combination of chemical compounds and identification of additional kernel/seedling traits for haploid identification

Out of 16 treatment combinations involving different chromosome doubling chemicals [Amiprophos-methyl (APM), pronamide, trifluralin, oryazlin and Para-dichloro benzene] and treatment durations, four treatments (APM 20 ppm+Pronamide 2 ppm+Trifluralin 1 ppm for 12 h; APM 20 ppm+Trifluralin 1 ppm for 8 h; APM 20 ppm+Pronamide 1 ppm for 12 h and APM 20 ppm+Oryzalin 10 ppm for 12 h) were found promising on the basis of preliminary observations and will be re-evaluated during *kharif* 2020 for identification of the most effective treatment combination.



Crossed-seed in the ears of induction cross (red arrows); Putative haploid seed (top), Diploid seed (middle) and Selfed-seed (bottom)

In the induction cross of normal corn hybrid CMVL 55 and IC 805127 (Haploid Inducer Line), in which seeds do not exhibit *R1-nj* expression, identification of haploid seed was attempted on the basis of kernel pigmentation in the basal portion of the seed. The putative haploid seed will be raised during *kharif* 2020 to assess the efficiency of this selection method.

Doubled haploid (DH) production aimed at consolidation/accumulation of multi-trait marker tagged genes in elite backgrounds

- Haploid seed obtained from double-trait (Tryptophan+ProvitA, Tryptophan+Low phytate & ProvitA+Low phytate) induction crosses was subjected to chromosome doubling treatment and selfed-seed was harvested from diploidized plants.
- DH lines will be raised from the selfed-seed of diploidized plants during *kharif* 2020 and screened for presence of trait combinations using trait-specific molecular markers.

Up-scaling of doubled haploid maize programme

More than 600 doubled haploid lines of normal corn, sweet corn and QPM generated during *kharif* 2018 and evaluated during *kharif* 2019. Promising DH lines exhibited transgressive segregation for important agronomic traits were identified and used for developing new hybrid combinations. Eleven induction crosses involving normal corn, sweet corn and double/triple-trait biofortified hybrid combinations have been generated during *kharif* 2019, which are expected to yield another 550-600 DH lines during *kharif* 2020.

Variability in DH lines derived from Vivek QPM 9 (left) and FQH 106 (right)

6.1.2. Information Dissemination System(s) for Empowering Farming Community of Uttarakhand

The objective of the project was to strengthen the information dissemination system for hill farmers by bridging the gap between the scientific information and its applicability in farmers' field, so that farmers can make decisions based on scientific information delivered to them. Communication profile, media ownership and information seeking behaviour of hill farmers from three districts of Uttarakhand, *viz*. Uttarkashi, Almora and Bageshwar were ascertained. Based on information needs of farmers, need based tailor-made content were developed. Media was selected in participatory mode and messages were treated as per participatory learning technique (Fig. 6.1.1).

Media ownership of hill farmers

Now a days, majority of farmers are possessing mobile handsets in comparison to other media, hence, it can be treated as one of the best media for information dissemination (Fig. 6.1.2).

Information search behaviour of farmers

Information search behaviour of farmers was calculated based on the number of information sources used for accessing farm related information. Cluster analysis was performed to identify homogenous subgroups of farmers with similar information source usage. To identify the subgroups, information source index was calculated. Based on search behaviour, farmers were classified as very low, low, medium, high and very high searchers (Fig. 6.1.3).

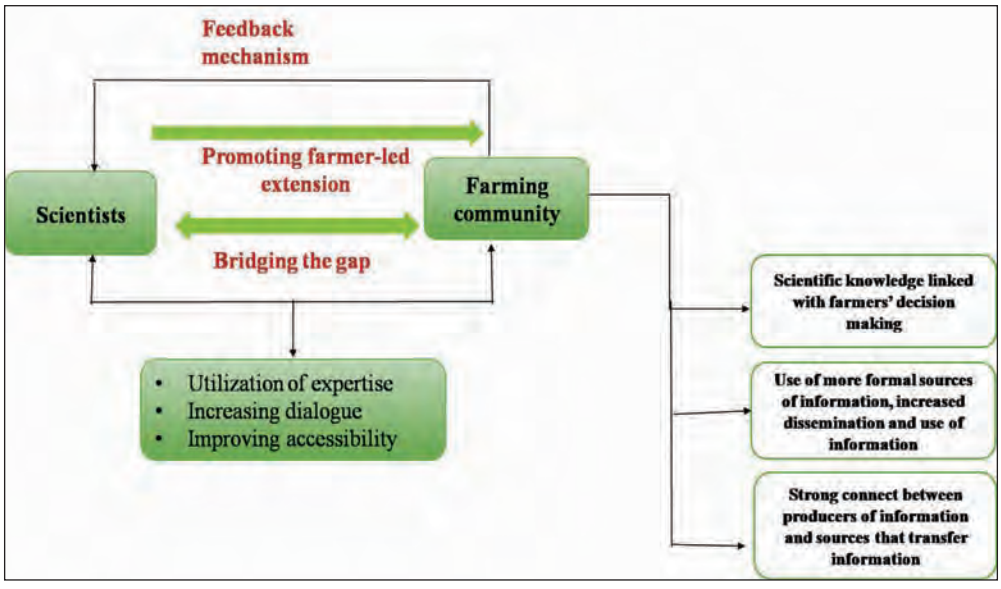


Fig. 6.1.1. Strengthening information dissemination system for farmers

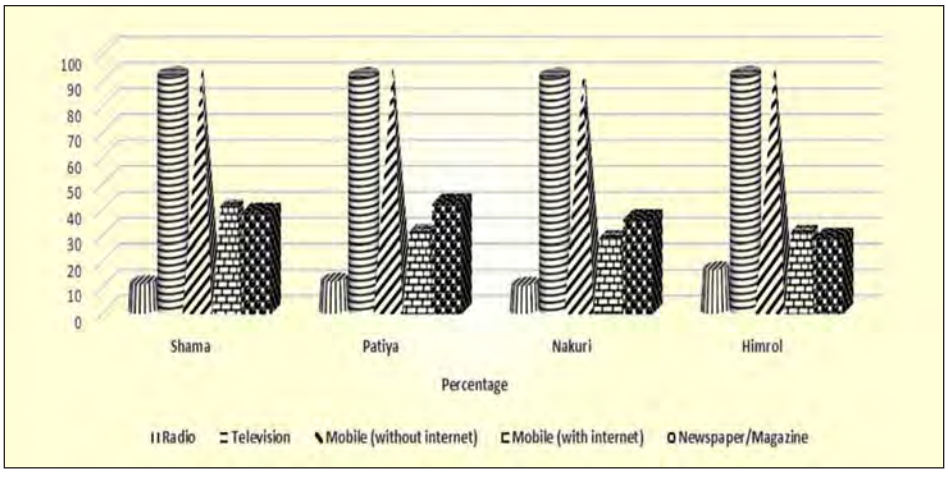


Fig. 6.1.2. Accessibility/ownership of different media by farmers in selected clusters

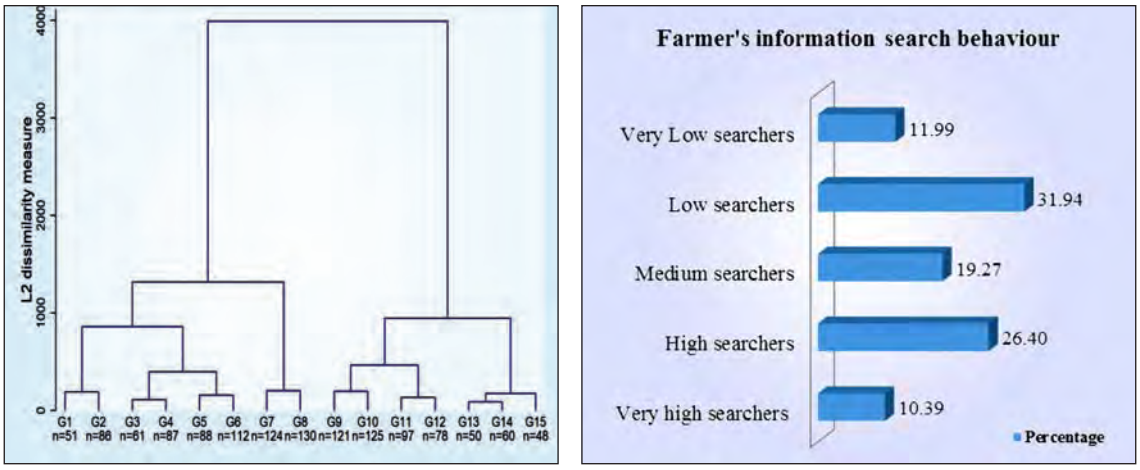


Fig. 6.1.3. Information search behaviour of farmers

Most of the farmers were in the category of low searcher (31.9%) followed by high searchers (26.4%) while only a few farmers (19.3%) were moderate searchers. It can be inferred that majority of farmers were not making use of multiple information sources.

Analysis of variance showed variation in information search behaviour of farmers across socio-economic characteristics. Information search behaviour varied across gender, source of livelihood, caste, education and size of land holding (Table 6.1.1).

Among the socio-demographic variables, gender, source of livelihood, income and education significantly affected information search behaviour of farmers (Table 6.1.2).

Table 6.1.1. Information search behaviour of farmers across socio-demographic characteristics

Socio-demographic characteristics	Information search behaviour					ANOVA
	Very High	High	Medium	Low	Very Low	
Age (Mean)	47.3	48.8	49.3	48.7	50.0	F=1.14, P>F=0.3365
Gender	0.788	0.724	0.709	0.682	0.652	F=2.12, P>F=0.0764
Main source of livelihood	0.321	0.422	0.331	0.116	0.038	F=40.74, P>F=0
Alternate source	0.029	0.060	0.059	0.086	0.089	F=1.74, P>F=0.1379
Caste	0.350	0.250	0.327	0.366	0.411	F=4.14, P>F=0.0015
Education	1.759	1.833	1.680	1.540	1.180	F=19.02, P>F=0
Land holding	1.189	1.169	1.141	1.081	1.044	F=6.75, P>F=0
Family type	0.562	0.514	0.492	0.496	0.551	F=0.78, P>F=0.5388

Table 6.1.2. Factors affecting information sources usage among farmers

Information search behaviour	Coefficient	S.E.	t	P>|t|
Constant	56.7453	1.1057	51.32	0
Age	0.0099	0.0153	0.65	0.518
Gender	0.7046	0.3702	1.90	0.05*
Main source of livelihood	3.4303	0.4537	7.56	0*
Alternate source	-1.3792	0.6661	-2.07	0.039*
Caste	-0.4003	0.3638	-1.10	0.271
Education	1.2613	0.2173	5.8	0*
Land size	0.1438	0.5557	0.26	0.796
Family type	0.2902	0.3367	0.86	0.389
Income	0.4103	0.3810	1.2	0.049*

Design and development of need based agricultural information and media packages for different segments of the farming community

A mobile application '*e-sanchar'* has been developed to cater the information needs of the farmers. The information in the mobile app was categorized in different sections for farmers of lower hills, mid hills and higher hills. Further, the content was organised under three media, *i.e.* audio, video and print. Content was selected for designing messages to be delivered and media to be used was decided in participatory mode. Based on farmers' preference, tailor-made information and media packages were developed and included in a mobile app.

Android based mobile application '*e-sanchar*' was demonstrated among farmers of different village clusters at mid hills (Patiya-Almora) and higher hills (Shama-Bageshwar). Perception, impact and attitude of the farmers towards "*e-sanchar"* mobile application was analysed. Most of the respondents (71.8%) had favourable attitude followed by 15.4% most favourable and 12.8% least favourable attitude towards the *e-sanchar* mobile application (Fig. 6.1.4).

Content developed for mobile App 'e-sanchar'

Demonstration of mobile app in Shama and Patiya village cluster

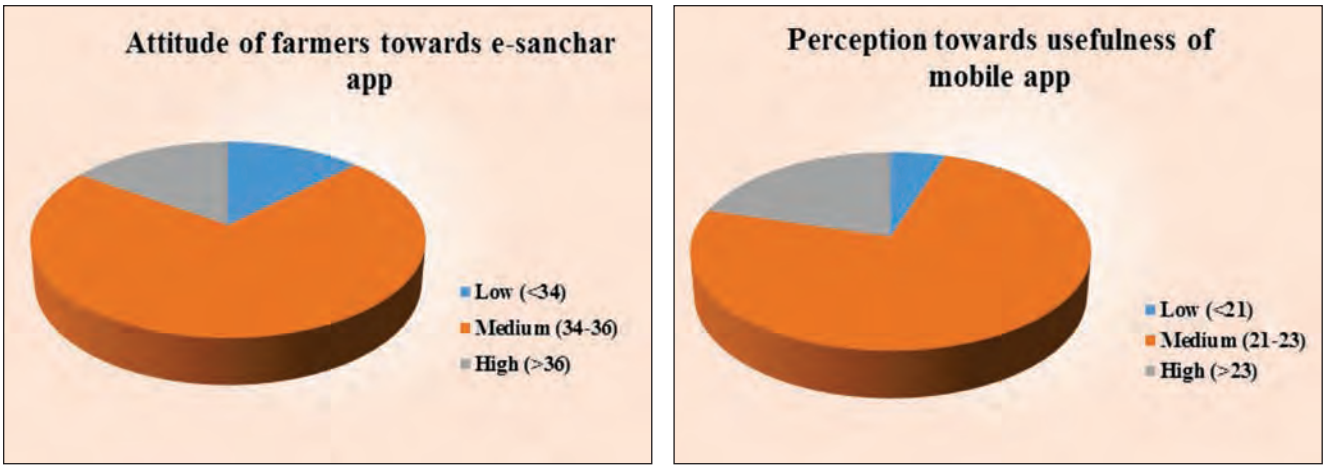


Fig. 6.1.4. Perception and attitude of farmers towards developed mobile app

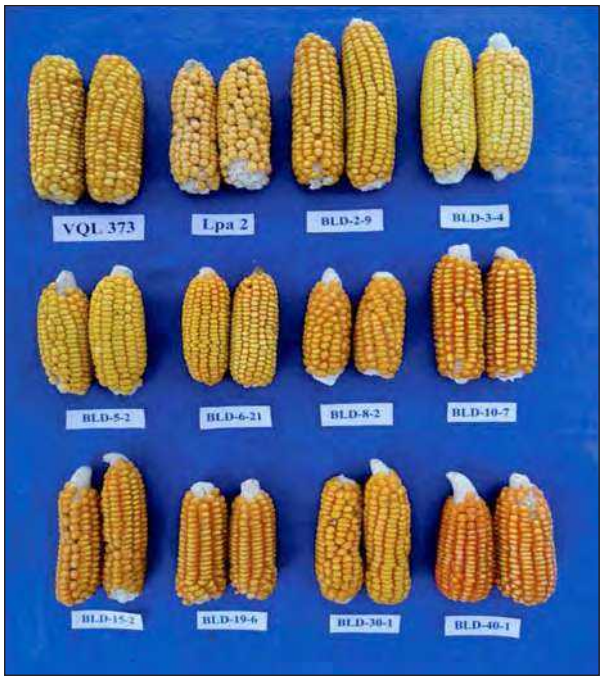
6.2. Consortium Research Platform (CRP) Projects

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

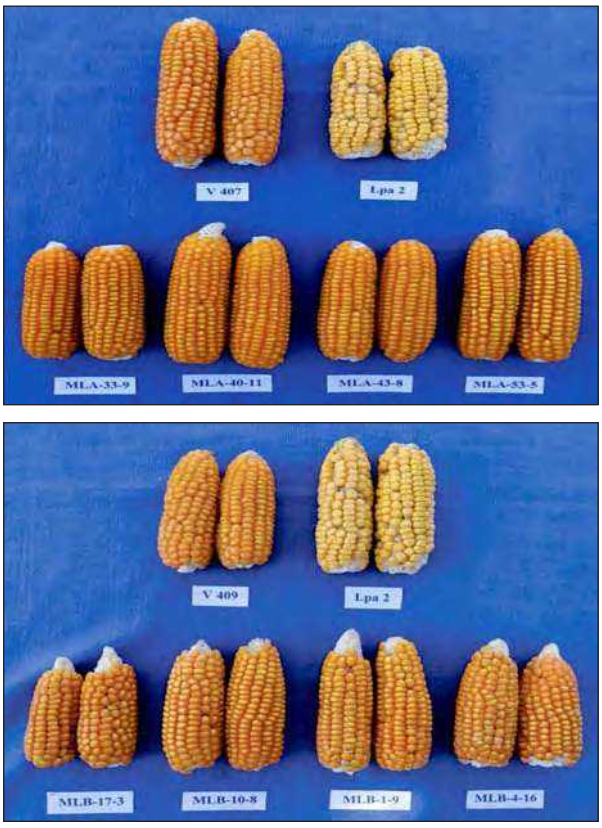
F_6 populations of four crosses between elite QPM lines (VQL 1, VQL 2, VQL 17 and VQL 373) and low phytate donor Lpa 2 were raised at Almora during *kharif* 2019. Foreground selection/biochemical evaluation for high tryptophan and low phytate was carried out using trait-specific markers and agronomically superior individuals (high vigour, good ear size, tolerance/resistance to turcicum leaf blight) carrying the desired trait combination [high tryptophan (>0.6%)+low phytate (<2.5 mg/g)] were selected for further advancement.

6.2.2. ICAR-CRP on Molecular Breeding in Maize

BC_2F_4s between trait specific donors and their respective recipient lines [QPM (V407/VQL 373), β-carotene (V 400/CIMMYT 4 and V 412/ CIMMYT 13) and low phytate (V409/LPA 2 and V 407/LPA 2)] generated during *kharif* 2018 were raised



Variation in ear characteristics of low phytate lines derived from VQL 373/Lpa 2 cross



BC2 F4 progenies of cross V 407 x Lpa 2 (left) and V 409 x Lpa 2 (right)

during *kharif* 2019 at Almora. Individual plants were screened with suitable foreground markers (umc1006 and phi057 for high tryptophan, crtRB1 for high β-carotene and umc2230 for low phytate).

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

Four hundred eighty-two wheat accessions were inoculated for confirmation of loose smut resistance during 2017-18 and were sowed in expression nursery. Among these, 173 found free (0.0% infection) and 52 found resistant (0.1 to 5.0% infection) to loose smut. In addition, 580 accessions were evaluated for expression, 44 were found free (0.0% infection) and 21 found resistant (0.1 to 5.0% infection) to loose smut. Powdery mildew was recorded in 26 accessions and 19 were found resistant to powdery mildew (Av. score 0-3). Another set of 644 new accessions were inoculated during *rabi* 2018-19.

6.2.4. CRP on Molecular Breeding Wheat

Two popular wheat varieties [VL *Gehun* 907 (timely sown condition) 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. Yr*10 and *Lr* 24. During *rabi* 2018-19, F_{3s} RILS [(VL *Gehun* 892/ *Yr*10/5*Datatine //VL *Gehun* 892), (VL *Gehun* 892/ FLW1//VL *Gehun* 892), (VL *Gehun* 907/ *Yr*10/5*Datatine //VL *Gehun* 907) and (VL *Gehun* 907/ FLW 1 /VL *Gehun* 907)] were planted at experimental farm, Hawalbag. After foreground as well as agronomic selection, 560 positive genotypes were advanced and planted in offseason nursery during *kharif* 2019.

Level of loose smut infection

Loose smut resistant genotypes

Field view of CRP molecular breeding materials

6.3. UNEP-GEF Project

Mainstreaming Agricultural Biodiversity Conservation and Utilization in Agricultural Sector to Ensure Ecosystem Services and Reduce Vulnerability

Under the UNEP-GEF project a total of 94 landraces comprising rice (30), finger millet (27), black soybean (9), horse gram (15), amaranth (18) and buckwheat (12) were evaluated during *kharif* 2019 in mother trials. Seeds of the landraces were also distributed among farmers of the target site for their evaluation in crowd sourcing trials. A total 37 farmers conducted crowd sourcing trials in target crops.

Seed of landraces of target crops comprising rice (46), black soybean (20), horse gram (23), amaranth (20) and finger millet (7) were multiplied and will be used in UNEP-GEF project trials to be conducted during *kharif* 2019. Three exposure visits of farmers were conducted at experimental farm Hawalbag.

Farmers' varieties of rice (26), finger millet (3), amaranth (2) and black soybean (2) collected form target site were characterised for DUS grouping traits and being purified for registration with PPV & FR Authority, New Delhi.

Glimpses of trials under UNEP-GEF project

Exposure visit of farmers to seed multiplication plots at Experimental farm ICAR-VPKAS, Hawalbag under UNEP-GEF project

Popular farmers' varieties of target crops under UNEP-GEF project

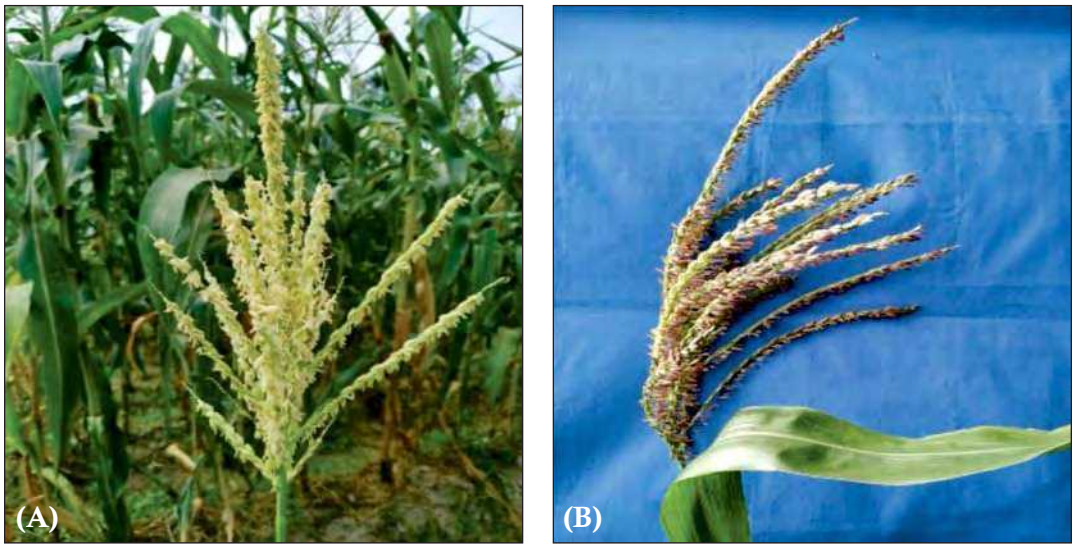
Farmers of the target site are exposed to the mechanical methods of postharvest processing of millets. *Vivek* Millet Thresher-cum-Pearler (17 no.) were distributed among farmers of UNEP-GEF project site to facilitate farmers for pearling and threshing of finger millet & barnyard millet and dehusking of barnyard millet.

6.4. PVP & DUS Test through ICAR-SAU System

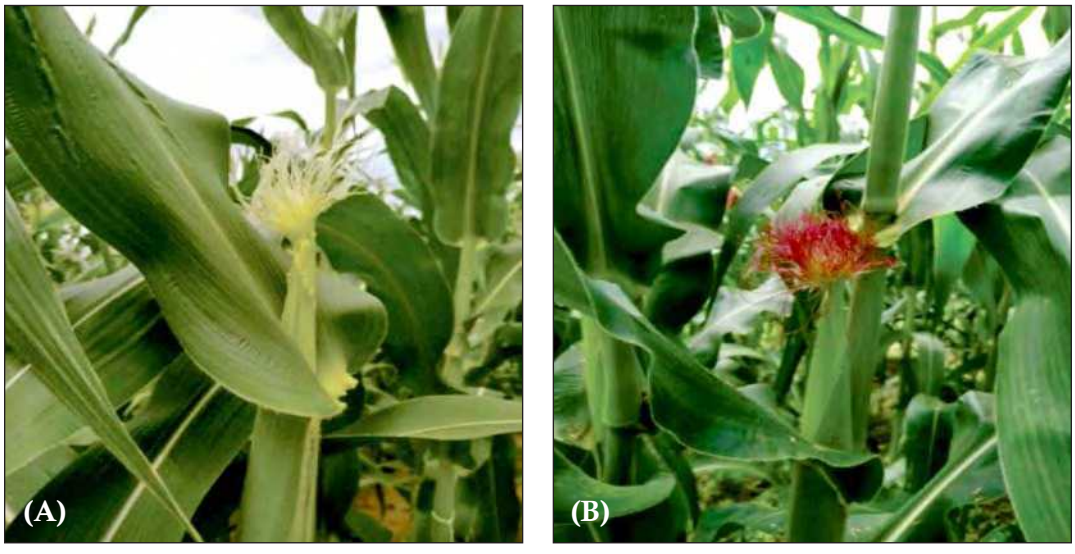
Maize: Twenty one farmers' varieties, *viz*. trial code 2883/2205, 2883/2206, 2883/2210, 2883/2213, 2883/2215, 2883/2220, 2883/2224, 2883/2225, 2883/2227, 2883/2229, 2883/2234, 2877/2137, 2883/2238, 2883/2239, 2883/2244, 2883/2249,

Hands on training of farmers of UNEP-GEF project for millet processing by *Vivek* Millet Thresher-cum-Pearler

2883/2250, 2881/3686, 2877/2133, 2883/2237, 2877/2138 along with two reference varieties, *viz.* *Vivek* Maize Hybrid 53 and *Vivek* Maize Hybrid 57 were raised for grow out test (1st year of testing) and characterized for DUS traits as per national guidelines to conduct the DUS test on maize.



Tassel- Anthocyanin colouration of anthers (A) Absent (B) Present



Ear- Anthocyanin coloration of silk (A) Absent (B) Present

Stem- Anthocyanin coloration of brace roots (A) Absent (B) Present

Kidney bean: Four candidate varieties, *viz*. trial code 2881/3622, 2881/3624, 2883/2259 & Reg/2017/1859 along with three reference varieties, *viz*. PDR 14, HUR 15 & *Arka Anoop* were raised for grow out test (1st year of testing) and characterized for 22 DUS traits as per national guidelines for the conduct of test for DUS on kidney bean.

Soybean: Two farmers' varieties of black soybean, *viz*. Reg/2017/1708 and Reg/2017/1709 along with two reference varieties, *viz*. VL *Bhat* 201 and VL *Soya* 65 were raised for DUS testing (2nd year of test) and characterized for 22 DUS traits as per national guidelines for the conduct of test for DUS on soybean.

6.5. All India Coordinated Research Projects (AICRP)/Network Projects

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

Light weight multi fruit-cum-vegetable grader for hilly areas

Seasonal and off-seasonal vegetables and temperate fruits like peach, pear, plum, apple, apricot is grown mainly in the hills of Uttarakhand. Grading of fruits and vegetables is an essential step in post-harvest management due to increasing of consumers preferences for quality products. The

Farmers' variety of kidney bean (trial code 2881/3622)

Light weight multi fruit-cum-vegetable grader

Small seed (< 10g/100 seed)

Large seed (> 13g/100 seed)

known traditional method of grading fruits and vegetables in hills of Uttarakhand is manual, but it is time-consuming and error prone. Therefore, ICAR-VPKAS developed a light weight (45 kg) multi fruit-cum-vegetable grader suitable for hilly areas, which is solar (12 V DC motor) as well as pedal operated.

The dimensions of the grader are 170x45x110 cm with hopper capacity of 10 kg. The grading capacity is 500 to 600 kg fruits or vegetables/hour depending on type of commodity to be graded. It has stainless steel rollers and can grade into four graders with rpm of 70 to 80 depending on load. The multi fruit-cum-vegetable grader will not only reduce the labour requirement in manual grading but also enhance marketing efficiency. Grading of commodities like fruits and vegetables in different grades according to size and shape will fetch better prices in market.

6.5.2. Use of Plastics in Agriculture Particularly in Protected Cultivation, Water Harvesting and Packaging (AICRP on PET)

Design and development of low-cost water lifting device for river-bed cultivation in hilly region

Institute has fabricated prototype of low-cost water lifting device specially for river-bed cultivation in hilly region. Two plunger pump assembly was used to pump water from river. River current with the help turbine was used as motive power to drive the pumps. Initially 14 number of blades were used in the turbine. The gear on the turbine drive shaft was

of 14 teeth and that of pump driven shaft was of 36 teeth. Although the torque was sufficient, but pump reciprocating motion was quite less. The pump displacement was kept around 5 cm and the discharge of one-meter height was 10 lpm and it decreased as height increased. At 7 m height discharge was 5.0 lpm, *i.e.* 7200 liters in 24 hours. This low-cost water lifting device will utilize the flow of water as source of energy will be most useful for lifting of water from river with negligible operation cost. It will help the farmers' to get a better yield in situations of unreliable electricity availability in river-bed of hilly region.

Performance of VL portable polyhouse

The newly developed low-cost VL portable polyhouse (62.4 m^2 surface area with 12.0 m length × 5.2 m width × 2.6 m height) was tested for vegetable production. It took only four hours by four persons to shift (uninstallation as well as reinstallation) it from one field to other. Rain-water and dew harvesting provision have been provided in this polyhouse, which is very useful during winter season. This is a naturally ventilated polyhouse with negligible operational cost. The temperature and relative humidity inside this polyhouse were within tolerable limits. During peak winter (January 2019), the monthly average ambient temperature, soil temperature and relative humidity inside the polyhouse were higher by 3.7°C, 3.6°C and 23.8%, respectively than outside open conditions, which proved very beneficial for the crop growth. The vegetable crops under polyhouse produced 3.7 times higher vegetables than open condition. This polyhouse can be used for crop cultivation, covering fish-ponds during severe winter, drying of farm produce and covering of harvested material as per requirement, thus making the multiple use. The cost of this polyhouse is approx. Rs. 75,000/-

6.5.3. All India Network Project on Soil Arthropod Pests (White Grub)

In-situ species composition and abundance of phytophagous scarab beetles

The scarab beetles emerge out from the soil especially after summer showers during May-June at dusk time for feeding and mating. Considering this period, the host trees were surveyed for collection of phytophagous scarab beetles to study the nonphotoactive beetle diversity that may not come to light trap. In this study a total of 843 beetles were collected from May to August, 2019 from strategic locations at experimental farm, Hawalbag that included 18 species belonging to 4 subfamilies, *viz.* Rutelinae (6 species accounting to

Crop/ variety	Inside portable polyhouse	Outside (open conditions)
French bean (VL *Bean* 2)		
Vegetable pea (*Vivek Matar* 15) + radish (private hybrid) on bunds		
Tomato (Pant *Tamatar* - 3)		

Vegetable crops inside the portable polyhouse and outside open conditions

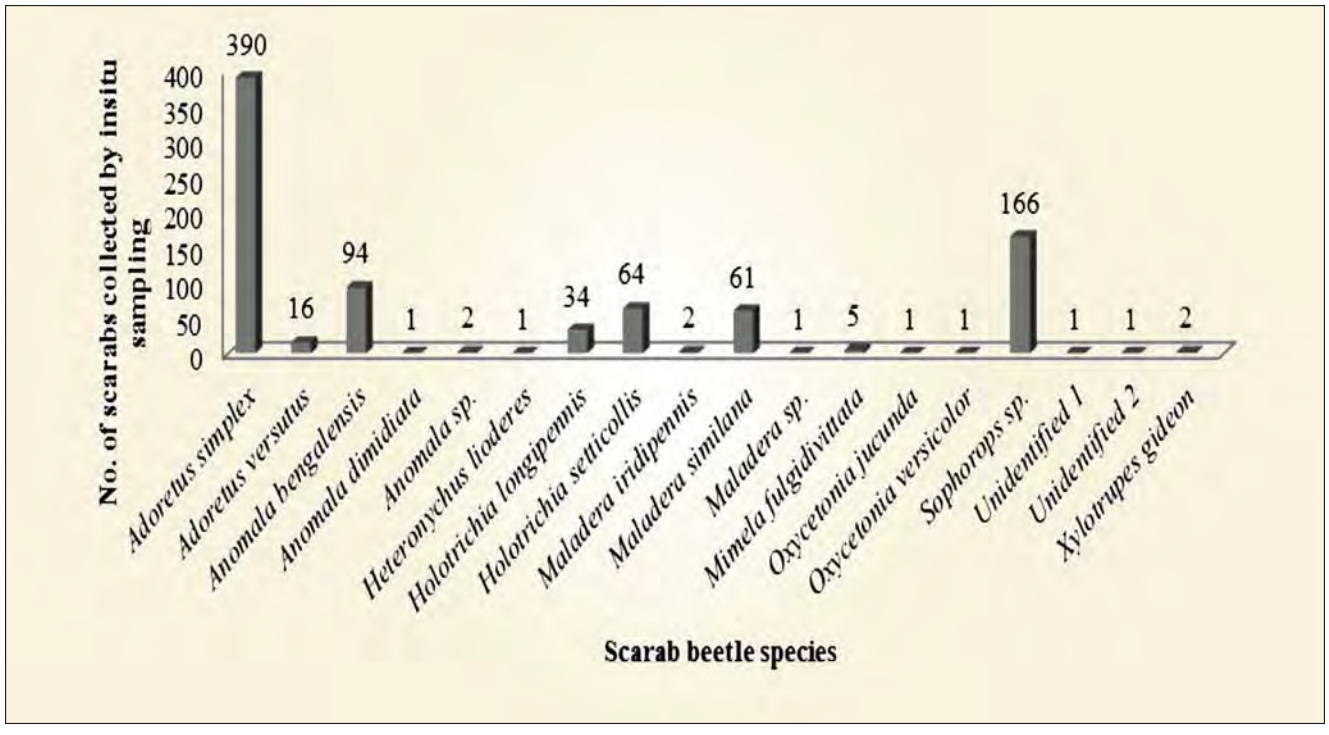


Fig. 6.5.1. Scarab beetles collected by *in-situ* sampling using insect net and hand picking at different locations in Experimental farm, Hawalbag, Uttarakhand (July 2019)

60.26%), Melolonthinae (6 species accounting to 38.91%), Dynastinae (2 species accounting to 0.24%) and Cetoniinae (2 species accounting to 0.36%). *Adoretus simplex* was found in *Zinnia elegans*, rose and *Lagerstroemia indica* plants, *Sophrops* sp. in pecan nut (*Carya illinoinensis*) and rose whereas *Anomala bengalensis* was found only in *Ligustrum* sp and *Maladera similana* in zinnia. Sampling of scarab beetles were made in four locations of experimental farm under different trees by visible counting and capturing (Fig. 6.5.1).

Efficacy of insecticides against whitegrub adults

At the time of outbreaks, the scarab beetles emerge in large numbers and get concentrated on the host trees for feeding and mating. Therefore, it is easier to control these gregarious beetles in the host trees itself if the trees are treated with efficacious insecticides. Leaf dip bioassays was conducted to know the efficacy of 13 commonly used commercial insecticides (Table 6.5.1) against adult beetles of three predominant whitegrub species, *viz*. *Adoretus simplex*, *Anomala bengalensis* and *Sophrops* sp. Although species dependent variations are observed, overall mortality data showed acephate 75% SP @ 1.6 g/l and chlorpyriphos 20% EC @ 2 ml/l are most efficient and significantly superior over all other treatments. Against *A. simplex*, chlorpyriphos, malathion and metasystox reported 100% mortality within 24 hours after treatment (HAT). Similarly, against *Anomala bengalensis*, dichlorvos and against *Sophrops* sp., acephate and chlorpyriphos reported cent percent mortality within 24 HAT.

Evaluation of chemical insecticides against scarab beetle *(Anomala bengalensis)*

Table 6.5.1. Evaluation of chemical insecticides against scarab beetle *(Anomala bengalensis)*

Insecticide	Dose (ml or g/l)	Mortality of scarab beetles (%) hours after tratement (HAT)					
		Anomala bengalensis		*Sophrops sp.*		*Adoretus simplex*	
		24	48	24	48	24	48
Acephate 75% SP	1.6	80.0	100.0	100.0	100.0	91.7	100.0
Cartap hydrochloride 50% SP	1.0	0.0	25.0	20.0	20.0	8.3	25.0
Cholrantraniliprole 18.5% W/SC	0.3	0.0	0.0	0.0	10.0	0.0	0.0
Chlorpyriphos 20% EC	2.0	37.5	100.0	100.0	100.0	100.0	100.0
Cyantraniliprole	1.0	0.0	16.7	8.3	16.7	8.3	8.3
Deltamethrin 2.8% EC	1.0	20.0	20.0	25.0	58.3	58.3	75.0
Dichlorvos 76% EC	1.0	100.0	100.0	8.3	50.0	91.7	100.0
Imidacloprid 17.8% SL	0.3	12.5	50.0	20.0	40.0	33.3	83.3
Indoxacarb 14.5% SC	1.0	0.0	66.7	8.3	50.0	8.3	25.0
Malathion 50% EC	2.0	12.5	12.5	40.0	80.0	100.0	100.0
Metasystox 25% EC	1.0	33.3	77.8	58.3	75.0	100.0	100.0
Spinosad 45% SC	0.5	0.0	8.3	16.7	33.3	25.0	50.0
Triazophos 40% EC	2.0	25.0	75.0	0.0	60.0	91.7	100.0
Untreated control	-	0.0	0.0	0.0	0.0	0.0	0.0

6.5.4. Network Programme on Organic Farming (NPOF)

Evaluation of organic, inorganic and integrated production systems

Different crop management practices 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. Application of 100% of the recommended N of crop through farmyard manure (FYM) and 75% of the recommended N of crop through FYM+innovative practices produced highest energy equivalent grain yield of 52×10^3 and 50×10^3 MJ/ha for finger millet+black soybean-wheat+*toria* and grain amaranth-wheat+lentil, respectively (Fig. 6.5.2). The highest yielding treatment recorded 90 and 103% higher energy equivalent grain yield of finger millet+black soybean-wheat+*toria* and grain amaranth-wheat+lentil, respectively than 100% inorganic package, respectively.

The highest protease and phosphodiesterase activity were recorded under 100% organic management system of grain amaranth-wheat+lentil cropping system (148 µg tyrosine/g/2 h and 126 µg p-NP/g/h, respectively). But, the inorganic pyrophosphatase activity was recorded under 100% organic management system of finger millet+black soybean-wheat+*toria* cropping system (83 µg p-NP/g/h) (Table 6.5.2). The soil enzyme activity index (SEAI) was developed to provide a single comprehensive unitless value. The highest SEAI was recorded under 100% organic management system of finger millet+black soybean-wheat+*toria* cropping system, although the highest activity several enzymes recorded under grain amaranth-wheat+lentil cropping system (Fig. 6.5.3).

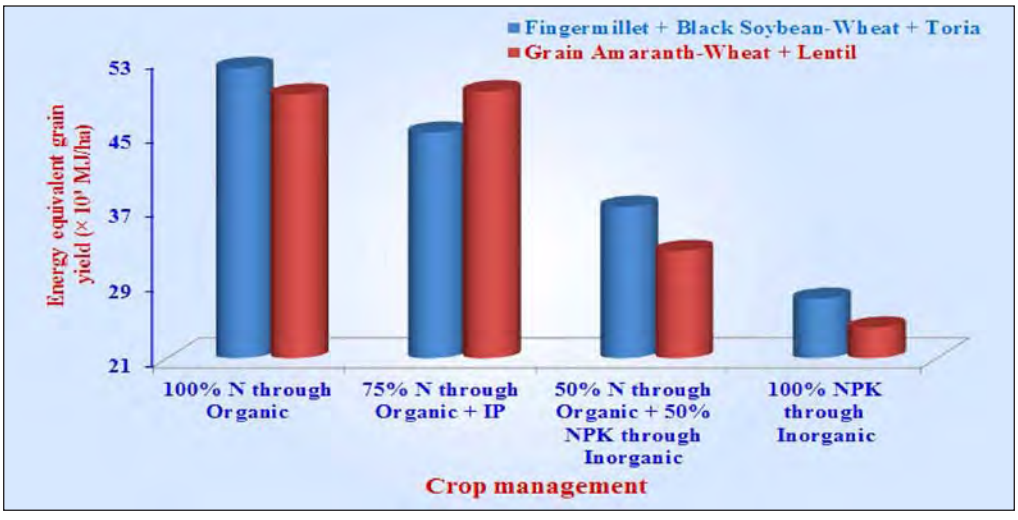


Fig. 6.5.2. Energy equivalent grain yield of finger millet+black soybean-wheat+*toria* and grain amaranth-wheat+lentil in different crop mnagement system (IP = Innovative practices – 3% *Panchagavya* and vermiwash)

Table 6.5.2. Influence of cropping system and crop management on activity of different soil enzymes

Cropping system	Nutrient management	Protease (µg tyrosine/g/2 h)	Inorganic pyrophosphatase (µg PO_4^{3-} P/g/5 h)	Phosphodiesterase (µg p-NP/g/h)
Amaranth-wheat + lentil	100% Org	148	76	126
	75% Org + IP	132	69	117
	50% Org + 50% Inorg	126	66	99
	100% Inorg	87	47	83
Finger millet + black soybean-wheat + *toria*	100% Org	140	83	119
	75% Org + IP	125	75	106
	50% Org + 50% Inorg	119	61	91
	100% Inorg	75	49	82

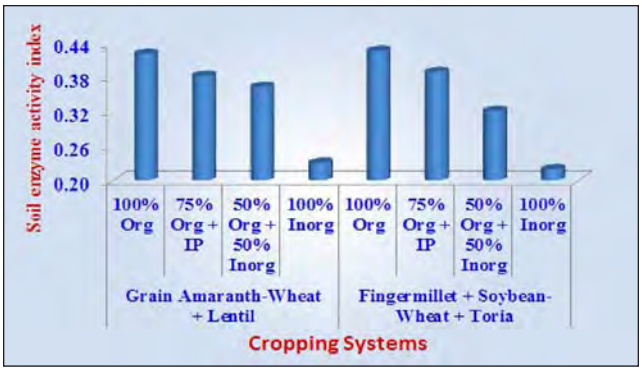


Fig. 6.5.3. Influence of cropping system and nutrient management on soil enzyme activity index

Field evaluation of organic pest management options for pests of soybean

A field experiment with seven treatments including control was laid out to evaluate the organic pest management options for soybean pests. Table 6.5.3. shows the sucking bug, *Chauliops choprai* infestation in the treatments. The pre-treatment counts showed severe infestation of sucking bug (3 to 4 bugs per leaf as taken average of top, mid and bottom leaves). The average bug reduction was about 0.20 to 0.98 in various treatments. Apart from chemical pesticide, Cartap hydrochloride which registered 84% reduction, melia extract 5 and 10% provided 47 and 43% reduction of soybean sucking bug, respectively.

The effect of organic pest management options on aphids of soybean is given in table 6.5.4. The pre-treatment count has severe incidence of aphids of 33.33 to 50.94 aphids per plant. The incidence was reduced in all the treatments including control drastically to 9.67 to 15.45 aphids per plant. So, the treatment effects are not very clear in this experiment.

Pest incidence in organic production system

The infestation/damage of leaf webber in grain amaranth grown in full organic conditions was 6.6%, whereas it was 12.0% damage in full inorganic plots. Sporadic infestation of grasshoppers was found in finger millet crops as shown in the table 6.5.5. Soybean grown under full organic condition was found to harbour a greater number of sucking bug, *Chauliops choprai* (11.4 bugs per 3 leaves) and 100% inorganic had the least number of sucking bugs (5.8 bugs per 3 leaves). The infestations of aphids in toria under wheat+*toria* intercropping were 68, 39 and 55 and 47% for application of 100% N requirement

Table 6.5.3. Effect of organics on the management of sucking bug of soybean

(Mean of six replications)

Treatment	PTC	2 DAT	5 DAT	7 DAT	Average	Reduction w.r.t. control (%)
Melia azederach extract 5%	4.00	0.89	0.83	0.61	0.77	**46.56**
Melia azederach extract 10%	3.56	0.61	0.55	1.05	0.74	**43.05**
Nimbicidine 3 ml/l	3.00	1.11	0.72	1.11	0.98	**10.09**
Beauveria bassiana 3g/l	2.61	0.67	0.50	1.22	0.79	**15.99**
Parthenium extract 5%	3.05	0.85	0.56	1.06	0.82	**25.70**
Cartap hydrochloride 1g/l	3.56	0.33	0.17	0.11	0.20	**84.28**
Control	3.00	1.17	1.66	0.45	1.09	-

PTC – Pre-treatment count; DAT – Days After Tranplanting

Table 6.5.4. Effect of organics on the management of aphids of soybean

Treatment	PTC	2 DAT	5 DAT	7 DAT	Average	Reduction w.r.t. control (%)
Melia azederach extract 5%	37.06	17.89	13.11	10.05	13.68	**19.17**
Melia azederach extract 10%	33.33	12.05	11.28	11.44	11.59	**23.87**
Nimbicidine 3 ml/l	35.00	13.72	14.33	10.61	12.88	**19.39**
Beauveria bassiana 3g/l	50.94	17.39	14.83	11.89	14.70	**36.81**
Parthenium extract 5%	40.11	14.28	15.83	9.67	13.26	**27.63**
Cartap hydrochloride 1g/l	34.11	9.72	10.78	14.00	11.50	**26.19**
Control	37.61	20.84	15.27	15.45	17.18	-

of crop through FYM, 75% N requirement of crop through FYM+3% *Panchagavya*+Vermiwash, INM and 100% inorganic conditions, respectively. No insect pest incidence was observed in wheat crop.

Effect of organics in the management of aphids in toria

An experiment was conducted in the laboratory to evaluate the organic pest management options for the management of aphids in mustard/toria. The twigs infested with toria aphids were taken to laboratory from the field without any treatment for use in laboratory evaluation. Six different organic treatments were tested against toria aphids in the laboratory, especially three botanical extracts, two bioagents along with commercially available neem oil (Nimbicidine) and chemical pesticide. None of the treatments except the chemical insecticide, acetamiprid was found to reduce the infestation of aphids in mustard considerably. Nimbicidine spray 3 ml/l was found to reduce the aphid infestation by 26.59% (Table 6.5.6).

Organic management of toria aphids

A field experiment was conducted to evaluate the organic pest management options for the management of aphids in toria. Pre-treatment count shows severe infestation of aphids up to 100%. None of the treatments, except the chemical insecticide, acetamiprid was found to reduce the infestation of aphids in mustard considerably, *i.e.* more than 80%. Nimbicidine spray 3 ml/l was found to reduce the aphid infestation by 16.67%. (Table 6.5.7). New treatments and treatments with increased dosage are to be tried. Use of predators is to be tried especially of coccinellids and syrphids in the next season.

Disease infestation in organic and inorganic production system

The intensity of different diseases in different crops during *kharif* season was relatively higher under inorganic management system compared to other systems (Table 6.5.8). The management with organic inputs recorded very low infestation of various pathogens.

Table 6.5.5. Infestation of insect under different production systems

Treatment	Amaranth Leaf webber damage (%)	Finger millet Grasshopper damage (%)	Soybean Sucking bug (No/ 3 leaves)	Toria Aphid infestation (%)
100% Organic	6.6	18.8	11.4	68.0
75% Organic + 3% *Panchagavya* + Vermiwash	10.7	12.6	8.4	38.7
50% Organic + 50% inorganic	9.3	7.0	6.0	54.7
100% Inrganic	12.0		5.8	47.0

Table 6.5.6. Effect of organics on the management of aphids in toria

Treatment	Infested twigs before treatment	Mortality (%) hours after treatment (HAT)				
		24	48	72	96	Average
Melia extract 5%	100	0.0	1.33	11.67	35.7	12.18
Artemisia 5%	100	0.0	2.67	10.67	58.3	17.91
Pine extract 5%	100	0.0	1.33	10.0	50.0	15.33
Nimbicidine 3ml/l	100	2.33	2.67	20.67	80.7	26.59
Metarhizium anisopliae 3g/l	100	0.0	5.33	21.67	69.0	24.00
Beauveria bassiana 3g/l	100	0.0	3.33	15.67	80.0	24.75
Acetamiprid 0.25g/l	100	5.0	66.7	100	100	67.93
Control	100	0.0	0.0	13.0	86.7	24.93

HAT - Hours after treatment

Table 6.5.7. Effect of organics on the management of aphids in toria

Treatment	PTC*	Per cent Reduction days after treatment (DAT)			
		3	6	10	Average
Melia extract 5%	100	7.0	7.0	7.0	7.00
Artemisia 5%	100	4.0	4.0	4.0	4.00
Pine extract 5%	93.3	7.0	13.0	13.0	11.00
Nimbicidine 3ml/l	100	10.0	10.0	30.0	16.67
Metarhizium anisopliae 3g/l	100	7.0	20.0	20.0	15.67
Beauveria bassiana 3g/l	100	10.0	10.0	10.0	10.00
Acetamiprid 0.25g/l	100	80.0	80.0	83.0	81.00
Control	100	0.0	0.0	0.0	0.0

PTC- Pre-treatment count (% infestation in the tagged plants)

Table 6.5.8. Disease index in different crops under organic and inorganic production system during *kharif* 2019

Treatment	Finger millet + black soybean intercropping					
	Finger millet			Black soybean		
	Finger blast*	Neck blast	Leaf blast	Frog eye leaf spot	Bacterial pustule	Pod blight
100% Organic	1	1	3	3	5	1
75% Organic + 3% *Panchagavya* + Vermiwash	1	1	3	5	5	1
50% Organic + 50% inorganic	3	1	5	5	5	3
100% Inorganic	3	1	7	3	5	1

	Rhizoctonia blight in grain amaranth
100% Organic	7
75% Organic + 3% *Panchagavya* + Vermiwash	7
50% Organic + 50% inorganic	5
100% Inorganic	3

*** Scale for finger blast and leaf spot of finger millet; Frogeye leaf spot yellow rust and Bacterial pustule of black soybean; Rhizoctonia blight of grain amaranth = 0-9 scale**

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

6.6.1. Developing PGPR Consortia for Enhanced Micronutrient (iron and zinc) Uptake and Yield of Finger Millet (*Eleusine coracana*) in Hilly Areas

Dual plate culture technique employed to access the compatibility among the selected zinc solubilizing strains/isolates (04no.) and siderophore producing bacterial isolates/strains (04no.) at 28°C for the development of eight PGP bacterial consortium. Double antibiotic markers have been developed for each strain/isolate for monitoring under field conditions. PGP bacterial consortia were prepared using compatible strains of *Pseudomonas* sp. by raising the cultures individually and mixing them in equal ratio in charcoal-based formulation containing 10^{10}cfu/g.

Eight PGP bacterial consortium were evaluated for plant growth promotion and micronutrient (Zn and Fe) uptake in three finger millet varieties (VL *Mandua* 376, VL *Mandua* 379 & VL *Mandua* 380) under pot conditions during *kharif* 2019. In pot condition, seed inoculation of finger millet with bacterial consortiums had significantly (P>0.05) improved root length (6.9 - 25.6%), shoot length (2.6 - 28.5%), dry root biomass (6.3 - 17.2%), dry shoot biomass (2.4 - 1.7 fold increase), proline content (1.1 - 22.5%), total phenolics (3.6 to 25.5%) in all the three tested finger millet varieties, as compared

to control treatment (without inoculation). All the PGP bacterial consortia showed enhancement in finger millet grain iron content (1.7 to 35.2%) and zinc content (4.79 to 25.6%) compared to uninoculated control.

6.7. NICRA Project under Competitive Grants Component (CGS)

6.7.1. Design & Development of Protective Structures for High Values Crops to Reduce Damage from Hail and Frost

In temperate climates, frost most commonly appears on surfaces near the ground as fragile white crystals; in cold climates, frost occurs in a greater variety of forms. In hills of Uttarakhand, the frost during winter season is very common due to which farmers face problems in preparing nursery of vegetable crops during this time. The Institute under the NICRA project has developed VL Polytunnel as a protective structure for high values crops to reduce damage from frost and hail. The VL Polytunnel is of semi-circular shape (3.0 m length × 1.0 width × 0.5 m centre height) covering ground area of 3 sq m. The price of one unit of VL Polytunnel is Rs. 2,500/-. The VL polytunnel has been demonstrated in the vegetable growing areas with Scheduled Caste farmers in Darmoli and Pitholi villages of Nainital district. In addition to its primary use in winter for nursery raising, farmers can also use it for drying and covering their farm produce during rainy season.

6.8. National Mission on Himalayan Studies (NMHS)

6.8.1. Strategies to Improve Health and Nutritional Status of Hill Farmwomen through Technological Interventions

Chronic energy deficiency

On the basis of Body Mass Index (BMI), different grades of Chronic Energy Deficiency (CED) was evaluated and the overall prevalence of malnutrition depicted as different grades of CED along with low normal BMI was 36.5% (Fig. 6.8.1). About 15.9% women were in the category of obesity (over nutrition). The mean BMI (±SD) of the women was 21.9 (±3.1) kg/m².

VL Polytunnel demonstration at farmer's field

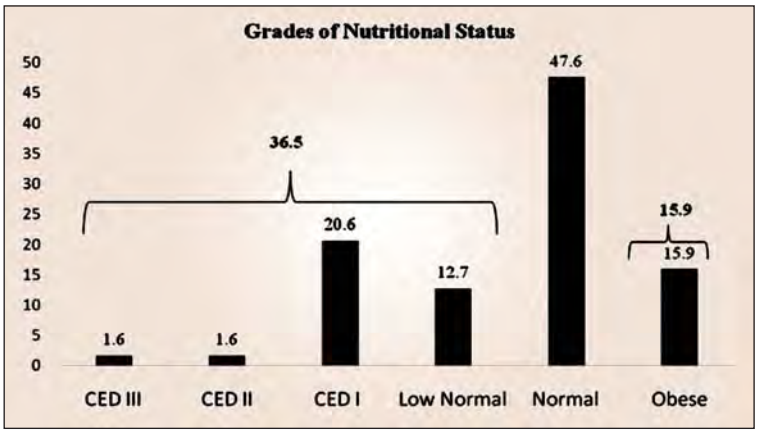


Fig. 6.8.1. Prevalence of chronic energy deficiency among women in hills

Dietary diversity score

In the present study, the selected women were encouraged to produce seasonal vegetables in nutri-gardens along with mushroom production and bee-keeping. Regular trainings and exposure visits were conducted on improved package of practices for vegetable production along with field monitoring for controlling insect-pest infestations. Women were linked to need-based SMS service for receiving messages related to insect-pest infestation, improved agronomic practices, improved crop varieties and health & nutrition issues.

Minimum Dietary Diversity for Women (MDD-W) of reproductive age was calculated before the implementation of the interventions and after interventions with same respondents. Women had very low dietary diversity score (3.9) with standard deviation of 0.9 as 69.8% were found to be consuming less than five food group in their diet. After the implementation of nutrition sensitive agricultural intervention, MDD-W score reached to 5.5 with standard deviation 0.8. More than 90% of women achieved minimum dietary diversity and they are more likely to have higher (more adequate) micro-nutrient intake (Table 6.8.1).

It is also very important to present the average number of fruit/vegetable groups consumed out of the four groups (dark green leafy vegetables, other vitamin A-rich fruits and vegetables, other fruits and other vegetables). Before the intervention, consumption of number of fruit/vegetable groups was 1.5 with standard deviation of 0.87 whereas after intervention it got increased to 2.5 with a standard deviation of 0.76 among women of high hills (Fig. 6.8.2). There was found to be a significant difference at 0.05 level of probability in consumption of number of fruit/vegetable groups after the implementation of interventions.

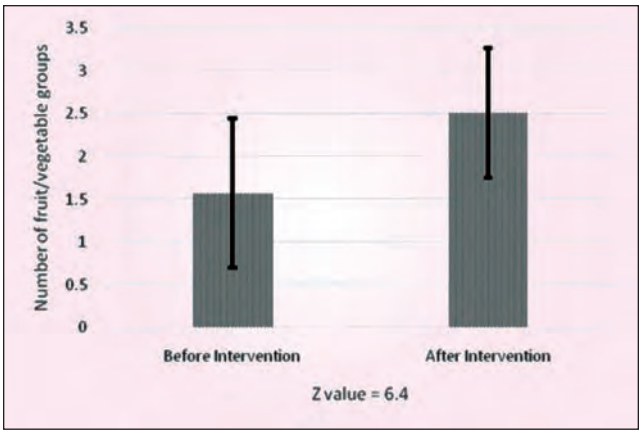


Fig. 6.8.2. Mean number of fruit/vegetable groups consumed before and after interventions

Dietary consumption pattern

In order to know the impact of nutrition-sensitive agriculture interventions, food consumption pattern of selected women was examined before and after the implementation of interventions. There was an increase in respondents consuming diversified food groups in their daily diet after interventions. Cereals (including millets) were the staple food consumed daily by the women in order to meet daily requirements of calories. Only 50.8% women consumed pulses daily but after the intervention (high yielding varieties of pulse crop, health related awareness programmes), the consumption was increased by 43%. Women of the region were consuming other vegetables mostly on a weekly basis but after interventions like demonstrations of nutri-gardens, 76.2% women have started consuming it on daily basis. Similarly, percentage of women consuming green leafy vegetables and milk & milk products daily has increased by 15 and 55.2%, respectively (Table 6.8.2). Before nutritional awareness programme and interventions, roots and tuber consumption is very high among women of hill region which has now slightly decreased after interventions as it has been balanced with other micro-nutrient rich food groups. Consumption of mushroom is also introduced in the project area among women which was earlier unknown food item for them.

Table 6.8.1. Minimum Dietary Diversity Score before and after nutrition-sensitive agriculture interventions

Range of Minimum Dietary Diversity Score	Before intervention	After intervention	Difference
Less than 5	69.8	7.9	Z value = 9.3*
% and above 5	30.2	92.1	P value = <0.0001
Mean and SD	3.9 ± 0.9	5.5 ± 0.8	

*significant at 0.05 probability level

Table 6.8.2. Food consumption pattern of women before and after implementation of nutrition sensitive agricultural interventions

Food Groups		Daily (%)	Weekly (%)	Occasionally (%)	Never (%)	% increase in respondents consuming food groups in their daily diet after intervention
Cereals	BI	100	-	-	-	0
	AI	100	-	-	-	
Pulses	BI	50.8	39.7	9.5	-	43
	AI	73	27	-	-	
Root & tubers	BI	95.2	4.8	-	-	-11.7
	AI	84	16	-	-	
Green leafy vegetables	BI	15.8	71.4	12.8		15
	AI	39.6	60.4	-	-	
Other vegetables	BI	-	23.8	76.2	-	100
	AI	76.2	23.8	-	-	
Meat/fish/egg/ mushroom	BI	-	11	28.6	60.4	0
	AI	-	23	15	39.7	
Milk and milk products	BI	28.6	36.5	19	15.9	55.2
	AI	44.4	28.6	14.3	12.7	

BI-Before Interventions AI-After Interventions

Awareness programme on importance of nutritional security

Demonstration of small improved tools in nutri-gardens

Demonstration on honey bee rearing in nutri-gardens

Training of farm women on nursery preparation

6.9. National Mission for Sustaining the Himalayan Ecosystem (NMSHE)

Pilot studies for revalidation

During *rabi* season of 2019-20, a total of 76.3 kg seed of different crops, *i.e.* wheat (*VL Gehun* 829, *VL Gehun* 804, *VL Gehun* 907, *VL Gehun* 892), lentil (*VL massor* 133), gardenpea (*Vivek matar* 11, *Vivek matar* 10), *toria* (VL*Toria* 3), *methi* (PEB), *Lahi* (*Hathikan*) and *Dhaniya* (PD1) were distributed among the farmers, which covered 1.40 ha area.

Out of the four wheat varieties, the highest yield was recorded for VL *Gehun* 829 and VL *Gehun* 892 (1,983 kg/ha each), followed by VL *Gehun* 907 (1,917 kg/ha) and the lowest in VL *Gehun* 804 (1,725 kg/ha). The comparative study between the experiment and farmers' field revealed that 27.9, 27.7 and 37.3% yield gap were recorded for VL *Gehun* 829, VL *Gehun* 907 and VL *Gehun* 804, respectively at farmers' field (Table 6.9.1). The varieties of lentil, *i.e.* VL *Masoor* 126 (1,819 kg/ha) and VL *Masoor* 133 (1,638 kg/ha) recorded 30 and 17% higher grain yield at farmers' field compared to experiment result. VL *Masoor* 126 produced 11% higher grain yield compared to VL *Masoor* 133 at farmers' field. The barley variety, VL *Jau* 118 produced 1,663 kg/ha at farmers' field, which was 20.8% lower than the experimental yield (Table 6.9.1).

During *kharif* 2019, a total of 85.7 kg seed of different crops, *i.e.* rice, maize, finger millet, barnyard millet, horsegram, soybean, french bean, grain amaranth was distributed among the farmers, which covered 4.27 ha area.

Table 6.9.1. Grain yield of different varieties of wheat (*Gehun*) and lentil (*Masoor*)

Crop	Variety	Yield (x00kg/ha) at farmer's field			Standard Deviation (x00kg /ha)	Experimental yield (x00kg/ha)	Deviation from Experimental yield (%)
		Mean	Lowest	Highest			
Wheat	VL *Gehun* 829	19.83	17.5	22.0	1.57	27.5 (25-30) (rainfed)	-27.89 (rainfed)
	VL *Gehun* 907	19.17	18.0	21.0	1.13	26.5 (25-28) (rain fed)	-27.66 (rainfed)
	VL *Gehun* 804	17.25	15.5	19.0	1.33	27.5 (25-30) (rain fed)	-37.27 (rain fed)
	VL *Gehun* 892	19.83	17.5	22.0	1.57	30-35 (32.5)	- 38.99
Lentil	VL *Masoor* 126	18.19	14.5	21.0	2.31	14.0 (12-16)	29.93
	VL *Masoor* 133	16.38	14.5	18.0	1.25	14.0 (12-16)	17.00

Table 6.9.2. Grain yield of different crop varieties

Crop	Variety	Yield (x00kg/ha)			SD (x00kg/ha)	Exp. Yield (q/ha)	Deviation from Exp. Yield (%)
		Mean	Lowest	Highest			
Finger Millet	VL *Mandua* 352	21.0	17.0	23.0	2.18	27.5 (25-30)	-23.6
	VL *Mandua* 347	21.3	18.0	23.5	1.70	27.5 (25-30)	-22.5
	VL *Mandua* 324	21.1	19.0	24.0	1.60	20.5 (19-22)	2.9
	VL *Mandua* 315	20.7	18.0	23.0	1.90	22.5 (20-25)	-8.0
Soybean	VL *Soya* 47	29.1	27.0	32.0	1.8	26 (25-27)	11.9
	VL *Soya* 65	29.6	25.0	32.0	2.3	12.5 (11-14)	135.3
	VL *Bhat* 201	29.2	27.0	31.0	1.3	27.00	8.1
Maize	VL *Makka* 31	20.1	17.0	23.0	2.0	42.5 (40-45)	-52.7
	VL Amber Popcorn	18.9	16.0	22.5	2.1	22.5 (20-25)	-16.0
Horse gram	VL *Gahat* 19	22.3	20.0	24.0	1.4	5.64	294.5
Amaranthus (Chua)	VL *Chua* 44	20.6	19.0	22.0	1.02	11.5 (10-13)	79.0

The barnyard millet variety, VL *Madira* 207 (2,230 kg/ha) produced 27.4% higher grain yield compared to the experimental yield. Among the finger millet varieties, the highest yield was recorded by VL *Mandua* 347 (2,130 kg/ha) followed by VL *Mandua* 324 (2,110 kg/ha), VL *Mandua* 352 (2,100 kg/ha) and the lowest in VL *Mandua* 315 (2,070 kg/ha). VL *Mandua* 347, VL *Mandua* 352 and VL *Mandua* 315 recorded lower yield at farmers' field, whereas VL *Mandua* 324 yielded 2.9% higher at farmers' field compared to the experimental yield. Among soybean varieties, the highest yield was recorded by VL *Soya* 65 (2,960 kg/ha), followed by VL *Bhat* 201 (2,920 kg/ha) and VL *Soya* 47 (2,910 kg/ha). It was observed that all soybean varieties produced higher yield at farmers' field in comparison to the experimental yield. Among the maize varieties, the highest yield (2,010 kg/ha) was recorded in VL *Makka* 31 followed by VL Amber Popcorn (1,890 kg/ha). The yields of all maize varieties at farmers' field were lower than the experimental yield. The yield of VL *Gahat* 19 at farmers' field was 2,225 kg/ha, which was 295% higher than the experimental yield. The variety of grain amaranth, VL *Chua* 44 produced (2,058 kg/ha) 79% higher grain yield compared to the experimental yield (Table 6.9.2).

Poly shed cum net house

In order to improve the yield of crops and to protect them from the damage of wild animals, a low-cost poly shed-cum-net house was constructed leaning to one side of the terrace riser.

Poly shed cum net house

Bio fencing

The wild animal is a major problem for hill agriculture. Most of the crops, vegetables, fruits are damaged by the monkey and wild boars. In order to prevent/restrict the entry of wild animals to agriculture fields, the bio-fencing through planting of mulberry cuttings was established around fields under NMSHE project. The survival of planting of mulberry cutting was 90%. The cuttings planted on risers didn't establish, but the survival of planting of cutting was 99%, when planted 50 cm inside the field. However, grazing of bio-fencing prepared from small cuttings by goats was observed after establishment. Hence, one-meter length cutting will be planted next year onwards to avoid damage by goats. The mulberry will be developed as hedge. It will restrict the free entry of wild animals and will provide the fodder for animals.

Bio fancing through mulberry

Construction of Vermicompost pit

One vermi-compost and Vermi wash pit using blocks was constructed.

Capacity building and forecsating

Analysis of Rainfall Variability and Farmers' Perception

Farmers' perception on climate change plays a key role for appropriate adaptation and mitigation strategies related to agricultural practices for

decision making on effective strategies for access to improved varieties and financial help to farmers. Perception of climate change and variability supported by local knowledge has helped to advance understanding of climate change and its impacts on agricultural production. Data was collected to examine factors which affect farmers' perception on climate change. Further, constraints experienced by farmers in adopting adaptation measures were also assessed. Data was collected from farmers of Almora, Nainital and Dehradun districts of Uttarakhand. Responses of 100 farmers towards climate change and adaptation strategy were recorded. Meteorological data was taken from IMD website. Standardised anomaly index was calculated for rainfall and compared with farmers' perception on rainfall variability (Fig. 6.9.1 & 6.9.2).

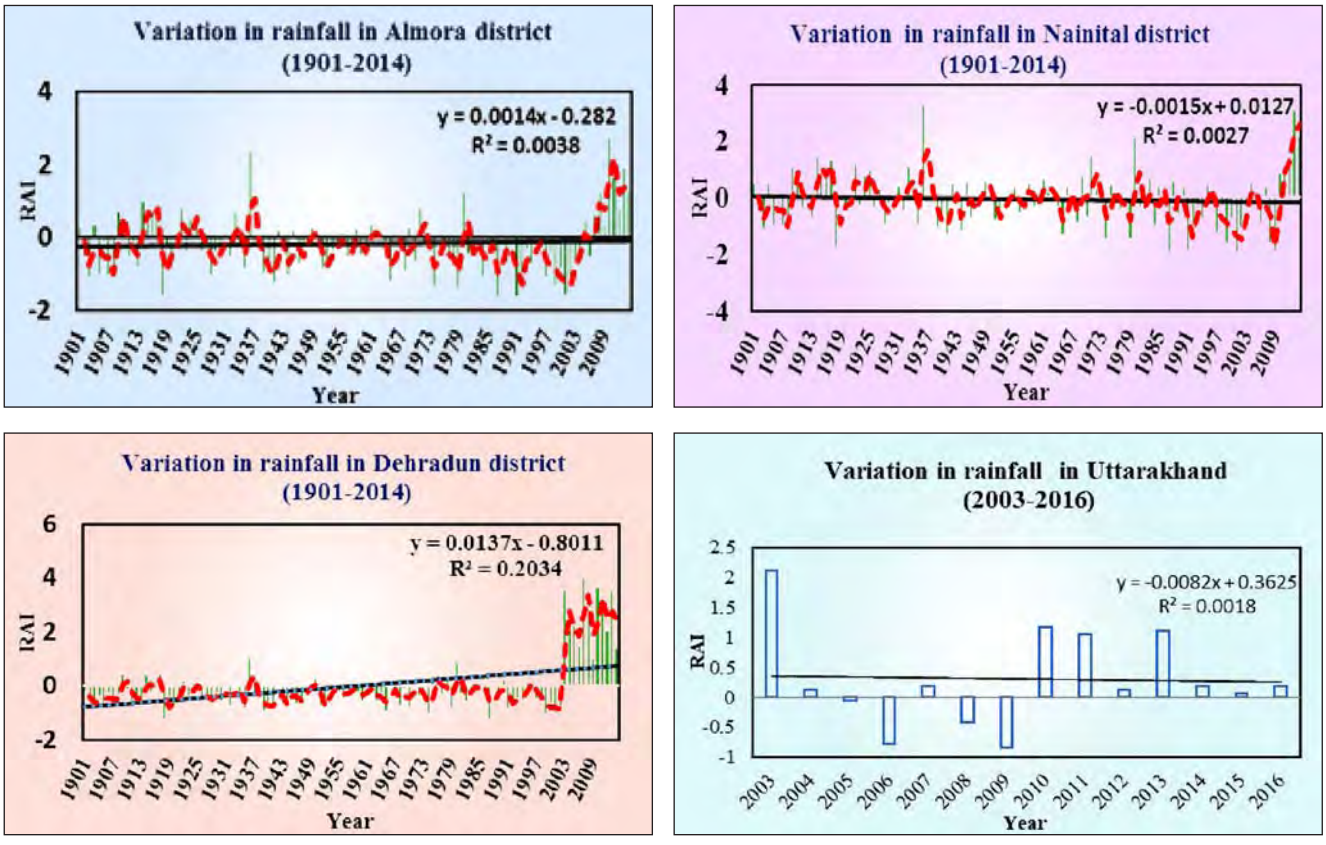


Fig. 6.9.1. Anomaly (RAI) and Moving average of rainfall of (a) Almora, (b) Nainital, (c) Dehradun and (d) Uttarakhand

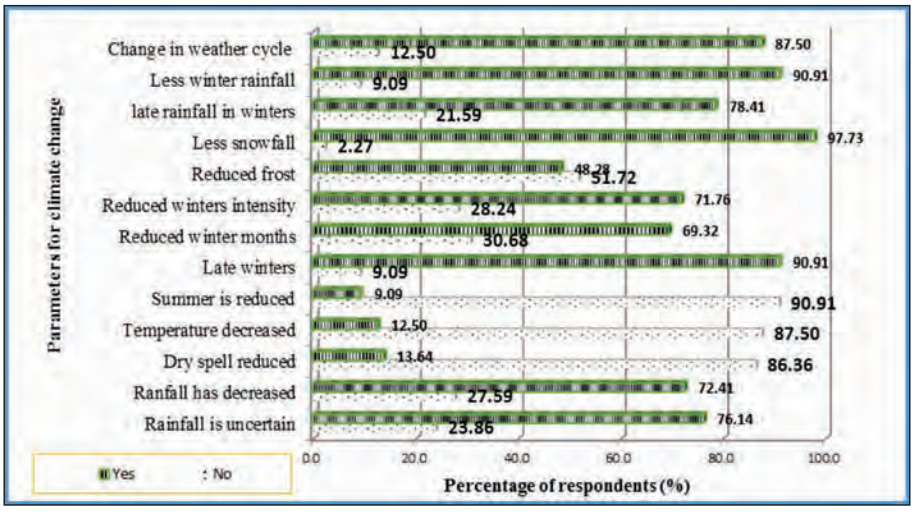


Fig. 6.9.2. Farmer's perception of climate change

Rabi **crop demonstration at Jur Kafun Farmers' field**

Kharif **crop demonstration at Jur Kafun Farmer's field**

Value addition in Barnyard millet (Processing, packaging and labelling)

Farmers' perception was compared with climate data of the study area. Farmers' perception about rainfall matches closely to the empirical observations. Most of the farmers are aware of the increasing temperature trend and fewer rains, which are in accord with empirical climatology records.

Factors affecting farmers' perception of climate change

Binary logistic regression was used to estimate factors those influence the farmers' perception in the area. Among the factors studied, number of crops grown, training experience and extension contact influenced farmers' perception on climate change positively. Hence, more attention must be given to trainings on climate smart agricultural practices and extension contact. Crop diversification must be promoted as an intervention. Gender concerns must be mainstreamed for creating awareness and enabling farmers for climate change adaptation (Table 6.9.3).

Table 6.9.3. Determinants of farmer's perception of climate change

Aware of climate change	Coef.	Std. Err.	z	P>z
Age (yrs)	0.042	0.027	1.57	0.116
Gender	-0.057	0.830	-0.07	0.945
Education	0.623	1.037	0.6	0.548
Land holding (ha)	0.649	0.493	1.32	0.188
No. of crops grown	0.581	0.218	2.67	0.008*
Training experience	1.854	0.673	2.75	0.006*
Extension contact	1.399	0.599	2.34	0.02*
_cons	-5.768	2.053	-2.81	0.005

*Significant at $p < 0.05$

Trainings/awareness creating/skill upgradation

A *kisan goshthi* was organized at Jur Kafun village on 14th November 2019, in which farmers were apprised with crop management practices for wheat and lentil. Information on the improved varieties of wheat was provided along with package of practices. Seed of *rabi* crops were distributed and demonstrated at farmers' field. Line sowing was demonstrated. In the *goshthi*, the profit from sale of processed barnyard millet was distributed to farm women of the group *"Jai Durga"*. The group processed 54 kg of barnyard millet and earned a profit of Rs. 1,585/- from its sale. Other farmers also showed their interest in taking up millet processing activity for income generation.

6.10. NABARD Funded Project

Formation and Promotion of Farmers' Producer Organisation

Under the project, two exposure visits showcasing and sale of agri products by Farmer Producer Organisation (FPO) at *Kisan Mela* was organized. Farmers were exposed to Haldwani and Rudrapur mandi for collective purchase of seeds, fertilizers and pesticides through FPO. During the year 2019, FPO carried out collective purchase and selling of vegetables of more than one lakh rupees. Biocontrol agents (*Bacillus cereus* WGPSB 2, *Trichoderma* 202 and *Trichoderma* 28) were distributed among FPO members as a measure of pest management.

Meeting of FPO members with scientists and NGO personnel

6.11. High Altitude Testing Site (HATS), Mukteshwar

Yield evaluation trials

Wheat: Fourty-two entries including 2 checks (VL 907 & HS 562) were planted in 2 replications and entry VW 1823 and VW 1814 were the top yielding entries with a grain yield of 46.0 and 45.7 q/ha, respectively.

French bean: Eighteen new genotypes (advance lines) were evaluated with three checks (VL Bean 2, *Arka Suvidha*, *Swarn Priya* and *Pant Anupama*) for their suitability to high altitude in randomized block design during *kharif* 2019. VLFB 1805 (144.3 q/ha), VLFB 1804 (133.7 q/ha) and VLFB 1827 (129.1 q/ha) were found promising during off season cultivation in high altitude.

Garden pea: Twenty-eight new genotypes of garden pea (advance lines) and seven checks were evaluated for their suitability to high altitude during off season in randomized block design during *kharif*, 2019.

VP 1714 and VP 1803 produced 98.5 and 94.2q/ha green pod yield, respectively.

Breeder seed production

Onion & Garlic: VL *Piaz* 3 and VL *Lahsun* 2 (long day garlic) were grown for breeder seed production in 1000 m² and 500 m² area, respectively. Around 5 and 6 q bulbs of onion and garlic were produced as planting material, respectively.

Saffron cultivation

Two quintals of saffron corm were planted in raised bed 20 cm channel between beds and crop was maintained in around 1000 m² areas.

Seedling production

Around 4 Lakhs seedling of VL *Piaz* 3 were produced and supplied under SCSP and TSP programme of Institute during 2018-19.

Station trial of garden pea

Harvesting of VL *Lahsun* 2 (Breeder seed)

Raised beds of Saffron crop

Nursery of VL *Piaz* 3

Newly constructed polyhouse (200 m²)

7. Technology Assessment and Transfer

Krishi Vigyan Kendra, Chinyalisaur

Krishi Vigyan Kendra, Bageshwar

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 feed back 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 and 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. Krishi Vigyan Kendra, Chinyalisaur

7.1.1. Trainings

Krishi Vigyan Kendra (ICAR-VPKAS) Chinyalisaur, Uttarkashi has offered 42 training courses for the practicing farmers, farm women, and rural youths on various topics in the disciplines of Horticulture, Agricultural Extension and other running projects with an objective to uplift the socio-economic status of underprivileged farmers through improvement in agriculture production, allied enterprises. Total 1113 participants (392 Male and 721 Female) attended the programme (Table 7.1.1).

Table 7.1.1. Discipline wise training programme conducted by KVK, Chinyalisaur

Discipline	No. of courses	No. of participants		
		Male	Female	Total
Horticulture	26	242	435	677
Agricultural Extension	10	55	229	284
Sponsored Training Programme	6	95	57	152
Total	42	392	721	1113

7.1.2. Front Line Demonstrations

Front line demonstration on oilseed, pulses and other crops were conducted at the farmers' field in an area of 47.0 ha during *kharif 2019* and *rabi* 2019-20 (Table 7.1.2 & 7.1.3). A total of 780 farmers were benefited.

Table 7.1.2. Front line demonstration conducted during *kharif* 2019

Crop	Variety	Area/ Nos.	No. of farmers
Soybean	VL *Soya* 63/65	5.0	71
Okra	VL *Bhindi* 2	2.0	21
Pigeon pea	VL *Arhar* 1	7.5	155
Finger Millet	VL *Mandua* 324	5.0	156
Maize	VL *Makka Sankul* 31	5.0	60
Total		24.5	463

Table 7.1.3. Front line demonstration conducted during *rabi* 2019-20

Crop/ livestock	Variety	Area/Nos.	No. of farmers
Pea	Vivek *Matar*- 11	1.0	33
Onion	VL *Piaz* -3	0.5	15
Lentil	VL *Masoor* 514 and 126	10.0	132
Wheat	VL*Gehun* 829, 892 and 907	10.0	126
Oat	Kent	1.0	11
Total		22.5	317

7.1.3. On-Farm Trials

Six on-farm trial (OFTs) were conducted in different problems under various farming system (Table 7.1.4).

Table 7.1.4. On farm trials conducted

Year 2019	Crop/ Variety	Replication	Farmers
Management of Marssonina blotch (*Marssonina coronaria*) in apple orchards.	Apple / Red Delicious	5	10
Management of Stemphylium blight in onion during seed production.	Onion/ VL *Piaz*-3	5	5

Assessment of effectiveness of mobile messaging and social media (WhatsApp) in bridging the information needs of the vegetable growers	Whatsapp in bridging the information needs of the vegetable growers	-	10
Assessment of effectiveness of nutritional practices for correcting malnutrition	Protein, calcium & iron rich food products (Soybean, sugar, *ragi*, barnyard millet and moong dal)	-	5
Nutritional kitchen gardening	Seeds and seedlings of seasonal vegetables.	-	10
Assessment of high yielding varieties of vegetable pea for mid and lower hills of Uttarkashi District	Vivek *Matar* 13 Vivek *Matar* 15	-	10

7.1.4. Seed Production

A total of 41.84 q seeds and 2,18,160 seedlings were produced at KVK farm.

7.1.5. Other Extension Activities

- ***Skill Development Training:*** The KVK organized two trainings for Assistant Gardener and Agriculture Extension Service Provider from January 21 to February 28, 2019 (200 hr each), in which 20 candidates participated in each training.
- ***Republic Day***: KVK celebrated 70th Republic Day on January 26, 2019.
- ***Pradhan Mantri Kisan Samman Nidhi Yojna:*** The KVK organized live telecast of the *Pradhan Mantri Kisan Samman Nidhi Yojna* on February 24, 2019 in which more than 200 farmers participated.
- ***Rural Agriculture Work Experience (RAWE):*** Nineteen B.Sc. Agriculture students joined Rural Agriculture Work Experience (RAWE) at KVK, Uttarkashi.
- ***Kisan Mela:*** KVK participated and awarded 1st prize in the kisan mela organized by ILSP-*Aajivika* project at Uttarkashi on February 15-16, 2019.
- ***World Environment Day:*** The KVK organized the World Environment Day and a plantation drive on June 5, 2019, and 1000 plants were planted.
- ***International Yoga Day:*** Yoga camp was organized on June 21, 2019 in which *yoga aasans* were practiced.
- ***Jal Shakti Abhiyan:*** *Kisan goshti* and farmers'-scientist interaction under *Jal Shakti Abhiyan* was organised on July 30, 2019 in which total 105 farmers and 35 extension officials participated.
- ***Independence Day:*** KVK celebrated Independence Day on August 15, 2019 in which different programmes were organized.
- ***Parthenium Eradication Week:*** The KVK celebrated parthenium eradication week from August 16 to 22, 2019 in which various programmes like farmers *gosthi*, rallies, parthenium eradication drive at KVK and nearby villages were organized.
- ***Harmony Day:*** Harmony Day was organized on August 20, 2019 at KVK, Uttarkashi in which a pledge was taken by all the staff and other participants.
- ***National Nutrition Week:*** The KVK celebrated National Nutrition Week from September 1 to 7, 2019 by organizing various nutrition awareness program like trainings, *gosthi*, awareness meetings for farmers and farm women.
- ***Pashu Arogya Mela:*** The KVK organised a *Pashu Arogya Mela* on September 11, 2019 and webcasted the launch of 'National Animal Disease Control Programme (NADCP) for FMD & Brucellosis' and 'National Artificial Insemination Programme (NAIP)' by Hon'ble Prime Minister in Mathura, Uttar Pradesh.
- ***Hindi Chetna Maas:*** The KVK celebrated *Hindi Chetna Maas* from September 14 to October 13, 2019 in which awareness was created on more use of hindi in offices.
- ***Scientific Advisory Committee:*** The KVK, Chinyalisaur organized 15th Scientific Advisory Committee meeting on September 17, 2019 at KVK Uttarkashi.

- ***Plantation Drive:*** The KVK organized "*Vrihad Vriksharopan*" & awareness program on September 17, 2019.
- ***Swachatta Hi Sewa:*** The KVK organized various activities during "*Swachhata hi Sewa*" campaign from September 11 to Oct 2, 2019 with local residents, farmers, nagar palika, Indian Army & students. Various activities like sanitation drive in colonies, national highway and market; awareness rallies, *gosthis* were organized during the programme.
- ***Gandhi & Shashtri Jayanti:*** The KVK celebrated Gandhi & Shashtri *Jayanti* on October 02, 2019 by organising various programs like quiz and speech competition.
- ***Fertilizer Awareness Programme:*** The KVK organized one day workshop on Fertilizer Awareness on October 22, 2019, benefitting more than 150 farmers.
- ***Vigilance Awareness Week:*** The KVK celebrated Vigilance Awareness Week from October 28 to November 02, 2019.
- ***Swchatta Hi Sewa:*** Various activities and events for recycling of single use plastic under "Swachhata hi Sewa" campaign were organised from October 3-27, 2019 with local residents, farmers, *nagar palika*, Indian Army & students.
- ***Rashtriya Ekta Diwas:*** On the occasion of birth anniversary of Sardar Vallabhbhai Patel on October 31, 2019, oath was taken by KVK staff.
- ***Exposure Visit of Farmers in Kisan Mela:*** KVK organized exposure visit of 20 farmers to experimental farm, Hawalbag, ICAR-VPKAS in the Kisan Mela on November 15, 2019.
- ***Energy Conservation Workshop:*** The KVK organized one day workshop cum awareness programme on 'Energy efficient agricultural pump set & energy conservation' on November 20, 2019 in which more than 150 farmers and officials participated.
- ***Constitution Day:*** The KVK Uttarkashi celebrated India's 70th Constitution Day on November 26, 2019 by organizing various events.
- ***World Soil Day:*** The KVK Uttarkashi celebrated World Soil Day by distributing soil health cards on December 5, 2019.
- ***Newspaper Coverage*:** A total of 41 activities were covered in various daily local and national newspapers.

7.2. KVK Bageshwar

7.2.1.Trainings

The KVK organised 42 training programmes inculding 08 sponsored training programmes, with the participation of 793 farmers (404 males, 389 females) on various topics (Table 7.2.1).

Table 7.2.1. Training Programmes conducted during 2019

Discipline	No. of trainings	No. of Trainees		
		Male	Female	Total
Animal Science	08	127	86	213
Plant Protection	10	124	67	191
Horticulture	09	54	55	109
Home Science	07	03	117	120
Sponsored Training	08	96	64	160
Total	**42**	**404**	**389**	**793**

7.2.2. Front Line Demonstrations

Front Line Demonstrations (FLDs) on various crops in *kharif* (2019) & *rabi* (2019-20) were conducted on 66.2 ha (29 ha in *kharif* and 37.2 ha in *rabi*) benefitting 2,404 participants (Table 7.2.2). Under poultry farming five hundred chicks were distributed to 33 farmers under FLD on backyard poultry farming. The FLDs resulted in increasing average yield from 10.7 to 48.6% in various hill crops.

Table 7.2.2. Details of frontline demonstrations on crops and other aspects

Season	Crop	Variety	Area (ha.)	No. of beneficiaries
kharif 2019	Cereals & millets	VL *Dhan* 62, 65 & *Vivek Dhan* 154, VL *Dhan* 156, Pusa Basmati 1509, VL *Mandua* 324 & VL *Madira* 172	16.95	412
	Oilseeds	VL *Soya* 47, VL *Soya* 65	6.00	341

kharif 2019	Pulses	VL *Aarhar* 1, VL *Gahat* 10 and VL *Gahat* 19	3.60	136
	Vegetables and fruits	Okra (VL *Bhindi* 2), cauliflower (Snowcrown F1), cabbage (*Varun* F1) and Red June	1.95	90
	Fodder	Maize (African Tall)	0.50	15
Sub-total			29.00	994
rabi 2019-20	Cereals & millets	VL *Gehun* 829, 892, 907 & 953,VL *Barley* 118 & 130	12.80	474
	Oil seeds	Ts 67 and *Uttara*	11.00	230
	Pulses	VL *Masoor* 126 & PL 8	10.30	340
rabi 2019-20	Vegetables	*Vivek Matar* 10, 12, 7, Arkel & VL *Piaz* 3	2.12	255
	Animal science	Poultry Chebro	500 Chicks	33
	Fodder	Oat JHO882, Berseem Meskavi/ *Vardan*	1.0	78
Sub-total			37.22 ha & 500 chicks	1410
Grand Total			66.22 ha & 500 chicks	2404

7.2.3. On Farm Trials

The following trials were conducted at farmers' fields:

- ***Management of Fusarium wilt and spiral nematode in pigeon pea:*** Chemical treatment (Thiram @ 2 g/kg seed treatment and Carbendazim @ 1.0 g/l water for drenching and Nemagone @ 2.0 mL/l soil drenching) yielded 8.50 q/ha, while bioagent treatment (*Trichoderma harzianum* @ 5g/kg 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 7.0 q/ha in comparison to farmers practice of 6.25 q/ha.
- Total three on-farm trials (OFTs) were started in *rabi* (2019-20) season. Ten trials under plant protection with title "*Efficacy of chemicals for management of purple blotch (Alternaria pori) disease in onion (VL Piaz 3)*" were conducted in 0.1 ha area. Two OFTs namely "*Varietal assessment of strawberry*" and "*Varietal assessment of newly released varieties of vegetable pea*" were conducted in 0.1 ha (5 farmers) area each.

7.2.4. Production of Seed and Bio-products

- During 2019-20, total 55.57 q quality seed, 1,21,965 numbers of vegetable seedlings, 160 q vermicompost and 4830 L milk were produced and a total revenue of Rs 4.43 lakhs was generated.

7.2.5. Other Extension Activities

- ***Farmers Field Days:*** The KVK organized three field days that includes two in Okra (VL *Bhindi* 2) and one in Soybean (VL *Soya* 65) crop in which 96 farmers (53 Male and 43 Female) participated.
- ***Live Telecast of Inauguration of National Animal Disease Control Programme:*** The KVK, Bageshwar organized National Animal Disease Control Awareness Programme (FMD & Brusolosis disease) for farmers that was inaugrated by Hon'ble Prime Minister of India at Mathura on September 11, 2019 in which 84 farmers participated.
- ***Large Scale Plantation Programme:*** The KVK organized large scale plantation programme on September 17, 2019, in which Shri Kishan Singh Malra "*Vraksha Mitra*" was the chief guest. Total 85 farmers participated in the programme sponsored by IFFCO.
- ***12th SAC Meeting of KVK:*** The KVK organized 12th meeting of Scientific Advisory Committee on May 08, 2019 under the chairmanship of the Director, ICAR- VPKAS, Almora.
- Organized one-day training programme in collaboration with UREDA, Bageshwar on "Energy and Water Conservation" sponsored by ICAR-ATARI, Zone 1, Ludhiana and DEE, New Delhi on May 28, 2019.
- KVK Bageshwar was associated in Action Plan Workshop 2019-20 of KVK's of Uttarakhand of ATARI Zone 1, Ludhiana at ICAR-VPKAS, Almora on July 22, 2019.
- ***National Nutrition Week:*** The KVK Bageshwar organized National Nutrition Week from September 01-07, 2019. One training programme

was conducted on importance of small millets for nutrition and distributed 8 kg of vegetable seeds to 20 farmwomen at KVK.

- ***Breast Feeding Week:*** The KVK Bageshwar organized Breast-feeding week from August 01 to 07, 2019. One awareness programme was conducted at *Aaganbari* & ANM centre and on campus training programme for lactating & pregnant women at KVK.
- ***Parthenium Awareness Week***: The KVK organized *Parthenium* weed eradication awareness programme week from August 16-22, 2019 by conducting different activities, *viz.* uprooting of weed from KVK campus, resident areas, nearby villages & public places. Awareness rally by NCC student of G.I.C., Kafligair, poster and speech competitions for students were also conducted.
- ***Fertilizer Application Awareness Programme:*** The KVK organized live telecast & *krishak goshti* on fertilizer application awareness programme for farmers that was inaugrated by Hon'ble Union Agriculture Minister on October 22, 2019. A total 124 farmers were participated in the programme.
- ***Swchatta Hi Sewa:*** *Swachhata hi sewa* programme was celebrated from September 11 to October 02, 2019 by organizing various activities, *viz.* awareness about no use of single use plastic among farmers & student, collection & dispose of plastic materials from KVK, campus, adopted villages, public path, local river, *naula* (local water source) & nearby town, organization of quiz, essay, speech & poster competitions.
- ***Participation in Fairs***: The KVK received second prize in *Vikas Pradarsani* of *Uttarayani Mela* (January 14-21, 2019) and first prize in *Hilance Kisan Mela* (February 12-13, 2019) at Bageshwar.

7.3. Institute Headquarter

7.3.1. Trainings Organized

Institute organized 19 trainings and 29 exposure visits for farmers, agricultural officers benefitting 717 persons during 2019 (Table 7.3.1).

Table 7.3.1. Trainings organized at the Institute

Topic	Block/District	Duration	Coordinators	No. of Trainees
Training				
Kaushal Vikas Sukshm Sinchai Taknikiyan	Block – Hawalbag, Dwarahat, District - Almora	December 27, 2018 to January 25, 2019 (30 day)	Dr. Jitendra Kumar	20
Kaushal Vikas Mushroom Utpadan	Block – Hawalbag, Dwarahat, Takula, Bageshwar District – Almora	February 01, 2019 (01 day)	Dr. K.K. Mishra	17
Parvatiya Fasalon ka Bijotpadan Evam Kirshigat Udyam Kaushal Evam Udhamita Vikas under ICAR Seed Project	Block- Bhaisiachana District – Almora	February 14-16, 2019 (3 day)	Drs. Renu Jethi and Hanuman Ram	24
Janjatiya Krishakon Ka Bijotpadan Mein Kaushal Vikas under TSP	Block- Sitarganj District – Udham Singh Nagar	February 19-21, 2019 (3 day)	Drs. Chaudhari Ganesh Vasudev, Hanuman Ram and Devender Sharma	34
Parvatiya Fasalon Ka Bijotpadan evam Krishigat Udyam under TSP	District- Lahaul Spiti	February 25 to March 1, 2019 (5 days)	Drs. Renu Jethi and Chaudhari Ganesh Vasudev	48
Poshan Vatika Mein Adhik Utpadan Hetu Unnat Takneekiyan under N.M.H.S. Project	Block- Berinag District – Pithoragarh	March 11-13, 2019 (3 days)	Drs. Renu Jethi and Ankita Kandpal	21
Summer training on hill agriculture for B.Sc. (Ag.) student from B.H.U., Varanasi	B.H.U., Varanasi	May 7-10, 2019 (4 days)	Drs. J. Stanley, Dibakar Mahanta and V.S. Meena	20

Topic	Block/District	Duration	Coordinators	No. of Trainees
Summer training on hill agriculture for B.Sc. (Ag.) student from B.H.U., Varanasi	B.H.U., Varanasi	May 21-24, 2019 (4 days)	Drs. J. Stanley, Dibakar Mahanta and V.S. Meena	21
Summer training on hill agriculture for B.Sc. (Ag.) student from B.H.U., Varanasi	B.H.U., Varanasi	May 28-31, 2019 (4 days)	Drs. J. Stanley, Dibakar Mahanta and V.S. Meena	29
Sensitization Programme on Maize Fall Army Worm Management Strategies for officials of State Agriculture Department, Seed Certification & Seed Production Agencies	Agriculture Department of Uttarakhand	June 7, 2019 (1 day)	Dr. R.K. Khulbe	13
Training on Doubled Haploid in Capsicum	Scientist from ICAR-VPKAS, Almora	August 5-7, 2019 (3 day)	Drs. N.K. Hedau, Arun Agrawal and Mr. Rohit	02
Training for Eco-taskforce personnel on hybrid napier grass cultivation and management for forage production	ITBP personnels	August 19-20, 2019 (2 day)	Dr. R.P. Yadav	10
Training Programme on *Unnat Sabji Utpadan evam Chara Prabandhan*	Block – Khetikhan District – Champawat	August 26-28, 2019 (3 day)	Drs. Anuradha Bhartiya, Kushagra Joshi and Hanuman Ram	30
Training Programme on Improved Production Technologies in Hill Crops for NEH Progressive farmers	District – Bishnupur, Tripura, Ribhoi, Pereu, Dimapur	September 16-19, 2019 (4 day)	Dr. K.K. Mishra	23
Training Programme on Improved Production Technologies in Hill Crops for NEH Progressive farmers	State – Manipur, Tripura, Nagaland, Mizoram	September 25- 30, 2019 (6 day)	Dr. R.K. Khulbe	18
Training Programme on Improved Production Technologies for Doubling farmer income for KVK SMS of Zone-VII under New program	North East States	November 03-07, 2019 (5 day)	Drs. J. Stanley, N.K. Hedau and R.K. Khulbe	20
Training Program on Improved Agricultural Technologies for doubling farmer income for KVK SMS of Zone-VII	State – Manipur, Meghalaya, Tripura, Nagaland, Mizoram	November 15-19, 2019 (5 day)	Drs. J. Stanley, K.K. Mishra and Sher Singh	13
Training Programme on *Jaivik Kheti*	Block – Amariya, Madanapur, Bhawalkhera, Bisalpur District – Pilibhit, Badaun, Bareilly, Shahjahanpur (U.P.)	November 18-22, 2019 (5 days)	Drs. Dibakar Mahanta, J.P. Aditya, V.S. Meena, Kushagra Joshi and R.P. Meena	30
Exposure Visits				
Exposure visit of students, G.I.C. Devlikhet, Almora	Block – Hawalbag District – Almora	February 05, 2019	Dr. Ramesh Singh Pal	66
Exposure visit of students, G.I.C. Devlikhet, Almora	Block – Hawalbag District – Almora	February 06, 2019	Dr. Manoj Parihar	63
Exposure visit of students, G.I.C. Lodhia, Almora	Block – Hawalbag District – Almora	February 11, 2019	Dr. Dibakar Mahanta, Er. D.C. Mishra	125
Exposure visit of students, G.I.C. Kathpuriya, Almora	Block – Hawalbag District – Almora	February 13, 2019	Dr. Dibakar Mahanta, Er. D.C. Mishra	37

Topic	Block/District	Duration	Coordinators	No. of Trainees
Exposure visit of students, Rajkiya Uchhattar Madhyamik Vidhyalaya, Raun-Dal, Almora	Block – Hawalbag District – Almora	February 23, 2019	Dr. Ramesh Singh Pal	30
Exposure visit of students, G.I.C. Jainoli, Tarikhet, Almora	Block – Tarikhet District – Almora	February 25, 2019	Dr. Ramesh Singh Pal	72
Exposure visit of students, Rajkiya Uchhattar Madhyamik Vidhyalaya, Talad, Almora	Block – Hawalbag District – Almora	February 26, 2019	Dr. N. Chandra	19
Exposure visit of students, Holy Angel Public School, Almora	Block – Hawalbag District – Almora	April 23, 2019	Dr. N. Chandra and Dr. V.S. Meena	20
Exposure visit of I.F.S	District – Dehradun	April 24, 2019	Dr. N. Chandra	32
Exposure visit of B.Sc. (Zoology) students from L.S.M.G.P.G.C., Pithoragarh	District – Pithoragarh	May 24, 2019	Dr. N. Chandra and Dr. Ramesh Singh Pal	22
Exposure visit of farmers	Block – Garur District – Almora	July 25, 2019	Dr. N. Chandra and Dr. J. Stanley	10
Exposure visit of GEF Project farmers	Block – Hawalbag, Tarikhet and Dwarahat District – Almora	July 26, 2019	Dr. Anuradha Bhartiya	21
Exposure visit of students, G.I.C. Hawalbag, Almora	Block – Hawalbag District – Almora	August 14, 2019	Dr. N. Chandra	32
Exposure visit of farmers	Block – Dwarahat, Tarikhet, Hawalbag District – Almora	August 27, 2019 (1 day)	Dr. Vijay Singh Meena	35
Exposure visit of farmers, under Lok Chetna Manch, Ranikhet	Block – Ranikhet District – Almora	September 16, 2019	Dr. N. Chandra	18
Exposure visit of B.Sc. (Ag.) students, Invertis University, Bareilly	District – Bareilly	October 03, 2019	Dr. Dibakar Mahanta	20
Exposure visit of Indian Administrative Service (IAS) trainees to ICAR-VPKAS	LBSNAA, Masoorie, Uttarakhand	October 14, 2019	Drs. P.K. Mishra & Nirmal Chandra	05
Exposure visit of B.Sc. students from Garhwal University, Srinagar	District – Pauri Garhwal	October 21, 2019	Dr. V.S. Meena	30
Exposure visit of students, Rajkiy Uchhattar Madhyamik Vidhyalaya, Raun-Dal, Almora	Block – Hawalbag District - Almora	October 23, 2019	Dr. Ramesh Singh Pal	18
Exposure visit of Nehru Yuva Sangathan	District- Almora, Champawat and Pithoragarh	November 16, 2019	Dr. Ramesh Singh Pal	40
Exposure visit of students of Koormanchal Academy Kosi, Almora	District - Almora	November 16, 2019	Dr. Ramesh Singh Pal	30
Exposure visit of students of Koormanchal Academy Kosi, Almora	District - Almora	November 18, 2019	Dr. Ramesh Singh Pal	30

Topic	Block/District	Duration	Coordinators	No. of Trainees
Exposure visit of students, G.I.C. Jainoli, Almora	District- Almora	November 25, 2019	Dr. J.P. Aditya Er. D.C. Mishra	55
Exposure visit of students, Rajkiya Uchhattar Madhyamik Vidyalaya, Dhaura, Almora	District- Almora	November 30, 2019	Er. D.C. Mishra	22
Exposure visit of students, G.I.C. Dwarson Almora	District- Almora	December 12, 2019	Er. D.C. Mishra	86
Exposure visit of farmers, under Jalagam Workshop	District- Uttarkashi	December 17, 2019	Dr. R.P. Meema Dr. Hanuman Ram	28
Exposure visit of farmers under *Harit Kaushal Vikas* programme	District- Almora	December 21, 2019	Dr. Subbanna	15
Exposure visit of students, G.I.C Ratighat, Nainital	District- Nainital	December 21, 2019	Er. D.C. Mishra	123
Exposure visit of students, Uchhatar Madhyamik Vidyalaya, Reetha	District- Nainital	December 23, 2019	Dr. Ramesh Singh Pal	23
Exposure visit of students, Uchhatar Madhyamik Vidyalaya, Chomu	District- Almora	December 28, 2019	Dr. Ramesh Singh Pal	31

7.3.2. Front Line Demonstration

To assess the performance of newly released varieties of small millets, soybean, rice, wheat and maize hybrids at farmers' field, Front Line Demonstrations (FLDs) were conducted in a total of 94.2 ha area across the state benefitting more than 450 farmers.

Soybean/ black soybean

Front Line Demonstrations of improved soybean and black soybean varieties with recommended package of practices for the cultivation were conducted in 2.50 ha area at *Patia* and *Katura* villages of Almora district during *kharif* 2019 involving 102 farmers. In FLDs, improved soybean varieties (VL *Soya* 59, VL *Soya* 47, VL *Soya* 63 and VL *Soya* 89) exhibited an average superiority of 25-30% whereas, black soybean varieties (VL *Soya* 65 and VL *Bhat* 201) yielded 45-55% higher than local traditional cultivars. In soybean and black soybean, truthfully labelled seed (approx. 3.5q) of improved varieties VL *Soya* 89 and VL *Bhat* 201 have been produced at experimental farm, ICAR-VPKAS, Almora during *Kharif* 2019 for the conduction of FLDs during *Kharif* 2020. To generate awareness among farmers about improved varieties, soybean production technology, crop protection, value addition and marketing options, a field day on soybean was organized on September 30, 2019 at *Patia* village of Almora district in which 104 farmers participated.

Front line demonstrations at Patia village

Small Millets

Front line demonstrations of four improved varieties of finger millet (VL *Mandua* 376, VL *Mandua* 379, VL *Mandua* 352 and VL *Mandua* 324) was conducted in 14.5 ha area at five villages of Kotdwara (Pauri-Garhwal), Uttarakhand. The improved varieties (VL *Mandua* 376, VL *Mandua* 379, VL *Mandua* 352 and VL *Mandua* 324) along with management practices exhibited yield advantage of 50.3, 43.2, 39.7 and 36.5% over the farmers practice, respectively. Finger millet field day was organised on September 30, 2019 and October 01, 2019 at two different blocks of Kotdwara (Pauri- Garhwal) to demonstrate farmers the benefits of adopting high yielding short duration varieties (VL *Mandua* 352, VL *Mandua* 376, VL *Mandua* 379 and VL *Mandua* 380) and management technologies. During the field days, 118 farmers were present belonging to four villages (Bamoli, Kathurbada, Goom and Gueen Bada), out of which 50% were women. Utility of *Vivek* millet thresher was also demonstrated at all the villages to reduce the drudgery involved in post-harvest management of finger millet.

Rice

Front line demonstrations of VL *Dhan* 68 was conducted during *Kharif* 2019 in 5.0 ha area of 5 villages of Almora District involving 41 farmers. The performance of improved cultivar was higher than the local checks namely Taichung, Thapachini and China 4. The average yield was recorded 4,173 kg/ha and overall yield advantage of improved cultivar was 21.9 per cent over local checks.

Monitoring of rice demonstration

Wheat

Wheat frontline demonstration of improved wheat variety VL *Gehun* 953 was conducted along with recommended package of practices in 7.2 ha area of 2 villages (Mangalta and Lingunta) of Almora district benefitting 63 farmers during *rabi* 2018-19.

Monitoring of finger millet demonstration

Monitoring of wheat demonstration

Spraying of weedicide in wheat demonstration


Harvesting and data collection in wheat demonstration

The yield and economic returns of FLD plot were compared with the corresponding farmers' practice. FLDs conducted at farmers' fields indicated that improved production technology of VL *Gehun* 953 produced an average yield of 3,760 kg/ha during 2018-19 which was 20.5% higher than the other improved varieties sown by farmers. Technology index was found to have negative value during 2018-19 showed that improved production technology of VL *Gehun* 953 performed better at farmers' field than its potential. Incidentally, 2018-19 received good rainfall too suggesting that this variety may capitalize if inputs are available. Further, economics analysis of data showed that cultivation of VL *Gehun* 953 along with recommended practices gave higher net return of Rs 35,739 compared to farmers practice (Rs 25,323). The profitability analysis exhibited that cultivation of VL *Gehun* 953 was highly profitable with benefit cost ratio of 1.06.

A three days training was organized for farmers on "*Parvatiya phasalon ka beejotpadan evam krishigat udyam*" at ICAR-VPKAS during February 14-16, 2019. Moreover, the women farmers were also trained in weedicide application through sprayers.

Three days training organized for farmers on seed production of hill crops

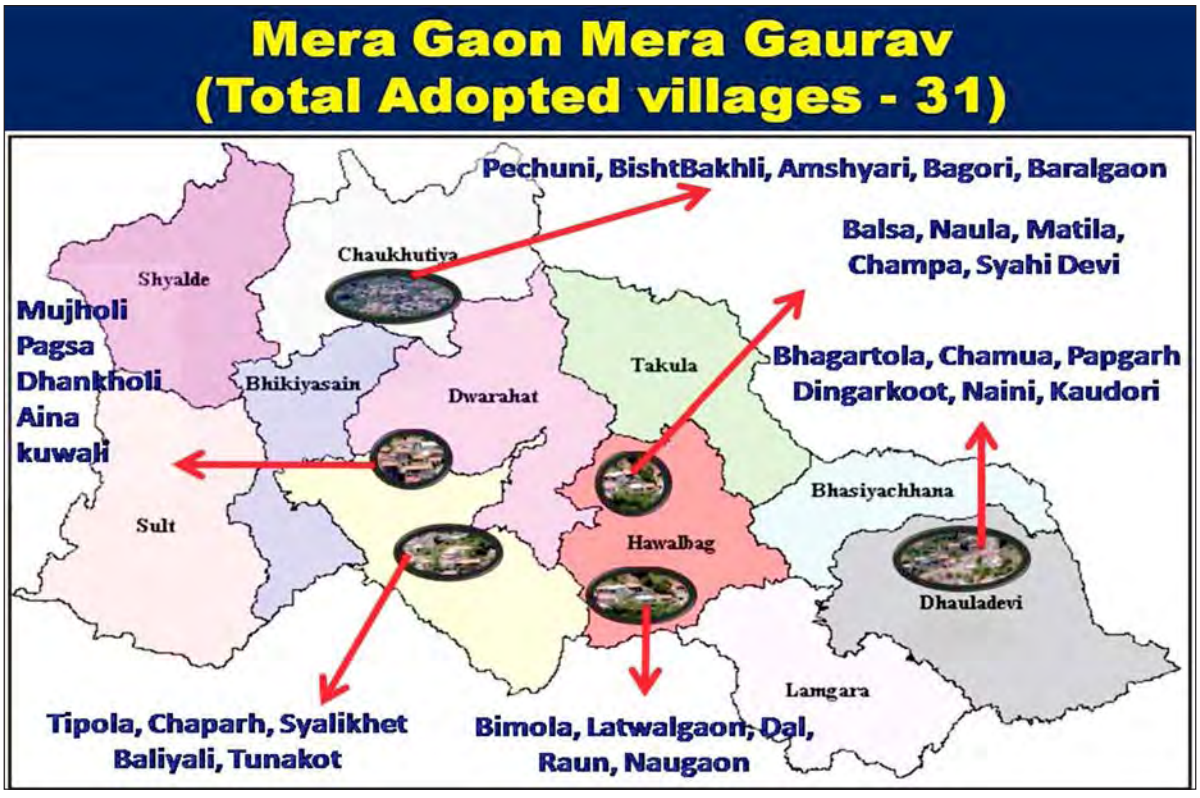
Maize

During *kharif* 2019, frontline demonstrations of VMH 45 were conducted in Dhanpau-Lakhwad, Dehradun (50 ha), Chamba, HP (5.0 ha), Jammu & Kashmir (5.0 ha each) and Peren, Nagaland (5.0 ha). In the FLDs, the yield of VMH 45 was assessed to be in the range of 45-55 q/ha and the superiority over the local cultivar was 37-52 per cent. Maize field days were organized at Bhanota (Chamba, HP), Jalukiekam (Peren, Nagaland) and Dhanpau (Kalsi, Dehradun).

Maize at farmer's field

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.



Drying of products in VL Solar Drier

Kudzu vine for fodder

Kiwi cultivation by farmer

1 m length bottle gourd harvested by farmer

Disease and pest surveillance in vegetable crop

Training on composting technique

Millet crop seed distribution to farmers

Farmer with vegetable produce at Bhagartola village

Activities organized under MGMG by the Institute

Name of activity	No.	No. of farmers participated/ benefitted
Visit to village by teams	55	884
Interface meeting/ *Goshthies*	20	612
Trainings conducted	9	92
Mobile based advisories	35	1278
Literature support provided	1598	590
Awareness created	25	921
Linkages developed with other agencies	4	261

7.3.4. *Krishi Samridhi* Programme

The 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 deliver 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 2019, fifty-two talks were recorded and broadcasted covering information pertaining to vegetable cultivation (13%), cereal, millet and pulses production techniques (15%), crop protection (15%), natural resource management techniques (15%), livestock rearing (2%), post-harvest management (4%), improved seed production (2%), agroforestory and fodder management (6%), mechanization and occupational health (6%), fruit trees management

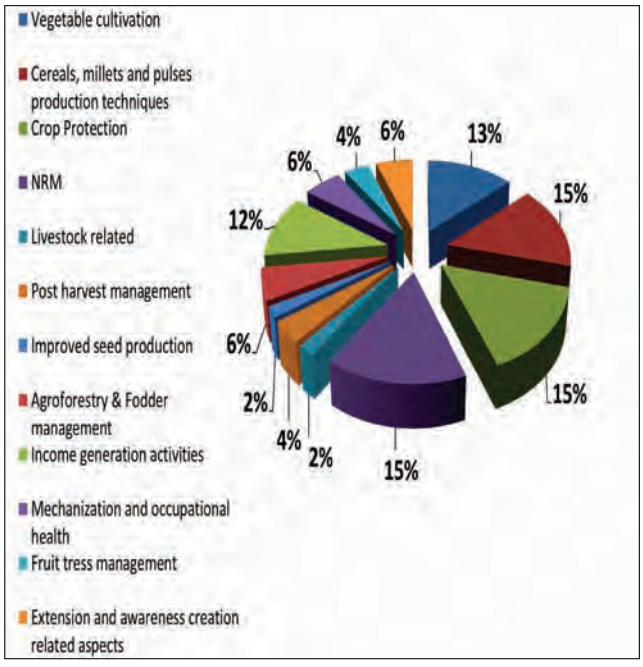


Fig. 7.3.1. Content analysis of radio talks broadcasted through *Krishi Samridhi* programme

(4%), income generation activities (12%) and extension and awareness generation related aspects (6%). A list of need based topics is prepared as per its importance in relation to seasonal farming operations. The content analysis of talks on various topics related to agriculture broadcasted through the programme is shown in Fig. 7.3.1.

7.3.5. Krishak Helpline

It offers a toll-free telephone (1800 180 2311) service to farmers by providing answers to the queries raised by them on working days during

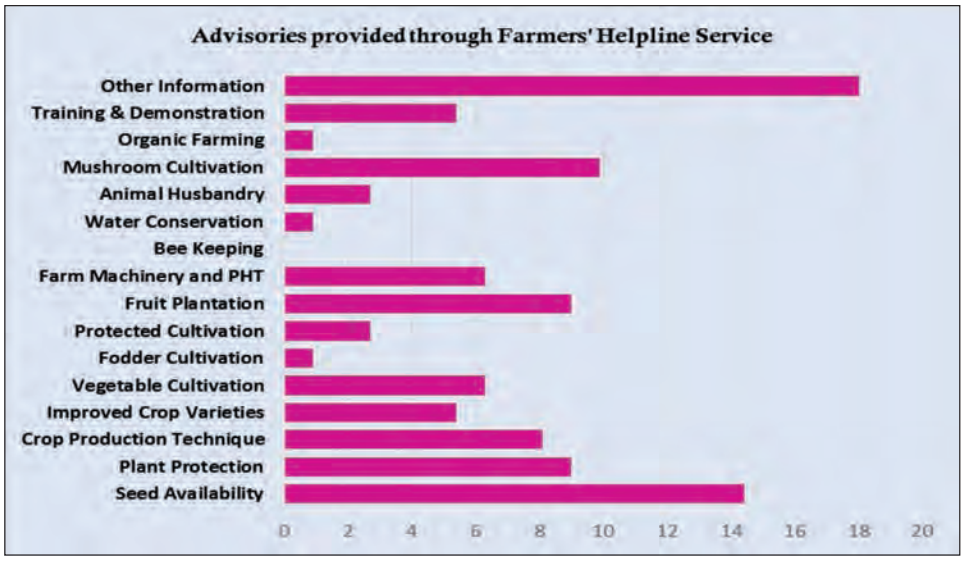


Fig. 7.3.2. Advisories provided through farmers' helpline service

10:00AM to 5:00PM. Content analysis of advisories provided to farmers showed that majority of the advisories (18%) were related to other information (employment opportunities, tenders, agriculture related schemes etc) followed by seed availability (14.4%) and mushroom cultivation (9.9%).

7.4. Swachhata Pakhwara

A *"Swachhata Goshthi"* was organized at block office, Hawalbag by group of ICAR-VPKAS employee during "*Swachhata Pakhwara* (December 16-31, 2019)" on December 30, 2019. Mr. Pankaj Kandpal, Block Development Officer, Hawalbag, chief guest of the programme addressed about the importance of the *Swachhata* for healthy life. Thereafter, cleaning of the Hawalbag ground and block area was done. Awareness on importance of cleaning of sewerage & water lines was deliberated to the people of Hawalbag block. Awareness was created on waste management, generation of wealth from waste, polythene free status and composting of kitchen & home waste materials that could help in maintaining cleanliness besides production of fresh organic food.

Institute organized *Swachhata Abhiyan* from September 11 to October 02, 2019 which started with taking pledge of *Swachh Bharat* Mission. A workshop on *Swachhata Abhiyan* programme was organized in the Institute in which staff was made aware about ill effects of plastics, plastic pollution and plastic waste management.

Institute staff taking *Swachhata* pledge

Scientists delivering lecture during *Swachhata Goshthi*


Scientists and staff participated in *Swachhata Goshthi*

Various methods of plastic waste management were discussed. A lecture was delivered on 'harmful effects of plastics' for creating awareness among people about harmful effects of plastic waste on agriculture land, water bodies and animals if not properly recycled. To make **'Say No to Plastic'** campaign a success, the team with staff members cleaned office campus and residential colony and made the surrounding area free of plastic.

All staff members of the institute at both the campus participated in cleaning of institute campus. During the programme, drainage, water lines and cleaning of the wall in the office premises was done.

An attempt was made to create mass awareness about the theme "**plastic waste awareness and management**'. A lecture on topic of "plastic waste: impact on life, their collection and management" was also delivered. In the campaign people were advised to minimize the use of plastic and suggested measures for management of plastic waste by segregating and recycling at household level.


Scientists and staff cleaning the institute premises


Cleaning of institute premises at Almora campus

Cleaning of institute premises at Hawalbag campus

Cleaning of residential area, Chhalar and Mallahata at Hawalbag

A competition on cleanliness was conducted by a team of scientist and officers. Various sections at ICAR-VPKAS were inspected for cleanliness and Standard Operating Procedure (SOP) for 'Swachh Office'.

Under the programme, management of compost pit was done and earthworms were released in it. The workers involved in cleaning of compost pits advised to convert biological wastes to compost for better utilization. The importance and significance of cleanliness to the society and country were also deliberated.

Cleaning of water storage tanks was done with active participation of institute employees. Efforts were made to create mass awareness about the theme of 'Cleanliness of water bodies'. In the

Team of officers inspecting for cleanliness for '*Swachh* Office'


Cleaning at public place near Raghunath City Mall


Cleaning of compost-pit, releasing of earthworm and covering of pits with dry straws


Cleaning of water storage tanks is being done by the employees at office premises


Cleaning of paths and walls in premises of the Institute

campaign people were advised not to contaminate water bodies.

Walkways in the campus were cleaned for unwanted weeds, plastic waste and other waste material. Collected waste material was disposed off safely. People in residential areas were urged to carry jute bags while going for shopping.

Various programmes, *viz*. cleaning activities, quiz, debate, essay and art competitions for school children and staff were organized.

Quiz and drawing competitions organised for staffs and students

***Swachhata* awareness programmes for staffs and students**

Removal of weeds and plastics near office and residential area

7.5. Tribal Sub Plan

7.5.1. TSP

Vivek Maize Hybrid 45 FLDs in Chamba (HP)

Front Line Demonstrations of *Vivek* Maize Hybrid (VMH) 45 were conducted during *kharif* 2019 in tribal clusters of district Chamba in Himachal Pradesh in collaboration with Krishi Vigyan Kendra, Chamba (Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, HP) under Tribal Sub-Plan. The FLDs were conducted in 20.0 ha with 50 farmers. A *Kharif-poorva Krishak Gosthi* was organized at KVK, Chamba on May 25, 2019 during which the farmers were provided information about hybrid maize varieties and improved cultivation practices of maize. At crop maturity, field visits were conducted in the village cluster to assess the performance of VMH 45 in the farmers field and farmers' feedback were obtained. A Maize Field Day was organized at village *Bhanota* on September 21, 2019 in which 30 farmers participated. The farmers appreciated the performance of VMH 45

Krishi goshthi, distribution of seeds, field demonstration and farmers with produce

for its higher yield and tolerance to lodging. In the FLDs, the yield of VMH 45 was assessed to be in the range of 45-55 q/ha and the superiority over the local cultivar was 37-52 per cent. The farmers expressed interest in growing VMH 45 in next *kharif* also.

Vivek Maize Hybrid 45 FLDs in Dhanpau-Lakhwad (Uttarakhand)

Front Line Demonstrations of Vivek Maize Hybrid (VMH) 45 were conducted during *kharif* 2019 in Dhanpau-Lakhwad and adjoining tribal clusters of Jaunsar region of district Dehradun under Tribal Sub-Plan. The FLDs were conducted in 20.0 ha with over 100 farmers. A maize field day was organized at village Dhanpau on October 13, 2019 in which about 25 farmers participated. The farmers appreciated the performance of VMH 45 for its higher yield despite lower rainfall during the season which affected plant stand and maize yield.

In the FLDs, the yield of VMH 45 was assessed to be in the range of 45-50 q/ha and the superiority over the local cultivar was 30-45 per cent. The small power-operated maize sheller provided by the institute to the village cluster in 2016 is also being very effectively used by the farmers on community basis. This intervention has greatly reduced the drudgery involved in maize shelling.

Demonstration on off season vegetable pea cultivation in Niti and Mana Valley, Joshimath

Twelve quintal of early garden pea (Arkel) seed was distributed among TSP farmer of 8 villages of Joshimath block of District Chamoli, Uttarakhand. Farmers-Scientist interactions were also organized in 4 villages of the region, *viz*. Gamshali, Malari, Mana and Hanumanchatti before the seed distribution. Some demonstration of newly released varieties of garden pea (VL *Sabji Matar* 13 & VL *Sabji Matar* 15) was also conducted in these areas during 2019. Performance of VL *Sabji Matar* 13 and VL *Sabji Matar* 15 was extremely good and preferred over the old varieties, *i.e.* Arkel by the farmers and superiority (14 and 21%) over Arkel was observed, respectively.

Pre-rabi Krishak Goshthi and Wheat Seed Distribution for Rabi 2019-20 FLDs in Dhanpau-Lakhwad cluster

Front Line Demonstrations of wheat varieties VL *Gehun* 829, VL *Gehun* 907 and VL *Gehun* 953 were conducted in Dhanpau-Lakwad tribal cluster of district Dehradun during *rabi* 2018-19. Farmers harvested 20-25 per cent higher yield than their

Krishi ghoshti and farmers with VMH 45 produce

Krishak-Scientist interaction and distribution of seeds

prevailing cultivars. In view of the promising performance of VL wheat varieties and request from the farmers for extension of wheat FLDs to the adjoining TSP clusters as well, FLDs of VL wheat varieties were planned to be organized in about 150 ha. in the tribal cluster during *rabi* 2019-20. Seed distribution programme was organized during October 13-15, 2019.

Seed of VL *Gehun* 829, VL *Gehun* 907 and VL *Gehun* 953 was provided to more than 350 farmers of over 15 villages. A pre-*rabi krishak gosthi* on *Gehun ki Unnat Utpadan Takniki* was held on October 13, 2019 in Dhanpau-Lakhwad cluster. During the goshti, information about the wheat varieties and scientific crop management practices was provided to the farmers. In addition to this, layout of Nutrient Expert experiment *rabi* 2019-20 was also finalized. In the Nutrient Expert experiment conducted during *rabi* (2018-19), 20-25 per cent higher wheat yield was recorded compared to the farmers practice.

Pre-Rabi Krishak Gosthi and Wheat Seed Distribution for Rabi 2019-20 FLDs in Kwanu cluster

In the FLDs of wheat varieties VL *Gehun* 804 and VL *Gehun* 953 conducted in Kwanu tribal cluster of district Dehradun during *rabi* 2018-19, farmers harvested 15-20 per cent higher yield than their prevailing cultivars. In view of the promising performance of VL wheat varieties and request from the farmers for continuation of wheat FLDS during *rabi* 2019-20 also, FLDs of VL wheat varieties were planned to be organized in about 60 ha. in the tribal cluster during *rabi* 2019-20. Seed distribution programme was organized on October 29, 2019. Seed of wheat varieties VL *Gehun* 804 and VL *Gehun* 953 was provided to more than 200 farmers of 5 villages in Kwanu cluster.

A pre-*rabi krishak gosthi* on *Gehun ki Unnat Utpadan Takniki* was also held. Information about the wheat varieties and scientific crop management practices was provided to the farmers during the *goshthi*. In addition to this, feedback about performance of VL *Syahi Hal* distributed to the farmers at the start of *kharif* season was also obtained. According to the farmers, VL *Syahi Hal* is more convenient to use and requires less draught power, which enables them to plough 30-40 per cent more area compared to the traditional plough.

7.5.2. TSP seed (IISS Main Scheme)

Farmer participatory seed production (FPSP) programme was organized during *Rabi* 2018-19 with Institute's wheat varieties, *viz*. VL *Gehun* 829, VL *Gehun* 907 and VL *Gehun* 953 on 12.9 ha area in the Jhankat village. Additionally, lentil varieties, *viz*. VL *Masoor* 126 and VL *Masoor* 133 were also provided for seed production on an area of 2.50 ha in village Jhankat. Similarly, in the Nakulia village, 48.56 ha area was covered under wheat variety VL *Gehun* 953. In addition to quality seed and inputs distributed to the farmers under FPSP; technical know-how was provided on different aspects of quality seed production through *Kishan goshthis*/ farm school/demonstrations/trainings.

As a result, during the year 2019, a total of 97.96 q quality wheat varietal seed & 1.23q quality lentil varietal seed was procured from the farmer beneficiaries of Jhankat village. Likewise, 72.2 q quality wheat varietal seed was procured from the farmer beneficiaries of Nakulia village.


Seed and input distribution to farmers under FPSP


Technical know-how and demonstration on *"Gehun me unnat utpadan takniki va beejotpadan"*


Field demonstrations on *'Gehun me kharpatvarnashi ka prayog'*

In the ongoing season *Rabi* 2019-20, four varieties of wheat, *viz.* VL *Gehun* 829, VL *Gehun* 907, VL *Gehun* 953 and VL *Gehun* 967 were provided to farmers of Jhankat and Nakulia villages under FPSP to cover a 9.64 and 14.4 ha area, respectively, under wheat seed production.

7.5.3. Scheduled Caste Sub-Plan (SCSP) Programme

Distribution of Vivek Millet Thresher-cum-Pearler

A total of 74 units of *Vivek* Millet Thresher-cum-Pearler were distributed to schedule caste (SC) farmers under SCSP Programme on the occasion of *Kisan Mela* on November 15, 2019.

Distribution of *Vivek* Millet Thresher Cum Pearler

Distribution of VL Solar Dryer and small farm tool kit

Three units of VL Solar Dryer and 20 small farm tool kits were distributed to Scheduled Caste farmers under SCSP programme during the occasion of *Kisan Mela-cum-Pradhanmantri Kisan Samman Nidi* Programme on February 24, 2019.

Distribution of VL Light Trap and Bacillus thuringiensis powder

Fifty units of VL Light Trap were installed in Darim village and its nearby areas on July 25, 2019. The *Bacillus thuringiensis* powder was also given to the farmers.

Distribution of vegetable pea seed

On August 28, 2019, total of 15 q seed of vegetable pea variety '*Arkel* was distributed to the farmers of village Darim and Hari Nagar covering an area of about 15 ha.

Distribution of VL Solar Dryer

Distribution of small farm tool kit

Distribution of VL Light Trap and *Bacillus cereus,* WGPSB2


Technological know-how of August sown pea to farmers

Jal Shakti Abhiyan

Under SCSP Programme, Darim village of Nainital district, Uttarakhand was selected for *Jal Shakti Abhiyan* during July 1, 2019 to September 15, 2019 under which 65 polytanks were constructed (42) and repaired (23). It will create additional water storage capacity of approximately 3312 cubic meter, which will enhance the farmers income and water availability throughout the year. A *Krishak Goshti* was organized on "*Jal Shakti Abhiyan*" on September 09, 2019 at village Darim.

Scientist-Farmers-Interaction

An interaction meeting with farmers was organised in Darim cluster of villages adopted under SCSP programme on July 03, 2019. Dr. H.S. Gupta, former director of the institute and Director General, Borlaug Institute for South Asia (BISA) was present in the launching and interaction meeting of SCSP program. Following suggestions were given by Dr. Gupta to make the project successful.

- Long-term preservation of fruits and vegetables in the form of beverages, jam, jelly, pickles, etc.
- Entrepreneurship development among the villagers.
- Introduction of solar dryer.
- Poultry can be put as a component of farming system.
- Holistic approach of development.
- Low cost storage for fruits and vegetables.
- Introduction of polyhouses for cultivation of off-season vegetables.
- Formation of Self Help Groups (SHG) and use of *Kisan Credit Card*.
- Apiary for better fruiting.
- Use of VL Light Trap and bacterial culture to control the white grub problem.

Jal Shakti Abhiyan

Scientist-Farmers Interaction Meeting

Dr. H.S. Gupta inspecting the area

Distribution of *Vivek* Millet Thresher-cum-Pearler to schedule caste (SC) farmers under SCSP Programme

8. Success Stories

8.1. Boosting Finger Millet Production and Empowering Women Farmers in Pauri Garhwal through Improved Technologies and Value Addition

The challenge

Pauri-Garhwal region of Uttarakhand is treasure trove of biodiversity, but yet has limited infrastructure and economic development. In this region, there have been many crops and farming practices which have been adopted and followed for millennia. For instance, finger millet is the most important crop during *kharif* season in the region. However, a sharp decline in cultivated area of finger millet has been observed in favour of cash crops. This is mainly due to non-availability of quality seeds of improved varieties, poor crop management, lack of awareness about post-harvest processing and value addition technologies.

The Solution

Improved high yielding varieties developed by ICAR-VPKAS, Almora, *viz*. VL *Mandua* 352, VL *Mandua* 376 and VL *Mandua* 379 have an average yield potential of 25-30 q/ha in lower and mid hills of Uttrakhand. Likewise, VL *Mandua* 324 and VL *Mandua* 380 are recommended for rainfed and organic production ecology of the state with an average yield potential of 19-21 q/ha. Besides high yield, these varieties are known for early maturity, resistance to neck and finger blast and high calcium content in the grains. Besides improved cultivars, agronomic practices like line sowing, recommended fertilizer dose and applications were also introduced in the region. Post-harvest activities of finger millet are tedious and time consuming for which the *Vivek* millet thresher developed by the Institute is the solution.

The Application

The improved varieties along with crop management and protection activities were demonstrated in five villages of the region, where finger millet is being grown under large scale. With all the efforts of the Institute, the average crop yield in the cluster was 21 q/ha, which was 42% more than the base year. *Vivek* millet thresher was introduced in the villages for post-harvest activities of the produce. A demonstration on preparing finger millet *namkeen* was provided to self help group of women farmers of Pauri and Kotdwara to start as an entrepreneurship with the brand name of *"Jaivik mandua (Ragi) ki namkeen"*. Self help group of women were also encouraged to make it compulsory to prepare *mandua namkeen* as an essential dish during any auspicious function, like marriage, naming ceremony and engagement in the family or village.

The Impact

Farmers realized a significant yield increase in finger millet cultivation by growing improved varieties and best crop management practices. The income from 1 acre of finger millet cultivation increased from Rs 12,210 to 18,200 with net benefit of Rs 10,225 in the improved practice. The benefit-cost ratio increased from 1.20 to 2.18 with the interventions. Overall, the farmers earned additional benefit of Rs 5,340 from additional yield and use of thresher compared to the conventional practice. The thresher saved considerable time and energy compared to manual threshing and significantly reduced drudgery involved in manual finger millet threshing.

8.2. Strengthening Soybean and Black Soybean Production in Hills through Technological Interventions

The Challenge

Soybean and *Bhat* are among the most important *kharif* crops in North Western Himalayas, which play an integral role in hill agriculture and provide livelihood to the millions of rural inhabitants. Due to non-availability of quality seeds of improved varieties, less crop management and poor agricultural mechanization and post harvest processing, farmers of the region were not able to reap the potential benefit from the cultivation of these crops.

The Solution

Improved high yielding cultivars of soybean (VL *Soya* 47, VL *Soya* 59, VL *Soya* 63 and VL *Soya* 89) and black soybean (VL *Soya* 65 and VL *Bhat* 201) developed by the institute have yield potential of 25-30 q/ha and 14-16 q/ha, respectively to enhance the profitability. Soybean varieties, i.e. VL *Soya* 47, VL *Soya* 59, VL *Soya* 63 and VL *Soya* 89 have excellent resistance against frog eye leaf spot, pod blight and leaf blight diseases whereas, black soybean varieties (VL *Soya* 65 and VL *Bhat* 201) have suitability for organic farming conditions along with resistance against biotic stresses prevalent in hills. Besides improved varieties, agronomic practices, farm mechanization implements, and post harvest processing methods have also been standardised by the institute and these can be a solution for enhancing the profitability of farmers through soybean/*Bhat* cultivation.

The Application

High yielding varieties along with improved crop management practices were demonstrated in Patia and Katura villages of Almora district, where soybean and *Bhat* are grown at large scale. The crop yield improved in soybean and *Bhat* by 25-30 and 45-55%, respectively than the farmers' traditional crop cultivation practices adopting full package of practices. Improved small tools were also introduced for ease in adopting the improved agricultural practices. Preparation of value-added products like *tofu* and milk were also demonstrated to farmers for income generation.

The Impact

Appreciable yield enhancement and profitability was realized through the adoption of improved varieties with recommended package of practices. The income of farmers with the improved technologies was increased from Rs 17,505 - 35,794 in soybean whereas, in black soybean the increase in profit was more from Rs 19,611 - 42,052 due to premium prices of black soybean in the region. The B:C ratio also improved from 0.39 to 0.78 in soybean and from 0.41 to 0.89 in black soybean. Overall, from the cultivation of improved varieties farmers earned the benefit of Rs 18,289 and Rs 22,441 than traditional cultivars of soybean and black soybean, respectively. Use of improved small tools has saved

considerable time and energy of farmers compared and reduced drudgery of farm women in cultivating the crop. Knowledge of post harvest value addition methods for soybean/*Bhat tofu* and milk preparation has also paved the way for more income generation for farmers.

8.3. Farmers' Participatory Seed Production (FPSP)

The Challenge

The improved varieties developed by the institute are always in high demand, but there has always been shortage of the certified seeds of these varieties, especially for wheat and maize.

The Solution

In order to enhance the quality seed availability to the farmers, ICAR-VPKAS decided to carry out farmers' participatory seed production of wheat varieties suitable for hill and *tarai* region. The *tarai* region of Uttarakhand was selected for farmers' participatory seed production of wheat varieties as the land holdings in hills are very small and scattered which are predominantly rainfed.

The Application

The scientists from institute were involved in providing technical backstopping and continuous monitoring. Farmers' skills were developed through repeated trainings/farm schools at field level regarding weed control, maintenance of genetic purity through maintaining isolation distance, vigorous roguing, harvesting at appropriate stage and segregated threshing and post-harvest handling and disease identification. A buy back arrangement was made to purchase the seed produced by farmers by the institute on satisfaction of the quality of the seed at 20% higher rate than the prevailing Minimum Support Price (MSP).

The Impact

In past eight years, approximately 19,720 ha area was covered under Farmers Participatory Seed Production of wheat crop varieties and 555.6 q seed of wheat varieties has been produced. The income gained by seed producing farmers by direct procurement of seed by the institute (at 10-15% higher price than prevalent market rate) is 5.77 lakhs rupees. The total income gained by farmers by selling part of the produce (20 per cent) as grain in local market at MSP is 1,155.5 lakhs, after keeping sufficient amount for household consumption. The income gained by farmers by selling part of the produce (5 per cent) as seed at 20% higher than MSP is 346.7 lakhs. The total economic benefit to the farmer through FPSP is 1502.2 lakhs rupees.

9. Farmers' Feedback

Impressed by the FLDs of new wheat variety VL *Gehun* 967 conducted by ICAR-VPKAS at Kwanu tribal cluster of districted Dehradun. I cultivated wheat variety VL *Gehun* 967 in my village Mailot and obtained yield of 43.75 q/ha, which was 7.7 per cent higher than the local cultivar grown in the area.

Shri. Chandan Singh
Village – Mailot

Impressed by the, FLDs of maize hybrid VMH 45 during *kharif* 2019 conducted by ICAR-VPKAS in Peren district of Nagaland in collaboration with KVK Peren. I have adopted maize hybrid VMH 45 along with other farmers and obtained an yield of 40.1 q/ha, which was 26.4 per cent higher than the local cultivar grown in the area.

Shri. Sangrei Zeliang
Village - Jalukiekam

Impressed by the Front-Line Demonstration conducted by VPKAS, Almora during 2018-19 at Mangalta village, I have adopted the improved wheat variety VL *Gehun* 953 along with other farmers of the area. This variety has performed better than other varieties sown in the area and moreover, is rust resistant.

Shri. Gopal Singh
Village – Mangalta

Self-help group women of Kotyura village, got in touch with VPKAS and received messages and information on work simplification, new improved light weight tools and vegetable seeds for home gardening. The information helped us in saving our labour, time and adopting new simplified ways of carrying out farm activities, which helped us in maintaining good health and increased efficiency.

Smt. Leela Devi
Village - Kotyura

I have been cultivating saffron for the last 10-12 years. Due to lack of knowledge, I used to make profit by selling saffron corms only, but now I have come to know the usefulness of the flower. The seed given by ICAR-VPKAS Almora was disease-free and its germination was cent percent. After long time, this year I got a good production of saffron.

Shri. Narayan Singh Martolia
Village: Parsari

10. Trainings & Capacity Building

Training of Institute Personnel

The following institute personnel were deputed for different HRD programmes as per Annual Training Plan during 2019 (Table 10.1).

Table 10.1. Details of trainings undergone by institute staff

Duration	Participant	Topic	Venue
Scientific Staff			
International Trainings			
September 21-30, 2019	Dr. A. Pattanayak	International Executive Development Programme on developing effective organizational leadership for senior officers of ICAR	Netherland, Germany
November 18-29, 2019	Dr. Ganesh V. Chaudhari	38th International Vegetable training course on "Vegetable Breeding for the Tropics" organized by the world vegetable center	Thailand
National Trainings			
January 03-16, 2019	Dr. Kushagra Joshi	Training on experimental designs and statistical data analysis	ICAR-IASRI, New Delhi
February 01-06, 2019	Dr. Kushagra Joshi	MDP on information and communication technologies for empowering farm women	ICAR-NAARM, Hyderabad.
February 25 to March 03, 2019	Dr. A.R.N.S. Subbanna	Training on DNA-Barcoding and bioinformatics applications in entomology	ICAR-NBAIR, Bengaluru
August 2-4, 2019	Dr. A. Pattanayak	Domestic executive development programme	ASCI, Hyderabad
September 21 to October 11, 2019	Ms Ankita Kandpal	Quantitative methods for social sciences	ICAR-NIAP, New Delhi
October 15-19, 2019	Dr. Lakshmi Kant	Intellectual property valuation and technology management	ICAR-NAARM, Hyderabad
October 31 to November 01, 2019	Dr. Nirmal Chandra	Training workshop for vigilance officers of ICAR	ICAR-NAARM, Hyderabad
December 02-13, 2019	Dr. Pankaj Kumar Mishra	A pre -RMP programme	ICAR-NAARM, Hyderabad
Technical Staff			
January 2-11, 2019	Shri Govind S. Bisht	Good agricultural practices	ICAR-IARI, New Delhi
February 13-19, 2019	Shri Medni Pratap Singh	Farm management	ICAR-IIFSR, Modipuram, U.P.
February 15-25, 2019	Shri Saleem	Automobile maintenance/ repair of office vehicle/ tractor and farm implements	ICAR-CIAE, Bhopal, M.P.

September 02-06, 2019	Shri Neeraj Joshi	Fodder production conservation and utilization for field veterinarians	ICAR-IGFRI, Jhansi
September 17-23, 2019	Shri Medni Pratap Singh	Training programme on farm management	ICAR-IIFSR, Modipuram, U.P.
September 19-26, 2019	Omkar Pratap	Hands on training in laboratory instrument handling for technical personnel	ICAR-Central Research Institute for Jute & Allied Fibres, Barrackpore, Kolkata
Administrative Staff			
January 14-15, 2019	Shri H.L. Meena	Orientation training programme on GRF 2017	ISTM, New Delhi
Skilled Supporting Staff (SSS)			
March 27-28, 2019	Smt. Jubli Devi, Smt. Narayani Devi, Shri Narayan Singh, Smt. Radhika Devi, Shri Ram Singh, Shri G. B. Joshi, Shri N.S. Jeena, Shri Pratap Singh, Shri D.C. Tiwari, Shri Bachi Singh, Shri B.B. Tiwari.	Two-days capacity building training programme	ICAR-VPKAS, Almora, Uttarakhand

Capacity building training programme for skilled supportive staff

11. Awards & Recoginitions

- Drs. A. Pattanayak, R.K. Khulbe, B.M. Pandey & Kushagra Joshi received ICAR-Fakhruddin Ali Ahmed Award for Outstanding Research in Tribal Farming Systems for 2018 on July 16, 2019.

- Krishi Vigyan Kendra, Uttarkashi under ICAR-VPKAS, Almora has received the prestigious "Pt. Deen Dayal Upadhyay Rashtriya Krishi Vigyan Protshahan Puraskar Zonal-2018 (Best KVK of Zone I)". The award was given by the Hon'ble Agriculture Minister, Govt. of India in New Delhi on July 16, 2019.

- Dr. Jitendra Kumar, Scientist received ICAR Jawahar Lal Nehru Award for PG Outstanding Doctoral Thesis Research in Agriculture and Allied Sciences on July 16, 2019.
- Dr L. Kant conferred Fellow of National Academy of Agricultural Science (NAAS)
- Drs. J. Stanley & V.S. Meena awarded NAAS Associate of National Academy of Agricultural Science.
- Dr. Pankaj Kumar Mishra conferred Fellow of Indian Botanical Society (IBS).
- Dr. A.R.N.S. Subbanna awarded 'International Best Researcher in Agricultural Entomology' from Research Peace Awards of RULA Awards 2019.
- Drs. Kushagra Joshi, A. Kandpal, M.L. Roy, S.C. Panday, A. Mukharjee, J. Stanley, V.S. Meena and A. Pattanayak awarded 'Best Poster (First)' during National conference on Himalaya Matters in a Changing World at GBPNIHESD, Kosi-Katarmal, Almora during December 9-11, 2019.
- Drs. V.S. Meena, J. Stanley, K. Joshi, S.C. Panday and A. Pattanayak received Best Poster (Second) award during National conference on Himalaya Matters in a Changing World at GBPNIHESD, Kosi-Katarmal, Almora during December 9-11, 2019.
- Dr. Devender Sharma received Young Scientist Award for paper presentation during 13th UCOST 2018-19 during February 26-28, 2019 at Vigyan Dham, Dehradun.

- The Institute contingent participated in the ICAR Inter-Zonal Sports Tournament – 2018 held at ICAR – Indian Veterinary Research

Institute, Izatnagar, Bareilly during February 25-28, 2019 and bagged 7 medals (3 Gold, 2 Silver and 2 Bronze) in different events. Ms. Usha won gold medal in chess & high jump (women) and bronze medals in 100 and 200 m race. Mr. Rajender Prasad Meena won gold medal in 800 m race & silver medals in 1500 m and 400 m race. Mr. Rajendra Prasad Meena was declared Best Athlete in the ICAR Inter-Zonal Sports Tournament – 2018.

- Mr. Rajendra Prasad Meena received Institute honour for 'ICAR Best Athlete' on 96th foundation day (July 4, 2019) of ICAR-VPKAS, Almora.
- The Institute contingent participated in the ICAR North Zone Sports Tournament – 2019 held at ICAR – Indian Institute of Pulses Research, Kanpur from 12 to 14 December 2019 and bagged 15 medals (6 Gold, 4 Silver and 5 Bronze) in different events. The gold medals were won by Mr. Rajender Prasad Meena (800 and 1500 m race), Miss Usha Birdi (100 and 200 m race), Mr. Ashish Kumar Singh (Javelin throw) and in 4 x 100 meter (men) relay

race by the team of Drs. Rajashekara H., Vijay Singh Meena, Rajender Prasad Meena and Amit Paschapur. The silver medals were won by Mr. Rajender Prasad Meena (200 and 400 m race), Dr. Vijay Singh Meena (Javelin throw) and Ms. Usha Birdi (Chess). The bronze medals were won by Mr. Amit Paschapur (100 m race and long jump), Dr. Vijay Singh Meena (disc throw), Dr. Rakesh Bhowmick (high jump) and Miss Usha Birdi (long jump).

- Dr. J.K. Bisht was honoured as excellent forage scientist in AICRP on forage crop national group meeting at IGKVV, Raipur on February 26, 2019.

12. Linkages & Collaborations

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

12.1. Local Institution in the Area

- G.B. Pant National Institute of Himalayan Environment & Sustainable Development (GBPNIHESD), Kosi-Katarmal, Almora, Uttarakhand
- Defence Institute of Bio-energy Research (DIBER), Haldwani, Uttarakhand
- Kumaun University, SSJ Campus, Almora, 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 Millet Research, Hyderabad, Telangana
- ICAR-Indian Institute of Maize Research, Ludhiana, Punjab
- ICAR-Indian Institute of Pulses Research, Kanpur, Uttar Pradesh
- ICAR-Indian Institute of Farming System Research, Modipuram, Meerut, Uttar Pradesh
- 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, Uttar Pradesh
- ICAR-National Centre for Integrated Pest Management, New Delhi
- ICAR-Central Institute of Post Harvest Engineering and Technology, Ludhiana
- ICAR-Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh
- ICAR-Central Research Institute for Dryland Agriculture, Hyderabad, Telangana
- ICAR-Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh
- ICAR-Research Complex for NEH Region, Umiam, Meghalaya
- G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand
- CSK-Himachal Pradesh Krishi Vishwa Vidyalaya, Palampur, Himachal Pradesh
- Dr. Y.S. Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh
- Sher-e-Kashmir University of Agriculture & Technology, Srinagar, J&K

12.3. International Organizations

- IRRI, Manila, Philippines
- CIMMYT, Mexico
- ICRISAT, Hyderabad, India
- ICARDA, Beirut, Lebanon
- ACIAR 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 [Himalayan Environmental Studies & Conservation Organization (HESCO), Dehradun ; Himmotthan, Dehradun etc.]
- Food Corporation of India (FCI)
- Department of Agriculture and Cooperation
- Departments of North Eastern Hill States

13. Important Committees of The Institute

13.1. राजभाषा कार्यान्वयन समिति

- ❖ डॉ0 अरूणव पट्टनायक – निदेशक अध्यक्ष
- ❖ डॉ0 जे. स्टेनली – वैज्ञानिक सदस्य (20-12-2019 तक)
- ❖ डॉ0 रेनू जेठी – वैज्ञानिक सदस्य
- ❖ प्रशासनिक अधिकारी – सदस्य
- ❖ वित्त एवं लेखा अधिकारी – सदस्य
- ❖ श्रीमती रेनू सनवाल – तकनीकी अधिकारी सदस्य
- ❖ तेज बहादुर पाल – सहा0 मु0 तकनीकी अधिकारी, सदस्य सचिव (31-07-2019 तक)
- ❖ ललित मोहन तिवारी – सहायक प्रशासनिक अधिकारी, सदस्य सचिव (01-08-2019 से)

13.2. Quinquennial Review (QQR) Team

Chairman - Dr. Tej Pratap Singh, Vice-Chancellor, APG Shimla University, Shimla

Members - Dr. M.Y. Zargar, Director (Research), SKUAS&T -Kashmir, Srinagar; Dr. S.P. Sharma, [Ex-Director (Research), CSKHPKV]; Dr. K.V. Bhat, Ex. Principal Scientist, NBPGR; Dr. R.K. Maikhuri, Scientist & In-Charge (GU), Plant Pathology, Rural Eco System, G.B.P.N.I.H.E.S.D., Garhwal RC, Srinagar (Uttarakhand); Dr. N.P. Malkania, Former PC (Forage Crops), IGFRI, Deptt. of Environmental Science, School of Vocational Studies and Applied Sciences, Gautam Buddha University, Govt. of UP. Greater Noida

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

13.3. Institute Joint Council (IJC)

Chairman – Director

Members (Official Side) – Drs. B.M. Pandey, Pr. Scientist; Renu Jethi, Sr. Scientist; Mr. Y.S. Dhanik, Senior Administrative Officer (upto 17.09.2019); Mr. H.L. Meena, Administrative Officer (upto January 31, 2019); Mr. Tej Bahadur Pal, CTO (upto July 31, 2019); Mrs. Radhika Arya, Assistant Administrative Officer

Members (Staff Side) – Mr. Vishnu Dutt Pandey, LDC; Mr. Nandan Singh Rajwar; Mr. Manoj Kumar; Mr. N.K. Pathak; Mr. P.S. Nikhurpa and Mr. M.C. Bhatt

13.4. 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. J.C. Rana, National Coordinator, UN Environment-GEF Project Bioversity International-India Office, New Delhi; 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; Dr. A. Pattanayak, Director, ICAR-VPKAS, Almora, Uttarakhand; Shri. Nagendra Kumar, farmer member; Shri Sushil Tyagi, farmer member

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

13.5. 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 Rajnarayan, Station In-Charge, ICAR-IVRI, Mukteshwar; Dr. Mamta Arya, Office In-Charge, NBPGR Regional Station, Bhowali; Dr. J.K. Bisht, ICAR-VPKAS, Almora; Dr. Lakshmi Kant, ICAR-VPKAS, Almora; The Finance & Accounts Officer, IVRI, Bareilly; Shri Nagendra Kumar, Non-Official/ farmer member; Shri Sushil Tyagi, Non-Official/ farmer member

Member Secretary – Sr. Administrative Officer/ Administrative Officer

13.6. Institute Research Council (IRC)

Chairman – Director

Members – All the Scientists of ICAR- VPKAS, Almora

Member Secretary – In-charge (PME Cell)/ Coordinator (PME Cell)

13.7. Institute Technology Management Committee (ITMC)

Chairman – Director

Members – Head, Crop Improvement Division; Head, Crop Production Division; Dr. Prem Kumar, Pr. Scientist, ICAR-DCFR, Bhimtal; Dr. J.K. Bisht, Pr. Scientist

Member Secretary – Dr. Lakshmi Kant, Pr. Scientist & Head, CID

13.8. Institute Technology Management Unit (ITMU)

Chairman – Dr. Lakshmi Kant, Pr. Scientist & Head, Crop Improvement Division

Members – Drs. J.K. Bisht, Pr. Scientist & Head, CPD; R.K. Khulbe, Sr. Scientist; Sher Singh, Pr. Scientist; Finance and Accounts Officer

13.9. Study Leave Committee (SLC)

Chairman –Dr. J.K. Bisht, Head, CPD

Member – Drs. Nirmal Chandra, Pr. Scientist & I/c, SSS (upto 30.12.2019); P.K. Mishra, Pr. Scientist

Member Secretary – Shri Y.S. Dhanik, Sr. Administrative Officer (upto 17.09.2019), Dr. A.K. Joshi, Administrative Officer (*w.e.f* 18.11.2019)

13.10. PERMISNET/PIMSICAR/HYPM

Nodal Officer – Dr. Renu Jethi, Sr. Scientist

13.11. Committee for Monitoring of Field Experiments

Chairman – Director, ICAR-VPKAS, Almora

Members – All the Scientists of ICAR-VPKAS, Almora

Member-Secretary - In-charge/Coordinator, PME Cell

13.12. Vigilance Cell (VC)

Dr. K.K. Mishra, Pr. Scientist (upto February 26, 2019)

Dr. Nirmal Chandra, Pr. Scientist (*w.e.f.* February 27, 2019 upto 30.12.2019)

13.13. Grievance Cell (GC)

Chairman - Dr. Lakshmi Kant, Pr. Scientist & Head, CID

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

13.14. Women Cell (WC)

Chairman - Dr. Renu Jethi, Scientist

Members - Dr. Ankita Kandpal, Scientist (up to December 27, 2019); Mrs. Radhika Arya, Assistant Administrative Officer; Mrs. Renu Sanwal, Technical Officer

Member Secretary - Ms. Usha Birdi, Assistant

13.15. Internal Complaint Committee (ICC)

Chairman - Dr. Kushagra Joshi, Scientist

Members - Dr. Sher Singh, Pr. Scientist, Mrs. Renu Sanwal, T.O.; Ms. Usha Birdi, Assistant; Mrs. Lata Harbola, Programme Coordinator, Chirag

13.16. Purchase Advisory Committee (PAC)

(Upto 02.05.2019)

Chairman – Dr. P.K. Mishra, Pr. Scientist

Members – Drs. J. Stanley, Sr. Scientist; R.P. Yadav, Scientist; Dinesh Joshi, Scientist, Finance & Accounts Officer; Shri. Sanjay Kumar Arya, ACTO

Member Secretary - Administrative Officer (Store)

(*w.e.f.* 03.05.2019)

Chairman – Dr. Lakshmi Kant, Pr. Scientist & Head, CID

Members – Drs. R.K. Khulbe, Sr. Scientist; ARNS Subbanna, Scientist; Jitendra Kumar, Scientist; Finance & Accounts Officer

Member Secretary - Administrative Officer (Purchase & Store)

13.17. Standing Purchase Committee (SPC)

(Upto 02.05.2019)

Chairman – Dr. Lakshmi Kant, Head, CID

Members – Drs. Ramesh Singh Pal, Scientist; Renu Jethi, Scientist; Finance & Accounts Officer; Shri. Sanjay Kumar Arya, ACTO

Member Secretary - Administrative Officer (Store)

(w.e.f. 03.05.2019)

Chairman – Dr. J.K. Bisht, Pr. Scientist & Head, CPD

Members – Er. Shyam Nath, Scientist; Dr. Manoj Parihar, Scientist; Shri. Sanjay Kumar Arya, ACTO

Member Secretary - Administrative Officer (Purchase & Store)

13.18. Technical Vetting/ Screening Committee (TVC)

(Upto 02.05.2019)

Chairman – Dr. N.K. Hedau, Pr. Scientist

Members – Drs. A.R.N.S. Subbanna, Scientist; V.S. Meena, Scientist; Ramesh Singh Pal, Scientist; Shri. Sanjay Kumar Arya' ACTO

Member Secretary - Administrative Officer (Store)

(w.e.f. 03.05.2019)

Chairman – Dr. P.K. Mishra, Pr. Scientist

Members – Drs. B.M. Pandey, Pr. Scientist; Sher Singh, Pr. Scientist; Ram Prakash Yadav, Scientist; Shri Sanjay Kumar Arya, ACTO

Member Secretary - Administrative Officer (Purchase & Store)

13.19. 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 University, SSJ Campus, Almora (Outside Expert); Dr. A.S. Gusain, Medical Officer, Almora (Bio-safety Officer); Drs. K.K. Mishra, Pr. Scientist; Rajashekara, H., Scientist and Mr. Rakesh Bhowmick, Scientist (Internal experts)

Member Secretary - Dr. P.K. Mishra, Pr. Scientist

13.20. House Allotment Committee (HAC)

Chairman – Dr. J.K. Bisht, Pr. Scientist and Head, CPD

Members – Dr. B.M Pandey, Pr. Scientist; Er. D.C. Mishra, ACTO (*w.e.f.* 28.08.2019)

Member Secretary – Mr. T.B. Pal, ACTO (upto 31.07.2019); Administrative Officer (*w.e.f.* 01.08.2019)

13.21. Public Information Cell (PIC)

Public Information Officer – Dr. J.K. Bisht, Pr. Scientist & Head; Dr. B.M Pandey, Pr. Scientist; Shri Y.S. Dhanik, Senior Administrative Officer (upto 17.09.2019), Shri A.K. Joshi, Administrative Officer (*w.e.f.* 18.09.2019)

13.22. Public Information Officer (KVK, Chinyalisaur and Bageshwar):

Programme Coordinator, KVK, Bageshwar

Programme Coordinator, KVK, Uttarkashi

13.23. Strengthening Statistical Computing for NARS

Nodal Officer- Dr. Kushagra Joshi, Scientist

13.24. mKisan

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

Nodal Officer – Dr. Kushagra Joshi, Scientist

13.25. Institute Swachchhta Abhiyan Committee (ISAC)

Chairman - Dr. Nirmal Chandra, Pr. Scientist & In-charge, Social Science Section (upto 30.12.2019); Dr. K.K. Mishra, Pr. Scientist (*w.e.f.* 31.12.2019)

Member – Dr. Kushagra Joshi, Scientist and Mr. T.B. Pal, ACTO (upto 31.07.2019); Administrative Officer (*w.e.f.* 01.08.2019)

13.26. Human Resource Development (HRD)

Nodal Offcier – Dr. P.K. Mishra, Pr. Scientist

13.27. Research Data Management (RDM)

Nodal Offcier – Dr. P.K. Mishra, Pr. Scientist

Co-Nodal Offcier- Dr. Renu Jethi, Sr. Scientist

Members- Drs. Sher Singh, Pr. Scientist and K.K. Mishra, Pr. Scientist

13.28. Institute Germplasm Identification Committee (IGIC)

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

13.29. Innovation Cell (IC)

Nodal Offcier- Dr. P.K. Mishra, Pr. Scientist

Members- Dr. Renu Jethi, Sr. Scientist; I/c Finance & Accounts Officer; Administrative Officer

14. List of Publications

14.1. Scientific Paper Published in Peer Reviewed Journals/ Proceedings

Research Papers	NAAS Rating	Krishi Portal Id
Joshi, D.C., Zhang, K., Wang, C., Chandora, R., Khurshid, M., Li, J., He, M., Georgiev, M.I. and Zhou, M. (2019). Strategic enhancement of genetic gain for nutraceutical development in buckwheat: A genomics-driven perspective. *Biotechnology Advances*, https://doi.org/10.1016/j.biotechadv.2019.107479	17.45	http://krishi.icar.gov.in/jspui/handle/123456789/30070
Yadav, R.P., Gupta, B., Bhutia, P.L., Bisht, J.K. and Pattanayak, A. (2019). Biomass and carbon budgeting of land use types along elevation gradient in Central Himalayas. *Journal of Cleaner Production*, 211: 1284-1298.	11.65	http://krishi.icar.gov.in/jspui/handle/123456789/29880
Subbanna, A.R.N.S., Chandrashekara, C., Stanley, J., Mishra, K. K., Mishra, P. K. and Pattanayak, A. (2019). Bio-efficacy of chitinolytic *Bacillus thuringiensis* isolates native to northwestern Indian Himalayas and their synergistic toxicity with selected insecticides. *Pesticide Biochemistry and Physiology,* 158:166–174.	9.44	http://krishi.icar.gov.in/jspui/handle/123456789/29937
Pattanayak, A., Roy, S., Sood, S., Langrai, B., Banerjee, A., Gupta, S. and Joshi, D.C. (2019). Rice bean–a lesser known pulse with well recognized potential. *Planta,* 250: 873-890.	9.25	http://krishi.icar.gov.in/jspui/mydspace
Sood, S., Joshi, D.C., Chandra, A.K. and Kumar, A. (2019). Phenomics and genomics of finger millet: Current status and future prospects. *Planta,* 250*:* 783-801.	9.25	http://krishi.icar.gov.in/jspui/handle/123456789/31306
Joshi, D.C., Chaudhari, G.V., Sood, S., Kant, L., Pattanayak, A., Zhang, K., Fan, Y., Janovská, D., Megli, V. and Zhou, M. (2019). Revisiting the versatile Buckwheat: Reinvigorating genetic gains through integrated breeding and genomics approach. *Planta,* 250: 731-751.	9.25	http://krishi.icar.gov.in/jspui/handle/123456789/30068
Aditya, J.P., Bhartiya, A., Chahota, R.K., Joshi, D., Chandra, N., Kant, L. and Pattanayak, A. (2019). Ancient orphan legume horse gram: a potential food and forage crop of future. *Planta*, 250: 891-909.	9.25	http://krishi.icar.gov.in/jspui/handle/123456789/30077
Yadav, R.P., Gupta, B., Bhutia, P.L., Bisht, J.K., Pattanayak, A., Meena, V.S., Choudhary, M. and Tiwari, P. (2019). Biomass and carbon budgeting of sustainable agroforestry systems as ecosystem service in Indian Himalayas. *International Journal of Sustainable Development and World Ecology*, 26 (5): 460-470.	8.37	http://krishi.icar.gov.in/jspui/handle/123456789/28523

Research Papers	NAAS Rating	Krishi Portal Id
Khati, P., Sharma, A., Chaudhary, P., Singh, A.K., Gangola, S. and Kumar, R. (2019). High through put sequencing approach to access the impact of nanozeolite treatment on species richness and evenness of soil metagenome. *Biocatalyst and Agriculture Biotechnology*, https://doi.org/10.1016/j.bcab.2019.101249	8.14	http://krishi.icar.gov.in/jspui/handle/123456789/31490
Parihar, M., Meena, V.S., Mishra, P.K., Rakshit, A., Choudhary, M., Yadav, R.P., Rana, K. and Bisht, J.K. (2019). Arbuscular mycorrhiza: a viable strategy for soil nutrient loss reduction. *Archives of Microbiology*, 201 (6): 723-735.	7.61	http://krishi.icar.gov.in/jspui/handle/123456789/29700
Subbanna, A.R.N.S., Khan, M.S., Stanley, J. and Pattanayak, A. (2019). *Bacillus licheniformis* strain UKCH17 from northwestern Indian Himalayas: Characterization of chitinolytic enzyme and determination of its antifungal potential. *Indian Journal of Experimental Biology*, 57: 497-506.	7.48	http://krishi.icar.gov.in/jspui/handle/123456789/29941
Jeeva, J.C., Joshi, K., Singh, A. and Behera, B.C. (2019). Engendering finger millet based value chains for livelihood and nutritional security of women in agriculture. *Current Science* 116: 1893-1896.	6.88	http://krishi.icar.gov.in/jspui/handle/123456789/29867
Panday, S.C., Stanley, J., Kumar, A., Singh, S. and Bhatt, J.C. (2019). Crop planning based on probability of rainfall at Hawalbag, Almora. *Journal of Agrometeorology*, 21: 397-399.	6.56	http://krishi.icar.gov.in/jspui/handle/123456789/30209
Kumar, A.R., Kant, L., Pal, R.S., Stanley, J., Sharma, A., Raghu, B.R., Panday, S.C. and Bhatt, J.C. (2019). Climate resilient wheat production under changing climatic conditions in north western Himalayas of India. *Journal of Agrometeorology*, (21 SPECIAL ISSUE) :16-19.	6.56	http://krishi.icar.gov.in/jspui/handle/123456789/31492
Bhartiya, A., Mahajan, V., Singh, G., Aditya, J.P., Jain, S.K., Mishra, K.K., Singh, S., Khati, M.S., Kanwal C.S., Bankoti, G.S. and Ram, P. (2019). VL *Soya* 89 (VLS 89). *Indian Journal of Genetics and Plant Breeding,* 79: 515.	6.41	http://krishi.icar.gov.in/jspui/handle/123456789/31480
Khulbe, R.K., Pattanayak, A. and Panday, V. (2019). R1-nj expression in parental inbreeds as a predictor of amenability of maize hybrids to R1-nj-based doubled haploid development. *Indian Journal of Genetics and Plant Breeding,* 79: 678-684.	6.41	http://krishi.icar.gov.in/jspui/handle/123456789/30929
Choudhary, M., Kumar, B., Kumar, P., Guleria, S.K., Singh, N.K., Khulbe, R., Kamboj, M.C., Vyas, M., Srivastava, R.K., Puttaramanaik, Digbijaya Swain, Mahajan, V. and Rakshit, S. (2019). GGE biplot analysis of genotype × environment interaction and identification of mega-environment for baby corn hybrids evaluation in India. *Indian Journal of Genetics and Plant Breeding,* 79: 658-669.	6.41	http://krishi.icar.gov.in/jspui/handle/123456789/30964

Research Papers	NAAS Rating	Krishi Portal Id
Pal, R.S., Bhartiya, A., Kant, L., Aditya, J.P., Mishra, K.K. and Pattanayak, A. (2019). Common and underutilized pulses from Northwestern Himalaya: A comparison study for quality traits. *Legume Research*, DOI: 10.18805/LR-3997.	6.23	http://krishi.icar.gov.in/jspui/handle/123456789/30051
Kumari, S., Hedau, N.K., Pal, R.S. Mukherjee, A., Kant, L. and Pattanayak, A. (2019). Delineating bioactive properties of sweet pepper advanced breeding lines adapted to Indian mid-Himalayas: A Chemometric approach. *Indian Journal of Horticulture,* 76(4): 653-662.	6.10	http://krishi.icar.gov.in/jspui/handle/123456789/31489
Bhowmick, R., Choudhudy, S., Subbanna, A.R.N.S., Roy, S. and Sharma, L. (2019). Genome wide identification of genic and non-genic Microsatellites in *Nilaparva talugens Stål*. *International Journal of Chemical Studies*, 7: 194-196.	5.31	http://krishi.icar.gov.in/jspui/handle/123456789/30072
Singh, S., Sahoo, D.C., Singh, N.K., Bisht, J.K. and Thakur, T.C. (2019). Feasibility assessment of Pant-ICAR animal drawn six-in-one tillage outfit in Kumaon Hills of Uttarakhand. *Agricultural Engineering Today,* 43 (1): 39-45.	5.30	http://krishi.icar.gov.in/jspui/handle/123456789/31493
Singh, S., Sahoo, D.C., Singh, S., Tuti, M.D. and Bisht, J.K. (2019). Development and evaluation of weed wiper for resource conservation in hills of north western Himalayas. *Agricultural Engineering Today*, 42(2): 67-71.	5.30	http://krishi.icar.gov.in/jspui/handle/123456789/30091
Aditya, J.P., Bhartiya, A., Pal, R.S., Rajashekhara, H. and Kant, L. (2019). Agromorphological diversity in local rice (*Oryza sativa* L.) collections from different altitudes of Uttarakhand hills. *Indian Journal of Plant Genetic Resources,* 32: 110-114.	5.12	http://krishi.icar.gov.in/jspui/handle/123456789/30078
Meena, V.S., Mondal, T., Roy, S., Yadav, R.P., Arya, S.K., Bisht, J.K. and Pattanayak, A. (2019). Chemical soil quality indicators in relation to topographic positions in the North-western Himalayas, India. *Climate Change and Environmental Sustainability*, 7(1): 39-50.	4.86	http://krishi.icar.gov.in/jspui/handle/123456789/29981
Yadav, R.P., Bisht, J.K. and Pattanayak, A. (2019). Biomass production and carbon stock of agroforestry practices in the mid hills of central Himalaya. *Indian Forester*, 145 (5): 409-412.	4.38	http://krishi.icar.gov.in/jspui/handle/123456789/28522
Jethi, R. and Jalal, A. (2019). Homestead vegetable production for enhancing dietary diversity and food security in hill region. *Progressive Research-An International Journal*, 14: 228-231.	3.84	http://krishi.icar.gov.in/jspui/handle/123456789/30888
Jethi, R., Roy, M.L., Mukherjee, A., Chandra, N. and Joshi, P. (2019). Knowledge level of vegetable growing farmers in hills of Uttarakhand: A comparative study. *TECHNOFAME- A Journal of Multidisplinary Advance Research,* 8(2): 1-8.	3.38	http://krishi.icar.gov.in/jspui/handle/123456789/30889

14.2. Book/ e-Book

Book/e-Book	Krishi Portal Id
Joshi, K., Pattanayak, A., Jethi, R. and Stanley, J. (2019). Inventory of ICAR-VPKAS Technologies: 95 Years of Science & Technology for Hill Regions of India. pp 135.	http://krishi.icar.gov.in/jspui/handle/123456789/30102
Stanley, J., Mishra, K.K., Subbanna, A.R.N.S., Rajashekara, H. and Pattanayak, A. (2019). Integrated Pest Management in Major Crops. ICAR-VPKAS, Almora, Uttarakhand. pp 272, ISBN: 978-93-5321-912-3.	http://krishi.icar.gov.in/jspui/handle/123456789/30485

14.4. Popular Articles

Popular Articles	Krishi Portal Id
Jethi, R., Jalal, A., Joshi, P., Nautiyal, P. and Chandra, N. (2019). *Parvatiya kshetron mein poshanvatika ka mahatva*. *Kheti,* 72(06): 3-6	http://krishi.icar.gov.in/jspui/handle /123456789/30899
Joshi, K., Singh, S., Nath, Shyam, Verma, N. and Chandra, N. (2019). *Krishi mein katai baad ki maskkat mein kami*. *kheti*, 72(03): 13-16.	http://krishi.icar.gov.in/jspui/handle/123456789/30103
Mishra, K.K., Mishra, P.K. and Stanley, J. (2019). Mushroom poisoning. *Indian Farmers Digest,* 52(6): 32-36.	http://krishi.icar.gov.in/jspui/handle/123456789/30166
Rajna, S., Paschapur, A.U. and Raghavendra, K.V. (2019). Nanopesticides: Its scope and utility in pest management. *Indian Farmer*, 6(1): 17-21.	http://krishi.icar.gov.in/jspui/handle/123456789/30054
Yadav, R.P., Bisht, J.K., Meena, V.S. and Pattanayak, A. (2019). *Aay Vridhi ka saral tarika hai van-bagwani*. *Kheti*, 71(09): 15-17.	http://krishi.icar.gov.in/jspui/handle /123456789/30167

14.5. Book Chapters

Book Chapters	Krishi Portal Id
Arya, M., Bhartiya, A., Aditya, J.P., Satpute, G. and Ratnaparkhe, M. (2019). Unravelling the complex networks involved in plant stress tolerance through metabolomics. *In*: Recent Approaches in Omics for Plant Resilience to Climate Change. Pp. 313-329.	http://krishi.icar.gov.in/jspui/handle/123456789/29847
Bisht, J.K. and Singh, S. (2019). Improved crop production techniques and pest management. *In*: Integrated Pest Management in Major Crops. Stanley, J., Mishra, K.K., Subbanna, A.R.N.S., Rajashekhara, H. and Pattanayak, A. (eds.), pp. 253-271.	http://krishi.icar.gov.in/jspui/handle/123456789/30305
Choudhary, M., Meena, V.S., Yadav, R.P., Parihar, M., Pattanayak, A., Panday, S.C., Mishra, P.K., Bisht, J.K., Yadav, M.R., Nogia, M., Samal, S.K., Ghasal, P.C., Choudhary, J. and Choudhary, M. (2019). Does PGPR and mycorrhizae enhance nutrient use efficiency and efficacy in relation to crop productivity? *In*: Field Crops: sustainable management by PGPR, sustainable development and biodiversity, Vol. 23, Maheshwari, D.K. and Dheeman, S. (eds.), pp. 45-68. Springer Nature Switzerland AG 2019.	http://krishi.icar.gov.in/jspui/handle/123456789/29956

Book Chapters	Krishi Portal Id
Dhiman, U., Rana, S., Kesar, S., Panwar, A., Devi, M., Kumar, V., Paschapur, A. U., Singh, L.B., Jeevan, B., Singh, A.K. and Parihar, R.D. (2019). Entomopathogenic Nematodes: Their occurrence and pathogenicity. *In:* Parasitology Taxonomy and Bioecology. pp. 61-83.	http://krishi.icar.gov.in/jspui/handle/123456789/31487
Jethi, R. and Jalal, A. (2019). Use of ICT initiatives in integrated pest management. *In:* Integrated pest management in major crops. Stanley, J., Mishra, K.K., Subbanna, A.R.N.S., Rajashekara, H. and Pattanayak, A. (eds.). pp. 245-252.	http://krishi.icar.gov.in/jspui/handle/123456789/30908
Jethi, R., Joshi, P., Kandapal, A. and Kashyap, P. (2019). Organizational and financial support for off-farm entrepreneurship development of women. *In*: Agri-Entreprenuership Challenges and Opportunities. pp. 319-335.	http://krishi.icar.gov.in/jspui/handle/123456789/30907
Joshi, K. (2019). Indigenous technical knowledge in pest management. *In*: Integrated Pest Management in major crops. Stanley, J., Mishra, K.K., Subanna, A.R.N.S., Rajshekhara, H. and Pattanayak, A. (eds.), pp. 233-244. ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora.	http://krishi.icar.gov.in/jspui/handle/123456789/31109
Mahanta, D. (2019). Weed management in major hill crops. *In*: Integrated Pest Management in Major Crops. Stanley, J., Mishra, K.K., Subbanna, A.R.N.S., Rajashekhara, H. and Pattanayak, A. (eds.). Published by ICAR-VPKAS, Almora, 201-214pp.	http://krishi.icar.gov.in/jspui/handle/123456789/31491
Mahanta, D., Bisht, J.K. and Bhatt, J.C. (2019). Organic farming in hill and mountain ecosystem. *In*: Organic Farming. Gopinath, K.A. Ramanjaneyulu, A.V. (Eds.), pp. 277-293. Daya Publishing House, Astral International Pvt. Ltd., New Delhi.	http://krishi.icar.gov.in/jspui/handle/123456789/30099
Mahara, G.S., Joshi, P., Dash, D., Mukherjee, A. and Joshi, K. (2019). Harnessing ICT and social media for achieving effective teaching learning environment at agricultural universities in India. *In*: ICT and Social Media for Skill Development in Agriculture. Om Prakash., Mukharjee, A., and Joshi, P. (eds.) pp. 63-72. Today and tomorrow's printers and publishers, New Delhi.	http://krishi.icar.gov.in/jspui/handle/123456789/31111
Prakash, O., Mukharjee, A., Joshi, K., Joshi, P. and Mehra, G. (2019). Use of ICT and advanced media for skill development in agriculture. *In*: ICT and Social Media for Skill Development in Agriculture, Om Prakash., Mukharjee, A., and Joshi, P. (eds.). Today and tomorrow's printers and publishers, New Delhi. pp. 1-10	http://krishi.icar.gov.in/jspui/handle/123456789/31110
Rawat, I., Verma, N. and Joshi, K. (2019). Cinnamon (*Cinnamomum zeylanicum*). *In*: Medicinal Plants in India: Importance and cultivation-Vol I. Ghosh, S.N. (eds.), pp.164-177. Narendra Publishing House, New Delhi.	http://krishi.icar.gov.in/jspui/handle/123456789/31031
Subbanna, A.R.N.S., Stanley, J., Rajashekara, H., Mishra, K.K., Pattanayak, A. and Bhowmick, R. (2019). Perspectives of microbial metabolites as pesticides in agricultural pest management. *In*: Co-Evolution of secondary metabolites, Reference series in Phytochemistry. pp. 1-28.	http://krishi.icar.gov.in/jspui/handle/123456789/30069

Book Chapters	Krishi Portal Id
Subbanna, A.R.N.S., Stanley, J., Venkateswarlu, V., Naik, V.C.B. and Khan, M.S. (2019). Toxicological prospects on joint action of microbial insecticides and chemical pesticides. *In:* Microbes for Sustainable Insect Pest Management, pp. 317-340.	http://krishi.icar.gov.in/jspui/handle/123456789/30104
Yadav, R.P., Gupta, B., Bisht, J.K., Kaushal, R., Mondal, T. and Meena, V.S. (2019). Impact of land uses on microbial biomass C, N and P and microbial populations in Indian Himalaya. *In*: Plant Growth Promoting Rhizobacteria for Agricultural Sustainability. Kumar, A. and Meena, V. S. (eds.). pp. 33-55. Springer Nature.	http://krishi.icar.gov.in/jspui/handle/123456789/29960

14.6. Institute Publications

- *Krishi* Calender 2019-20
- VPKAS Newsletter Vol. 22 (No. 1 & 2)

14.7. Extension Literature

- *Makka sheller ke samavesh se kathin shram nyoonikaran* (118/2019)
- *Parvatiya kshetro me Azolla ki kheti* (118/2019)
- *Poshan suraksha hetu Poshan Vatika Nirmarn* (119/2019)
- *Dhingri mushroom utpadan takneeki* (120/2019)
- *Parvatiya kehetro me button mushroom ki kheti* (121/2019)
- *Parvatiya mahilaon hetu poshan suraksha ka mahatva (2019)*
- *Soil health card (2019)*

14.8. Technical Bulletin

- Jethi, R., Jalal, A., Nautiyal, P., Singh, K., Joshi, P., and Chandra, N. (2019). *Poshan evam khadyan suraksha mein poshanvatika ka mahatva*. ICAR.

14.9. Peer recognition to ICAR-VPKAS scientists

Above NAAS Rating 8

- Journal of Cleaner Production (12.40), Science of the Total Environment (10.90), Renewable Energy: An International Journal (Solar and Wind Technology) (10.36), Chemosphere (10.21), Environmental Research (9.84), PLoS ONE (8.81), Applied Soil Ecology (8.79), Plant Physiology & Biochemistry (8.72), Archives of Agronomy and Soil Science (8.14), Nature Scientific Report (10.01)

Above NAAS Rating 7

- Journal of Microbiology (7.92), Crop Protection (7.83), Journal of Economic Entomology (7.82), Agroforestry Systems (7.79), Environmental Monitoring and Assessment (7.69), Scientia Horticulturae (7.62), Current Microbiology (7.32), 3Biotech (7.36), Journal of Apicultural Research (7.36), Environmental Engineering and Management Journal (7.33), Journal of Mountain Science (7.14)

Above NAAS Rating 6

- Biocontrol Science and Technology (6.92), Journal of Environmental Biology (6.70), Acta Agriculturae Scandinavica, Section B - Plant Soil Science (6.65), National Academy of Sciences Section Biology (6.37), Indian Journal of Traditional Knowledge (6.0)

15. List of Ongoing Projects

15.1. Institute's Core Research Projects

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. N.K. Hedau, PI & Sub-project PI – Ganesh Vasudeo Chaudhary]*
- Genetic Improvement of Pulses & Oilseeds for Higher Productivity, Quality, Biotic and Abiotic Stresses for North-Western Himalayan Hills *[Dr. Anuradha Bhartiya (on maternity leave upto May 28, 2019), 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 *[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. Rajashekara, H., PI]*
- Biointensive Management of Major Polyphagous Pests of Uttarakhand Hills *[Dr. A.R.N.S. 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-NASF Funded Project

- Utilization and Refinement of Haploid/ Doubled haploid Induction Systems in Rice, Wheat and Maize Using In-Vitro and Molecular Strategies *[Drs. R.K. Khulbe & A. Pattanayak]*
- Information Dissemination System(s) for Empowering Farming Community of Uttarakhand *[Dr. Kushagra Joshi]*

15.2.2. Consortium Research Platform (CRP) Projects

- ICAR-CRP on Biofortification in Selected Crops for Nutritional Security *[Drs. R.K. Khulbe, R.S. Pal & Rakesh Bhowmick (on study leave up to September 17, 2019)]*
- ICAR-CRP on Molecular Breeding in Maize *[Drs. R.K. Khulbe, R.S. Pal, Rajashekara H & Rakesh Bhowmick (on study leave up to September 17, 2019)]*
- CRP on Agrobiodiversity, PGR Management, Component II – Wheat *[Drs. Lakshmi Kant & K.K. Mishra]*
- CRP on Molecular Breeding Wheat *[Drs. Lakshmi Kant, K.K. Mishra & Rakesh Bhowmick (on study leave up to September 17, 2019)]*

15.2.3. UN Environment-GEF Project

- Mainstreaming Agricultural Biodiversity Conservation and Utilization in Agricultural Sector to Ensure Ecosystem Services and Reduce Vulnerability *[Drs. A. Bhartiya (on maternity leave upto May 28, 2019), Nirmal Chandra & Jitendra Kumar]*

15.2.4. PVP & DUS Through ICAR-SAU System

- DUS/GOT in Kidney Bean *[Dr. Anuradha Bhartiya (on maternity leave upto May 28, 2019)]*

15.2.5. AICRP/ Network Projects

- Post Harvest Technology for Value Addition and Marketing of Agricultural Produce *[Drs. Sher Singh, Shyam Nath, Jitendra Kumar & Kushagra Joshi*]
- Use of Plastics in Agriculture Particularly in Protected Cultivation, Water Harvesting and Packaging *[Drs. Sher Singh, Shyam Nath & Jitendra Kumar]*
- All India Network Project on Soil Arthropod Pests *[Drs. J. Stanley & A.R.N.S. Subbanna]*
- Network Programme on Organic Farming (NPOF) *[Drs. Dibakar Mahanta, P.K. Mishra, K.K. Mishra, J. Stanley, V.S. Meena, Manoj Parihar & Priyanka Khati]*

15.2.6. Network Project on AMAAS

- Developing PGPR Consortia for Enhanced Micronutrient (iron and zinc) Uptake and Yield of Finger Millet (*Eleusine coracana*) in Hilly Areas *[Drs. Pankaj K. Mishra & V.S. Meena]*

15.2.7.NICRA Project under Competitive Grants Component (CGS)

- Design and Development of Protective Structure for High Value Crops to Reduce Damage from Hail and Frost *[Dr. Sher Singh]*

15.2.8. NMHS Project

- Strategies to Improve Health and Nutriotional Status of Hill Farm Women through Technological Interventions *[Drs. Renu Jethi, Nirmal Chandra, Pankaj Nautiyal & Manisha Arya* (on study leave *w.e.f.* January 8, 2019)*]*

15.2.9. NMHSE Project

- National Mission for Sustaining the Himalayan Ecosystem *[Drs. A. Pattanayak, S.C. Panday, Kushagra Joshi, V.S. Meena & J. Stanley]*

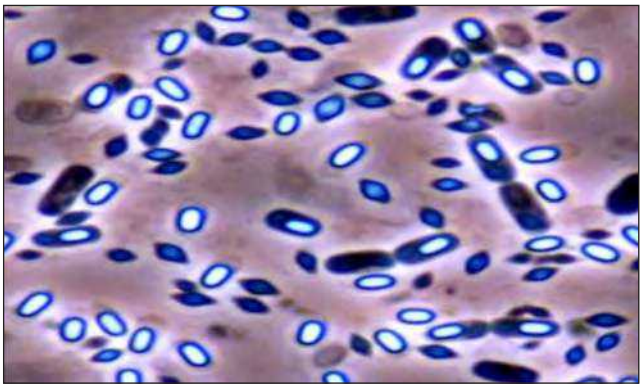
15.2.11. NABARD Funded Project

- Formation and Promotion of Farmers' Producer Organization *[Dr. Renu Jethi]*

16. Consultancy, Patents & Commercilization of Technology

16.1. Technology Approved for Grant of Patent: A process for the mass production of *Bacillus thuringiensis* (Bt) biocide using millet grain based agro-medium (1627/DEL/2008)

The invention employs cost effective high yielding agro based growth medium for the early, profuse sporulation and the process for the mass production of bio-insecticide, *Bacillus thuringiensis*. The millet based medium comprised of 0.06 to 3.2% by weight of finely ground finger millet grain powder; 60 and 85% tap water; 0.2 to 4.0% by weight of finely ground defatted soybean; 0.0 to 4.6% by weight of cow dung; 0.0 to 3.0% by weight of cow milk and 0.0 to 0.89% by weight of sporulation enhancer selected from potassium di-hydrogen orthophosphate (KH_2PO_4). This medium is supplemented with solid media with crop wastes to make it solid for mass production. The technology is cleared by the patent office for grant of patent on 27.02.2018 by Assistant Controller of Patents and Designs. The National Biodiversity Authority has approved the patent on 01.03.2019.



Sporulating culture of *Bacillus thuringiensis*

Bioassay of VLBt6

16.2. Commercialization of Institute Varieties and Machines

- ***Vivek* Maize Hybrid 53,** a potential maize hybrid with 'stay green' trait has been commercialized with Bhartiya Beej Nigam Ltd. (BBNL) Honda Campus, NH-74, Kichha Road, Village Bigwara, City Rudrapur, Udham Singh Nagar – 263148, Uttarakhand, India for production and distribution of Vivek Maize Hybrid 53 seeds through signing a Material Transfer Agreement (MTA) on 14.05.2019 for 5 years.
- ***Vivek* Maize Hybrid 45** is another promising maize hybrid which offer farmers dual advantage of grain as well as green fodder in the same crop. An MTA for production and sale of VMH 45 seed was signed on 14.05.2019 between ICAR-VPKAS, Almora and Bhartiya Beej Nigam Ltd. (BBNL) Honda Campus, NH-74, Kichha Road, Village Bigwara, City Rudrapur, Udham Singh Nagar – 263148, Uttarakhand, India for 5 years.
- **VL Small Tool Kit** is an environment friendly, cost effective, efficient and metallic farm hand tools, developed by ICAR-VPKAS, Almora. The durability of different tools (*kutala, khurpi,* hand fork and sickles) available in VL Small Tool Kit is more than the traditional one due to all metallic components. A Technology License Agreement (TLA) was signed between ICAR-VPKAS, Almora and M/s Himalayan Hi-Tech Nurseries, Subhash Nagar, P.O.- Bhotia Parao, Haldwani, District- Nainital, Uttarakhand, India on 24.06.2019 for production and sale of VL small tool for 3 years.

16.3. Technology Commercialization Programme

- India-Ethiopia Innovation & Technology Commercialization Programme (IEITCP) was organized by FICCI, Federation House, Tansen Marg, New Delhi on 11/09/2019. Dr. Lakshmi Kant, Head, CID & Chairman ITMU, ICAR-VPKAS, Almora, Uttarakhand and Dr. Sher Singh, Principal Scientist, ICAR-VPKAS, Almora, Uttarakhand participated in the meet. Only 30 technologies were finalized for commercialization in Ethiopia from total 200 applications from all over India. Out of 30, two technologies, *viz. Vivek* Millet Thresher 1 and VL Insect Trap were shortlisted and finalized from ICAR-VPKAS, Almora.

Technology commercialization

Presentation in IEITCP, New Delhi

17. QQR, RAC, IMC & IRC Meetings

17.1. Quinquennial Review (QQR) Team Meeting

ICAR constituted the Quinquennial Review (QQR) Team vide office order No. 16/6/2017-IA. IV dated December 11, 2017 for Quinquennial Review (QQR) of ICAR-VPKAS for the period 2013-2017, the committee started its work in July 2018.

Final meeting of QRT 2013-17 of ICAR-VPKAS, Almora was held on March 14-15, 2019 under the Chairmanship of Dr. Tej Partap, Vice-Chancellor, GBPUA&T, Pantnagar. QQR report 2013-17 of ICAR-VPKAS, Almora was submitted to Hon'ble DG, ICAR on April 15, 2019 by the Chairman, Dr. Tej Partap, Vice Chancellor, GBPUA&T, Pantnagar. On these occasions, institute's newsletter and technological inventory were also released by the dignitaries.

17.2. Research Advisory Committee (RAC) Meeting

The XXIII Research Advisory Committee (RAC) meeting of VPKAS, Almora was held on September 12, 2019 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. Hemendra Chandra Bhattacharyya, Director of Extension Education,

Release of Institute's Newsletter by QQR Chairman and Members

Release of Technological Inventory by the Hon'ble DG, ICAR and QQR Members

RAC Meeting at ICAR-VPKAS, Almora

Release of Institute's Newsletter

Assam Agricultural University, Jorhat; Dr. Arun Kumar Sharma, Ex. Director NBAIM, Mau; Dr. K.K. Satpathy, Ex. Director NIRJAFT, Kolkata; Dr. J.P. Singh, Professor (Horticulture), College of Agriculture, GBPUA&T, Pantnagar; Dr. B.S. Mahapatra, Prof. Agronomy, GBPUA&T, Pantnagar and Dr. Jai C. Rana, National Coordinator, UN Environment-GEF Project Bioversity International-India. The meeting was also attended by HODs and all scientists of the Institute.

17.3. Institute Management Committee (IMC) Meeting

The meeting of Institute Management Committee (IMC) was held on June 11, 2019 under the Chairmanship of Dr. A. Pattanayak, Director.

Institute Management Committee (IMC) meeting

17.4. Evaluation of Experiments by Field Monitoring Team

The monitoring of field experiments was conducted in *rabi* 2018-19 and *kharif* 2019 on April 15, 2019 and October 16, 2019, respectively at experimental farm, Hawalbag. All the scientists participated and monitored the experiments. The progress was reviewed by the Director.

Field monitoring during *rabi* 2018-19

Field monitoring during *kharif* 2019

17.5. Institute Research Council (IRC) Meeting

The Institute Research Council (IRC) meeting for *kharif* 2019 and *rabi* 2019-20 were held on July 11-12, 2019 and October 18, 2019, respectively under the Chairmanship of the Director ICAR-VPKAS, Almora. The progress of all research projects was reviewed and new experiments were discussed.

***Kharif* 2019 IRC meetings**

***Rabi* 2019-20 IRC meetings**

17.6. Institute Bio-safety Committee (IBSC) Meeting

The meeting of the Institutional Biosafety Committee (IBSC) was held on April 30, 2019 under the Chairmanship of the Director ICAR-VPKAS, Almora.

Meeting of Institutional Biosafety Committee (IBSC)

18. Participation of Scientists in Conferences, Seminar, Workshop, Symposia & Meetings

Name	Conference/Seminar/Workshop/Symposia/ Meetings
Dr. Lakshmi Kant	Review meeting of General body meeting at ICAR-VPKAS, Almora on January 17, 2019
Dr. J.K. Bisht	Meeting on Doubling of farmers' income at CDO Office, Almora on January 18, 2019
Scientist of ICAR-VPKAS	Workshop on 'Development and sensitization of academic community of Uttarakhand on formulation of the S&T proposals on location specific challenges' organized by HESCO on January 20, 2019 at ICAR-VPKAS, Almora
Dr. Manoj Parihar	e-Learning session on 'Soil Health Card Portal' ICAR-VPKAS, Almora on January 21, 2019
Dr. Nirmal Chandra	Institute tableau during Republic Day programme at Almora on January 26, 2019
Dr. Kushagra Joshi	Management Development Programme on 'Information and Communication Technologies for Empowering Farm Women' at ICAR-NAARM, Hyderabad during February 01-06, 2019
Drs. Renu Jethi & R. P. Yadav	2nd National seminar-cum-monitoring & evaluation (M&E) workshop of NMHS at GBPNIHESD, Kosi-Katarmal, Almora during February 4-7, 2019
Dr. A.R.N.S. Subbanna	Review meeting of DAC fumigation project at New Delhi on February 05, 2019
Dr. Nirmal Chandra & Shri G.S. Bisht	'Agri. Summit 2019' at Gandhi Maidan, Motihari, Bihar during February 10-12, 2019
Drs. J.P. Aditya & Rajashekara, H.	QRT and Hill workshop of rice at SKUAST, Srinagar during February 14-16, 2019
Dr. Lakshmi Kant	4th International group meeting held at CSKHPKV Palampur during February 14-16, 2019
Dr. J.K. Bisht	Radio Kisan *Diwas* at Almora on February 15, 2019
Dr. Nirmal Chandra & Shri G.S. Bisht	Agriculture fair and exhibition organized by State Department of Agriculture at Uday Shankar Academy, Almora during February 16-17, 2019
Dr. Manoj Parihar	Farmer's Fair organized by ATMA at KVK, Matela on February 17, 2019
Drs. J.K. Bisht, J. Stanley & Renu Jethi	XIV Agricultural Science Congress at NASC, New Delhi during February 20-23, 2019
Dr. J.K. Bisht	National group meeting of AICRP on forage crops at IGKV, Raipur, Manipur during February 26-27, 2019
Dr. Kushagra Joshi	Annual review meeting of NASF funded project at NAAS Complex on February 27, 2019
Mr. Rajendra Prasad Meena	PUSA *Krishi Unnati Mela* at IARI, New Delhi during March 05-07, 2019
Dr. S.C. Panday	Special session on for NMSHE project under seminar 'Emerging trends in Hi tech horticulture in climate change' at ICAR-CITH, Mukteshwar during March 6-7, 2019
Drs. Nirmal Chandra, S.C. Panday, D.C. Mishra & M.C. Pant	Farmers' fair at G.B. Pant University, Pantnagar during March 7-10, 2019
Dr. Pankaj Nautiyal	Spring festival at Rajbhawan Dehradun during March 9-10, 2019
Dr. J.K. Bisht	Startup *Samvad* organized by ICAR- NARM Technology Business incubator, Almora on March 25, 2019
Dr. R.P. Yadav	Scientific Advisory Committee at KVK, Matela, Almora on March 26, 2019
Dr. Lakshmi Kant	Wheat & barley field day at NBPGR, Isapur farm, New Delhi on March 28, 2019
Dr. Lakshmi Kant	Wheat & barley field day at IIWBR, Karnal on March 29, 2019

Name	Conference/Seminar/Workshop/Symposia/ Meetings
Dr. Pankaj Mishra	First half yearly meeting of IBSC at ICAR-VPKAS, Almora on April 30, 2019
Dr. Lakshmi Kant	Joint Annual Group Meeting of 34th AICRIP NSP (Crops), 14th Annual Review Meeting of ICAR Seed Project and 22nd Annual Breeder Seed Review Meeting at CCS HAU Hisar on April 7-9, 2019
Dr. Lakshmi Kant	Northern hill zone wheat and barley research workers zonal monitoring at Ranichauri, Majhera and Almora on April 23-26, 2019
Dr. S.C. Panday	Review meeting of NMSHE project at ICAR-VPKAS, Almora May 2, 2019
Dr. J.P. Aditya	SVT meeting at Regional Agriculture Testing and Demonstration Centre, Haldwani on May 2, 2019
Dr. Navin Chander Gahtyari	Annual review meeting of CRP on Agro-biodiversity at NBPGR, New Delhi on May13, 2019
Dr. S.C. Panday	General Body Meeting of IASWC, Dehradun on May 29, 2019
Dr. J.K. Bisht	KVK Meet of zone - VI at ATARI, Guwahati on May 30, 2019
Dr. J.K. Bisht	KVK Meet of zone - VII at ATARI, Umiam on May 31, 2019
Dr. J.K. Bisht	Meeting with State officials of Meghalaya on June 1, 2019
Dr. Lakshmi Kant	FAW sensitization workshop at Almora on June 7, 2019
Dr. Sher Singh & Er. Shyam Nath	Workshop on "Small Farm Agricultural Production and Post-Production Mechanization" at SKUA&T, Srinagar on June 12, 2019
Drs. A. Pattanayak & Sher Singh	Meeting with DDG (Agril. Eng.) regarding IFAD project proposal at New Delhi on June 14, 2019
Dr. Lakshmi Kant	CRP MB wheat meeting at IARI, New Delhi on June 15, 2019
Mr. Rajendra Prasad Meena	Workshop on "Zero Budget Natural Farming" organised by agriculture department, Uttarakhand at Dehradun on June 20, 2019
Dr. N.K. Hedau	XXXVII group meeting of AICRP-VC at TNAU, Coimbatore on June 22-25, 2019
Dr. S.C. Panday	Technical induction committee at GBPNIHESD, Kosi Katarmal during June 26, 2019 and November 18, 2019
Dr. K.K. Mishra	XXI AICRP on mushroom workshop at ICAR-DMR, Solan during June 28-29, 2019
Dr. K.K. Mishra	Brain storming session on Global Vs Indian scenario of mushroom production: Future challenges at ICAR-DMR, Solan on June 29, 2019
Dr. Dibakar Mahanta	Meeting on "Kosi River Rejuvenation" at Garhwali Popoli on July 17, 2019
Dr. Dibakar Mahanta	Meeting for Stakeholders consultation on "Advanced Agricultural Technologies for Doubling Farmers' Income" organized by UNDP in collaboration with Department of Agriculture, Utttarakhand" at Hotel Madhuban, Dehradun on July 01, 2019
Dr. R.P. Yadav	Meeting with District Magistrate related to Kosi river rejuvenation at District Magistrate office, Almora on July 08, 2019
Dr. S.C. Panday	Biennial Chief Scientists meet of AICRP—IWM at IGK Vishwavidyalaya, Raipur, Chhattisgarh during July 09 -11, 2019
Dr. J.K. Bisht	KVK Meet of zone Uttarakahand of ATARI, Ludhiana at GBPUAT, Pantnagar on July 22, 2019
Dr. Lakshmi Kant	KVK Action plan meeting at ICAR-VPKAS, Almora on July 22, 2019
Dr. Pankaj Mishra	State level workshop of annual action plan 2019-20 of KVKs of Uttarakhand at ICAR-VPAKS, Almora on July 22, 2019
Dr. R.P. Yadav	Networking of *Van Vigyan Kendra* and *Krishi Vigyan Kendra* at Forest Research Institute, Dehradun on July 25, 2019
Drs. Ganesh V. Chaudhari & Hanuman Ram	*Krishak Goshthi* on 'Vegetable production' organized by *Akashwani*, Almora on July 25, 2019
Dr. J.K. Bisht	KVK Workshop of ATARI, Ludhiana at GBPUA&T, Pantnagar during August 1-3, 2019

Name	Conference/Seminar/Workshop/Symposia/ Meetings
Mr. Amit Umesh Paschapur	13th Annual workshop on "Monitoring pesticide residues at National level" and 27th annual workshop on "Pesticide residue analysis" at KAU, Vellayani, Trivandrum, Kerala during August 2-3, 2019
Dr. Nirmal Chandra	Workshop on 'Value chain development for heirloom crops and varieties' at NBPGR, New Delhi during August 19–21, 2019
Dr. D.C. Joshi	Review and impact assessment meeting of the Indo-Australian Career Boosting Gold Fellowship at Department of Biotechnology (DBT), New Delhi on August 20, 2019
Dr. J.K. Bisht	Village adoption project meeting, partnership between LBSNAA, Mussoorie and HESCO, Mussorie at LBSNAA, Mussorie on August 21, 2019
Drs. Lakshmi Kant, K.K. Mishra, Dibakar Mahanta & Navin Chander Gahtyari	58th All India Wheat and Barley Research Workers' Meet held at IARI, Regional Centre, Indore during August 24– 26, 2019
Dr. Pankaj K. Mishra	Annual Review Workshop for Network Project on AMAAS at NASC Complex, New Delhi during August 29-30, 2019
Drs. J.K. Bisht & R.P. Yadav	National group meeting of AICRP on forage crops at Imphal, Manipur during August 30-31, 2019
Dr. D.C. Joshi	14th International symposium on buckwheat at North-Eastern Hill University, Shillong, India during September 3-6, 2019
Drs. Sher Singh, Jitendra Kumar & Utkarsh Kumar	Field day under *Jal Shakti Abhiyan* at village Darim (Nainital) on September 09, 2019
Dr. Pankaj K. Mishra	Annual day function and 25th Pandit Govind Ballabh Pant memorial lecture at GBPNIHESD, Kosi Katarmal, Almora on September 10, 2019
Drs. Lakshmi Kant & Sher Singh	India-Ethiopia Innovation and Technology Commercialization Programme (EIETCP) at FICCI, New Delhi on September 11, 2019.
Dr. Dibakar Mahanta	Global Organic Convention 2019 on 'Natural Resource Management for Sustainable Agriculture, Soil Health and Quality Food' at Nagpur during September 15-17, 2019
Dr. Lakshmi Kant	Scientist Assessment committee at IIWBR, Karnal on September 16, 2019
Drs. Lakshmi Kant, J.P. Aditya & Navin Chander Gahtyari	SVT *Rabi* meeting held at Dehradun on September 23, 2019
Dr. Nirmal Chandra	National Symposium on "Coldwater fisheries development in India: Innovative approaches and way forward for enhancing hill farmers' income" during September 24-25, 2019
Dr. J.K. Bisht	SAC Meeting of FRI at Dehradun on September 25, 2019
Er. Utkarsh Kumar	105th All india farmers' fair & agro-industrial exhibition at GBPUA&T, Pantnagar during September 27- 30, 2019
Dr. Anuradha Bhartiya	Field day of UNEP-GEF funded trials at Gallibasura, Almora on September 27, 2019
Drs. Anuradha Bhartiya, Sher Singh, J.P. Aditya, A.R.N.S. Subanna & L. Kant	Soybean field day at village Patiya (Block Takula), Almora on September 30, 2019
Dr. Kushagra Joshi	National Seminar on 'Development of Hill Agriculture: Policy and Institutional Imperative' organized by SKUAST, J&K and ICAR NIAP, New Delhi on October 01, 2019 at SKUAST, Srinagar
Dr. Lakshmi Kant	RAC meeting of Indian Institute of Wheat and Barley Research (IIWBR) Karnal on October 10, 2019
Dr. Lakshmi Kant	Training on IP valuation and technology management at NAARM, Hyderabad on October 15-19, 2019
Er. Utkarsh Kumar	Environmental summit at GBPNIHESD, Almora on October 20, 2019
Drs. Renu Jethi & J.P. Aditya	International Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences at NAARM Hyderabad, Telangana during October 20-22, 2019
All Scientists of ICAR-VPKAS	Meeting with Agriculture Minister of Uttarakhand State Shri Subodh Uniyal at Hawalbag on October 22, 2019
Dr. N.K. Hedau	Apple day/exhibition/workshop at CITHRS, Mukteshwar on October 23, 2019

Name	Conference/Seminar/Workshop/Symposia/ Meetings
Dr. D.C. Joshi	ICRISAT gene bank field day at ICRISAT, Patancheru, Hyderabad on October 25, 2019
Dr. J.P. Aditya	AICRP rice monitoring at Almora, Palampur and Malan during October 25-29, 2019
Dr. Nirmal Chandra	Workshop for vigilance officers of ICAR institutes at NAARM, Hyderabad duiring October 31 - November 01, 2019
Mr. Ashish Kumar Singh	7th International Cereal Nematodes Symposium at National Agricultural Science Complex, Pusa Campus, New Delhi, India during November 3-6, 2019
Drs. Sher Singh & Shyam Nath	15th Annual Workshop of AICRP on Plasticulture Engineering & Technology, ICAR-CIFA, Bhubaneshwar during November 05-06, 2019
Dr. Sher Singh	Golden Jubilee International Conference on "New Millennia Agriculture Novel Trends & Future Scenario" at CCS HAU, Hisar during November 06-08, 2019
Dr. J.K. Bisht	*Kisan mela* Jointly organized by ICAR-VPKAS and KVK, Sepahijala, Tripura on November 9, 2019 at Bishalgarh, Tripura
Drs. Rajashekara H. & Amit Umesh Paschapur	19th International Plant Protection Congress-2019 at ICRISAT, Hyderabad, Telangana during November 10-14, 2019
Dr. Dibakar Mahanta	14th Annual Group Meeting of Network Programme on Organic farming at ICAR-CIARI, Port Blair during November 12-14, 2019
Dr. N.K. Hedau	QQ Review Meeting of AICRPVC at IARI, New Delhi during November 20-21, 2019
Drs. L. Kant, J.K. Bisht, S.C. Panday, K. Joshi, V.S. Meena & R.P. Meena	National Conference on Himalayan Matters in a Changing World at GBPNIHESD, Almora during December 9–11, 2019
Dr. Sher Singh	7th Annual Review Workshop of NICRA project in New Delhi during December 17-18, 2019

19. Trainings, Workshops, Seminars, Farmers' Days Organized

Training Programme on Pests of *Rabi* Crops and their Management

ICAR-VPKAS conducted one day training on "Pests of *rabi* crops and their management" on January 05, 2019. About 50 state government officials from Almora district attended the programme. Dr. A. Pattanayak, Director ICAR-VPKAS inaugurated the programme and highlighted the importance of diseases and insect-pests in crops, especially in *rabi* crops and will be able to double our production and productivity by managing these notorious pests. There were lectures on different aspects of diseases and insect-pests management.

Workshop on Development and Sensitization of the Academic Community of the Uttarakhand-Almora on Formulation of the S&T Proposal on Location Specific Challenges

One-day workshop was organized by Himalayan Environmental Studies & Conservation Organization (HESCO) on "Development and sensitization of the academic community of the Uttarakhand-Almora on formulation of the S&T proposal on location specific challenges" at ICAR-VPKAS, Almora on January 20, 2019.

Startup Samvad

Startup Samvad was organized by a-IDEA, Technology Business Incubator of ICAR-NAARM, Hyderabad at ICAR-VPKAS, Almora on March 25, 2019 to sensitize the entrepreneurs, students, agri enthusiast by focusing on importance of entrepreneurship. This event was sponsored by Caspian Impact Investors (CII). The programme witnessed by more than 80 participants mainly comprised of students, scientists, researchers, entrepreneurs, start-ups, SHGs, FPOs.

Startup Samwad to sensitize the importance of entrepreneurship

Training Programme for Newly Appointed Skilled Supporting Staffs

A two days in-house Capacity Building Training programme for the Skilled Supporting Staff of the institute was organized during March 27-28, 2019 to create awareness among the newly appointed skilled supporting staff about the good laboratory, field and office practices, safety measures while using chemicals (pesticides/insecticides/weedicides), basic computing skills, components of MS-Office (MS-Word, MS-Excel), file maintenance, Hindi in official procedures and practical use of Hindi for filling up the different official forms. The training also focused on demonstrations and hands on activities for the participants. Eleven newly appointed skilled supporting staff (SSS) successfully completed the training.

Capacity Building Training Programme for SSS of ICAR-VPKAS

Lectures, demonstrations and hands on by participants

Training on "Micro Irrigation Technician" under the Skill India Programme of Government of India

ICAR-VPKAS has organized one-month training programme (200 working hours) on "Micro Irrigation Technician" for twenty farmers/students from December 27, 2018 to January 25, 2019. The programme was sponsored by National Skill Development Corporation under the Skill India Programme of Government of India.

The main aim of the training was to create awareness about water resource and identify/ familiarize candidates with components of micro-irrigation system, equipments, design, layout, installation of micro-irrigation system at field level, care and maintenance. The training also focused on water management demonstration and hands on activities. The assessment of candidates was done by external examiner appointed through committee members of Agricultural Skill Council of India, New Delhi.

ICAR-VPKAS, Almora Organized Training on "Mushroom Growers" under the Skill India Programme of Government of India

A twenty-five days training programme on "Mushroom Growers" for farmers/students was organized at ICAR-VPKAS during February 01-March 02, 2019. The programme was aimed to impart knowledge about different mushroom cultivation technologies, *viz.* button mushroom *(Agaricus bisporus)*, oyster mushroom *(Pleurotus* spp.*)*, milky mushroom *(Calocybe indica)* and some other medicinal mushrooms; spawn preparation, casing soil preparation, processing of mushrooms, value added product development, mushroom diseases, insect-pests and their management, amongst participants. Twenty participants (16 male and 04 females) from Almora and Nainital districts participated. In this programme, the candidates were assessed by external examiner appointed through committee members of Agricultural Skill Council of India, New Delhi.

Lecture and practical demonstrations on mushroom cultivation

Hands on mushroom packaging

Demonstration on spawn preparation

Hands on mushroom packaging

National Nutrition Week

ICAR-VPKAS celebrated National Nutrition Week at KVK, Bageshwar and KVK, Chinyalisaur during September 1-7, 2018. During the week, various awareness programmes were conducted for farm women, *anganwadi* workers, ANMs, ASHA and Students. Training programme on "Techniques of making high nutrition and low-cost food receipes at household level" was organised for farm women. An awareness programme was conducted on importance of balanced diet for the pregnant and lactating mothers. A Training programme was conducted on importance of nutritional garden at village level. An awareness programme was organized at KVK campus for school children on importance of balanced diet, good food habits, nutrient deficiency diseases and deficiency symptoms.

National nutrition week celebrated at KVKs

Summer Training for Agriculture students from BHU, Varanasi at ICAR-VPKAS, Almora

Summer training programmes on Hill Agriculture was conducted for three batches of B.Sc. (Ag) students from Banaras Hindu University, Varanasi during May 7-10, 21-24 and 28-31, 2019 at Experimental Farm, Hawalbag of ICAR- VPKAS. The whole training was planned and executed with lectures on hill agriculture coupled with hands-on training and exposure visits.

Summer training for students from BHU, Varanasi

Vigilance Awareness Week

ICAR-VPKAS, Almora celebrated the Vigilance Awareness from October 28 to November 2, 2019. The main focus of vigilance Awareness week is on "Integrity". All the staff members of the Institute gathered and took integrity pledge.

Vigilance awareness week at ICAR-VPKAS

Vigilance awareness week at ICAR-VPKAS

Kisan Mela

Institute organised *rabi Kisan Mela* and *Pradhan Mantri Kisan Samman Nidhi* on February 24, 2019 at ICAR-VPKAS, Almora. Shri. Ajay Tamta, Hon'ble Union Minister of state for textile and Member of Parliament was chief guest of the function. Institute also arranged the live telecast of *Pradhan Mantri Samman Nidhi* launching ceremony at the campus. On the occasion the chief guest released one variety of pea, *Vivek Matar* 15 for farmers. More than 500 farmers participated in the *Kisan Mela*.

***Rabi Kisan Mela* of Pradhan Mantri Kisan *Samman Nidhi* programme at almora**

A *Kisan mela* was organized at Experimental Farm, Hawalbag of the institute on November 15, 2019. On the occasion, Dr. Arunava Pattanayak,

Release of book during *Kisan Mela*

Distribution of *Vivek Mandua* thresher-cum-pearler during *Kisan Mela*

A section of audience during *Kisan Mela*

A section of audience during *Kisan Mela*

Director of the institute was the Chief Guest. He appraised the audience about the research work of the institute on various aspects of hill agriculture. He said that for development of the state, the farms have to be economically sound. Dr. R.S. Rawal, Director, GBPNIHESD, Kosi Katarmal stressed upon the conservation of traditional crop varieties. On the occasion, two varieties, *viz.* VL *Gehun* 967 and VL *Jau* 130 were also released for farmers. Vivek *Mandua* thesher-cum-pearler were also distributed to farmers under SCSP.

Visit of Additional Secretary (DARE) & Secretary (ICAR)

Shri Sushil Kumar, Additional Secretary (DARE) & Secretary (ICAR) visited ICAR-VPKAS, Almora, its Hawalbag Campus and model village Bhagartola during May 16 -19, 2019. A meeting with scientists and other staff members was held at Almora auditorium. Shri Sushil Kumar in his address appreciated the work of the institute. He asked the staff to work with full dedication so that the flag of ICAR always flies high. A leaflet titled *Parvatiya Mahilaon hetu Poshan Suraksha ka Mahatva* was also released by Hon'ble Secretary.

Release of leaflet by Hon'ble Additional Secretary

Model village Bhagartola Visit of Hon'ble Additional Secretary

Meetings under NEH Programme

A team of 6 Scientists, *viz.* Drs Lakshmi Kant, J.K. Bisht, Nirmal Chandra, K.K. Mishra, N.K. Hedau and Sher Singh under the leadership of Director, Dr A Pattanayak participated at ICAR-ATARI Zone VI, Guwahati, ICAR-ATARI Zone VII, Umiam and visited upper Shillong villages under NEH programme during May 28 to June 04, 2019. An interaction meet was held with the Director, ICAR-ATARI, Guwahati along with their KVK staffs on May 30, 2019. The Director, ICAR-VPKAS briefed about the technologies available with the Institute and requested the Director, ATARI for their technological demand so that the same may be implemented to North East region under NEH programme. On 31st May 2019, one meeting was held with Director, ICAR-ATARI, Umiam along with their KVK staffs and state government officials for getting their demand for Institute technologies. On June 01, 2019, the team visited farmers' field at Umroi Madan near Barapani area for exploring the possibilities to implement Institute technologies particularly water harvesting and polyhouse cultivation.

Participants in the meeting between ICAR-VPKAS and Department of Agriculture, Horticulture, Soil Conservation, Govt. of Meghalaya

International Day of Yoga Organized

"5th International Day of Yoga" was successfully organized on June 21, 2019 by ICAR-VPKAS at its headquarter Almora, Experimental Farm Hawalbagh, Krishi Vigyan Kendra Chinyalisaur and Krishi Vigya Kendra, Kafligair as per the Common Yoga Protocol (CYP) developed by the Ministry of AYUSH, Government of India. The Yoga programme began with the prayer followed by loosening exercises, *Yogaasana, Kapaalbhaarati,*

Pranayama, Dhyana/Meditation under supervision of Dr. P.K. Mishra, Principal Scientist. The programme ended with *Sankalpa* followed by *Shaanti Paatha*.








International Day of Yoga at ICAR-VPKAS

Kisan Diwas

Kisan Diwas was organized at experimental farm, Hawalbagh on December 23, 2019 as a part of action plan of *Swachhata Pakhwara. Kisan Diwas* is celebrated every year to promote awareness among people about the importance of the farmers to the society. A *Kisan Goshthi* was organized in which scientists and farmers of nearby villages, *viz.* Patia and Katura shared the knowledge on various aspects of farming. Director of the institute emphasized on importance of cleanliness and effective ways of waste disposal in agriculture. Farmers shared their experiences and problems in farming and made the scientists aware about the problems faced by them while adopting the new technologies. Onion seedlings of VL *Piaz* 3 were distributed to farmers for demonstration. *Kisan Gosthis* were organized to create awareness about *Swachhata* and to solve the problems related to *rabi* crops at KVK, Kafligair, Bageshwar. *Vivek Mandua* Thresher-cum-Pearler was demonstrated and provided to the 15 farmer groups of scheduled caste under the SCSP Project of ICAR-VPKAS, Almora.

Goshthi* organized by ICAR-VPKAS on *Kisan Diwas

Distribution of onion seedlings to farmers

Sensitization Workshop on Fall Army Worm Management

A sensitization workshop on 'identification, importance and management of fall army worm in maize' was conducted at ICAR-VPKAS experimental farm, Hawalbag for state department officials of Kumaun Mandal on June 7, 2019 and at Directorate of Agriculture, Dehradun for state department officials of Garhwal Mandal on June 10, 2019.

Sensitization workshop ICAR-VPKAS, Hawalbag

Sensitization workshop at Agricultural Secretariat, Dehradun

Parthenium Awareness Week

ICAR-VPKAS, Almora, Krishi Vigyan Kendra, Bageshwar and Krishi Vigyan Kendra, Chinyalisaur, Uttarkashi organized Parthenium Awareness Week from August 16 to 22, 2019 under the directions of ICAR-ATARI, Zone-I, Ludhiana & ICAR-Directorate of Weed Research, Jabalpur, M.P. Various activities including uprooting of weed in KVK, campus, villages, adjoining market and resident area; awareness rally by the NCC students, poster and debate competition were organized. *Goshthis* were organized in which farmers, students and local people were briefed about the ill effects of Parthenium weed on human and animal health and environment. Management by biological means (by releasing Mexican beetles at different places) and mechanical means, *i.e.* uprooting the weed and utilizing it in preparing compost was also demonstrated to the farmers and local residents.

Gosthi organised on Parthenium awareness week

Uprooting of parthenium grasses from fields

Awareness programmes organised on parthenium

96th Foundation Day

ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan celebrated its 96th Foundation Day on July 4, 2019 with great enthusiasm. Dr. H. S. Gupta, Ex-Director General, BISA, New Delhi was the chief guest on the occasion.

Felicitation of institute employees on Foundation day

Kisan Mela under NEH Programme

A Kisan Mela was organized in collaboration with KVK, Sepahijala on 09th November 2019 at Bishalgarh town of Tripura State under NEH programme of Institute. *Kisan mela* was jointly ingaurated by Agricultural Minister of Tripura state and MP of Agartala.

Constitution Day Celebrated

ICAR-VPKAS, Almora celebrated 'Constitution Day' or *'Samvidhan Diwas'* on November 26, 2019 to mark the 70th anniversary of adoption of the constitution by the constituent assembly. All the staff members of the institute gathered and took a pledge to abide by the fundamental duties enshrined in it.

Oath Ceremony on Constitution Day

***Goshthi* on Constitution Day**

20. राजभाषा सम्बन्धी गतिविधियां

संस्थान में राजभाषा हिन्दी के प्रगामी प्रयोग सरकार की राजभाषा नीति के कार्यान्वयन, नियमों उपबन्धों एवं सर्वाधिक उपबन्धों के उचित अनुपालन एवं इनकी समीक्षा हेतु संस्थान राजभाषा कार्यान्वयन समिति का गठन किया गया है। समिति की प्रत्येक तिमाही में बैठक की जाती है। वर्ष 2019 के दौरान समिति की बैठकें क्रमशः 30.03.2019, 29.06.2019, 28.09.2019 एवं 30.12.2019 को आयोजित की गयी। राजभाषा वार्षिक कार्यक्रम की विभिन्न मदों में 'क' एवं 'ख' क्षेत्र के साथ हिन्दी पत्राचार 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 80–82 प्रतिशत 'ख' क्षेत्र साथ 70–72 प्रतिशत तथा 'ग' क्षेत्र के साथ 65–70 प्रतिशत पत्र व्यवहार किया जा रहा है। राजभाषा अधिनियम की धारा 3(3) का अनुपालन सुनिश्चित किया जा रहा है। वार्षिक कार्यक्रम में नोटिंग के लिए 75 प्रतिशत का लक्ष्य रखा गया है, जबकि संस्थान द्वारा 95 प्रतिशत से अधिक नोटिंग का कार्य हिन्दी में किया जा रहा है। संस्थान द्वारा संचालित सभी प्रशिक्षण कार्यक्रमों में व्याख्यान हिन्दी में तैयार किए जाते हैं तथा सभी प्रशिक्षण कार्यक्रम हिन्दी में ही सम्पन्न होते है।

संस्थान में कार्यरत कार्मिकों को हिन्दी की ओर रूचि बढ़ाने एवं अपना अधिक से अधिक दैनिक कार्य हिन्दी में करने के लिए प्रोत्साहित करने हेतु संस्थान में 14 सितम्बर 2019 से 13 अक्टूबर 2019 तक 'हिन्दी चेतना मास' का आयोजन किया गया। चेतना मास के दौरान अनेक कार्यक्रम जैसे– नोटिंग – ड्राफ्टिंग प्रतियोगिता, हिन्दी टंकण प्रतियोगिता, निबन्ध प्रतियोगिता आदि का आयोजन किया गया। चेतना मास के दौरान दिनांक 14.09.2019 को हिन्दी दिवस समारोह एवं 09.10.2019 को हिन्दी संगोष्ठी का आयोजन किया गया, जिसमें स्वरचित कविता पाठ प्रतियोगितां का आयोजन किया गया। इन कार्यक्रमों में हिन्दी व अहिन्दी भाषी क्षेत्रों के कार्मिकों के उत्साह के साथ सहभागिता की।

भारत सरकार, राजभाषा विभाग द्वारा संस्थान को नगर राजभाषा कार्यान्वयन समिति की अध्यक्षता का दायित्व दिया गया है। संस्थान द्वारा नराकास के छमाही बैठकें निर्धारित समय पर आयोजित की जाती है। वर्ष 2019 के दौरान ये बैठकें 26.07.2019 एवं 30.12.2019 को आयोजित की गयी। वर्तमान में समिति के सदस्य कार्यालयों की संख्या 32 है जिसमें केन्द्रीय सरकार के शोध संस्थान, विभाग, राष्ट्रीयकृत बैंक, उपक्रम, सशस्त्र बल आदि सम्मिलित है। संस्थान द्वारा राजभाषा विभाग द्वारा मांगी गयी सूचनाएं निर्धारित समय पर भेजी जाती है तथा राजभाषा सूचना प्रबन्धन प्रणाली के अन्तर्गत सभी सूचनाएं आन लाइन प्रेषित की जाती है। संस्थान नराकास के सभी सदस्य कार्यालयों के बीच हिन्दी को आगे बढ़ाने के लिए सामन्जस्य स्थापित करने का निरन्तर प्रयास कर रहा है।

21. Distinguished Visitors

- Padma Shri Anil Joshi visited ICAR-VPKAS, Almora on January 20, 2019.
- Shri. Ajay Tamta, Hon'ble Union Minister of State for Textiles and Member of Parliament (MP) on February 24, 2019.

- Dr. Tej Pratap Singh, VC, G.B.P.U.A&T., Pantnagar on March 14, 2019.
- Dr R.C. Srivastava, VC, R.P.C.A.U., Pusa, Bihar on May 06, 2019.
- Shri Sushil Kumar, Additional Secretary (DARE) & Secretary (ICAR) visited ICAR-VPKAS, Almora, its Hawalbag Campus and model village Bhagartola during May 16-19, 2019.
- Dr H.S. Gupta, Ex. DG, BISA, New Delhi visited ICAR-VPKAS, Almora on July 04, 2019 and adopted village Bhagartola.

- Dr. K.R. Dhiman, Ex. Vice Chancellor, Dr. Y.S. Parmar University of Horticulture & Forestry, Nauni, Solan; Dr. Hemendra Chandra Bhattacharyya, Director of Extension Education, Assam Agricultural University, Jorhat; Dr. Arun Kumar Sharma, Ex. Director NBAIM, Mau; Dr. K.K. Satpathy, Ex. Director NIRJAFT, Kolkata; Dr. J.P. Singh, Professor (Horticulture), College of Agriculture, GBPUA&T, Pantnagar; Dr. B.S. Mahapatra, Prof. Agronomy, GBPUA&T, Pantnagar and Dr. Jai C. Rana, National Coordinator, UN Environment-GEF Project Bioversity International-India on September 12, 2019.
- Shri Subodh Uniyal, Hon'ble Minister of Uttarakhand State for Agriculture visited Experimental Farm, Hawalbag on October 22, 2019.

22. Institute Personnel

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, Senior Scientist (Plant Breeding)

Dr. Anuradha Bhartiya, Scientist (Plant Breeding)

Dr. D.C. Joshi, Scientist (Plant Breeding)

Dr. Ramesh Singh Pal, Scientist (Biochemistry)

Dr. Rahul Dev, Scientist (Economic Botany & Plant Genetic Resources) *w.e.f.* 03.12.2019

Mr. Rakesh Bhowmick, Scientist (Agriculture Biotechnology)

Dr. Chaudhari G. Vasudeo, Scientist (Vegetable Science)

Dr. Hanuman Ram, Scientist (Vegetable Science)

Dr. Navin Chander Gahtyari, Scientist (Genetics & Plant Breeding)

Dr. Devender Sharma, Scientist (Genetics & Plant Breeding)

Dr. Asha Kumari, Scientist (Plant Physiology)

Crop Production Division

Dr. J.K. Bisht, Principal Scientist (Agronomy) & I/c Head

Dr. S.C. Panday, Principal Scientist (Soil Physics and Soil Water Conservation)

Dr. P.K. Mishra, Principal Scientist (Agricultural Microbiology)

Dr. B.M. Pandey, Principal Scientist (Agronomy)

Dr. Sher Singh, Principal Scientist (Agronomy)

Dr. Dibakar Mahanta, Senior Scientist (Agronomy)

Dr. Ram Prakash Yadav, Scientist (Agroforestry)

Mr. Tilak Mondal, Scientist (Agricultural Chemistry) *(on study leave)*

Dr. Vijay Singh Meena, Scientist (Soil Science)

Mr. Mahipal Chaudhary, Scientist (Soil Science) *(on study leave)*

Er. Shyam Nath, Scientist (Farm Machinery & Power)

Dr. Jitendra Kumar, Scientist (Land & Water Management Engineering)

Dr. Manoj Parihar, Scientist (Soil Science)

Mr. Rajendra Prasad Meena, Scientist (Agronomy)

Er. Utkarsh Kumar, Scientist (Land & Water Management Engineering)

Dr. Priyanka Khati, Scientist (Agricultural Microbiology)

Crop Protection Section

Dr. K.K. Mishra, Principal Scientist (Plant Pathology) & I/c

Dr. J. Stanley, Senior Scientist (Agricultural Entomology) up to 20-12-2019

Dr. A.R.N.S. Subbanna, Scientist (Agricultural Entomology)

Dr. Rajashekara, H., Scientist (Plant Pathology)

Mr. Amit Umesh Paschapur, Scientist (Agricultural Entomology)

Mr. Ashish Kumar Singh, Scientist (Nematology)

Mr. Jeevan B., Scientist (Plant Pathology)

Social Science Section

Dr. Nirmal Chandra, Principal Scientist (Agricultural Extension) & I/c (upto 30.12.2019)

Dr. Renu Jethi, Senior Scientist (Home Science Extension)

Dr. Kushagra Joshi, Scientist (Home Science/FRM)

Dr. Ankita Kandpal, Scientist (Agricultural Economics) (up to 27.12.2019)

Mr. Sushil Kumar, Scientist (Agricultural Extension) (up to 23.08.2019)

Coordinators/ In-charge

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 (Hawalbag) (up to 31.03.2019); Dr. N.K. Hedau (*w.e.f.,* 01.04.2019)

Drs. N.K. Hedau & Sher Singh (Mukteshwar)

Vehicle

Mr. T.B. Pal (up to 31.07.2019)

Mr. A.K. Joshi, Administrative Officer (*w.e.f.* 01.08.2019)

Guest House

Dr. B.M. Pandey (Hawalbag) (up to 31.03. 2019); Dr. N.K. Hedau (*w.e.f.,* 01.04.2019)

Dr. Dibakar Mahanta (Hawalbag)

Mr. T.B. Pal (Almora) (up to 31.07.2019); Shri Sanjay Kumar Arya, ACTO (*w.e.f.,* 01.08.2019)

Maintenance

Mr. T.B. Pal (up to 31.07.2019)

Mr. A.K. Joshi, Administrative Officer (*w.e.f.* 01.08.2019)

Krishi Samridhi Radio Programme

Dr. Kushagra Joshi

Technical Officers

Shri. T.B. Pal (up to 31.07.2019)

Shri. S.K. Arya

Shri. D.S. Gosai

Shri. M.C. Pant

Shri. D.C. Mishra

Dr. G.S. Bisht

Shri. D.S. Panchpal

Shri. N.K. Pathak

Shri. G.S. Bisht (up to 30.06.2019)

Smt. Renu Sanwal

Shri. O.P. Vidhyarthi

Shri. Daya Shankar

Shri. C.S. Kanwal

Shri. B.S. Nagarkoti (up to Jan. 31, 2019)

Shri. J.K. Arya

Shri. Narayan Ram

Administration and Finance

Senior Administrative Officers

Mr. Y.S. Dhanik (up to 17.09.2019)

Administrative Officers

Mr. A.K. Joshi (*w.e.f.,* 15.01.2019)

Mr. H.L. Meena (up to January 31, 2019)

Assistant Administrative Officers

Mrs. Radhika Arya

Mr. Lalit Mohan Tewari

Finance & Accounts Officer

Mr. B.C. Pandey, FAO

Stores

Mr. A.K. Joshi (*w.e.f.,* 15.01.2019)

Managerial Staff at KVK, Chinyalisaur

Dr. Pankaj Nautiyal, CTO/ T-9, Horticulture

Ms. Manisha, ACTO, Home Science (on study leave *w.e.f.* 08.01.2019 to 07.01.2021)

Dr. Gaurav Papnai, ACTO, Agril. Extension

Managerial Staff at KVK, Bageshwar

Dr. Kamal Kumar Pandey, CTO/ T-9, Horticulture

Dr. N.K. Singh, ACTO, Veterinary Science (on study leave *w.e.f.,* 02.09.2019 to 01.09.2022)

Dr. H.C. Joshi, ACTO, Plant Protection

Shri. Medni Pratap Singh, Farm Manager/T-5

Smt. Nidhi Singh, Prog. Asst. (Lab Technician)/ T-5

New Colleagues

- Shri A.K. Joshi, Administrative Officer on January 15, 2019
- Shri Sandeep Kumar Verma, Assistant on November 28, 2019

- Dr. Rahul Dev, Scientist, Economic Botany and Plant Genetic Resources on December 3, 2019

Retirement

- Shri B.S. Nagarkoti, Technical Officer on January 31, 2019
- Shri Govind Singh Bisht, Technical Officer on June 30, 2019
- Shri Tej Bahadur Pal, Chief Technical Officer on July 31, 2019
- Smt. Radhika Devi, Skilled Supporting Staff on October 31, 2019

Transfer

- Shri H.L. Meena, A.O. transferred to ICAR-CIAH, Bikaner on 31.01.2019
- Dr. J. Stanley, Sr. Scientist (Agril. Entomology) to IIMR, Hyderabad on 20.12. 2019
- Dr. Ankita Kandpal, Scientist (Agril. Economics) to NIAP, New Delhi on 27.12.2019
- Dr. Nirmal Chandra, Pr. Scientist (Agril. Extension) to IARI, New Delhi on 30.12.2019

Resignation

- Ms. Monika Yadav, Technical Assistant/T-3 on 02.05.2019
- Shri. Sushil Kumar, Scientist (Agricultural Extension) on 23.08.2019
- Shri. Sudhanshu, Technical Assistant/T-3 (Librarian) on 24.12.2019

Promotion

- Dr. Dibakar Mahanta, Scientist to Sr. Scientist (RGP 8000/-) *w.e.f.* 01.07.2017.
- Dr. Kushagra Joshi, Scientist to Scientist (RGP 7000/-) *w.e.f.* 01.01.2017
- Dr. Rajashekara, H. Scientist to Scientist (RGP 7000/-) *w.e.f.* 01.01.2018
- Dr. Vijay Singh Meena, Scientist to Scientist (RGP 7000/-) *w.e.f.* 01.01.2018
- Dr. Renu Jethi, Scientist to Sr. Scientist (RGP 8000/-) *w.e.f.* 15.12.2018.
- Dr. Jay Prakash Aditya, Scientist to Sr. Scientist (RGP 8000/-) *w.e.f.* 07.01.2019.
- Dr. Pankaj Nautiyal, Subject Matter Specialist T 7-8 to T-9 *w.e.f.* 22.08.2019
- Shri Harish Chandra Pandey, Driver/T-2 to T-3 *w.e.f.* 28.01.2019
- Shri Birendra Puri Goswami, Driver/T-2 to T-3 *w.e.f.* 28.01.2019
- Shri Har Singh, SSS to Lower Division Clerk *w.e.f.* 08.04.2019
- Shri Vishnu Dutt Pandey, SSS to Lower Division Clerk *w.e.f.* 08.04.2019
- Shri Anand Singh Adhikari, SSS to Lower Division Clerk *w.e.f.* 08.04.2019
- Shri Khyali Ram, SSS to Lower Division Clerk *w.e.f.* 09.10.2019

Study Leave

- Ms. Manisha, ACTO, Home Science (on study leave *w.e.f.* 08.01.2019 to 07.01.2021)
- Dr. N.K. Singh, ACTO, Veterinary Science (on study leave *w.e.f.* 02.09.2019 to 01.09.2022)

Obituary

With profound grief, we inform you that Shri Y.S. Dhanik, Sr. Administrative Officer, ICAR-VPKAS (29.06.2016 to 17.09.2019) passed away on September 17, 2019

23. Human Resource Development (HRD)

A. Physical targets and achievements

Category	Total No. of Employees	No. of trainings planned for 2019 as per ATP	No. of employees undergone training during Jan-June 2019	No. of employees undergone training during July to December 2019	Total no. of employees undergone training during January to December 2019	% realization of trainings planned during 2019
Scientist	33	07	03	05	08	114.3
Technical	27	06	03	03	06	100.0
Administrative & Finance	14	03	01	00	01	33.3
SSS	34	11	0	11	11	100.0
Total	**108**	**27**	**07**	**19**	**26**	**96.3**

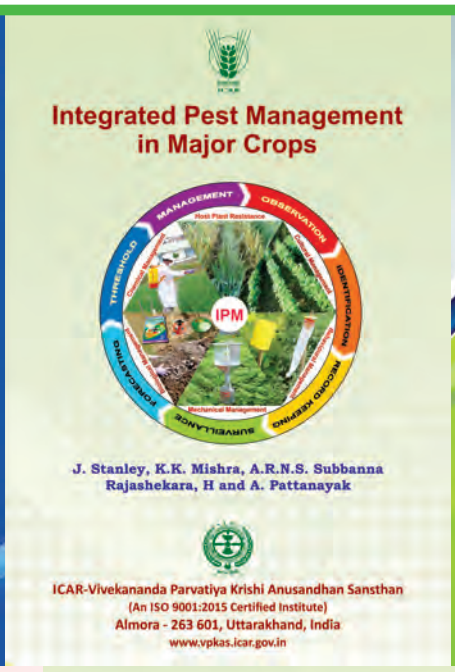
B. Financial targets and achievements (All employees)

RE 2019 for HRD (Rs.)	Actual Expenditure up to December 31, 2019 for HRD (Rs.)	% Utilization of allotted budget
2,00,000.00	1,99,000.00	99.5

C. Number of trainings organized for various categories of ICAR employees including winter/summer schools and short-term trainings

Category	No. of trainings organized during January to June 2019	No. of trainings organized during July to December 2019	Total no. of trainings organized during January to December 2019	No. of participants (Only ICAR employees)		
				Organizing Institute	Other ICAR Institutes	Total
Scientist	0	0	0	0	0	0
Technical	0	0	0	0	0	0
Administrative & Finance	0	0	0	0	0	0
SSS	0	01	01	11	0	11
Total	**0**	**01**	**01**	**11**	**0**	**11**


Inventory of ICAR-VPKAS Technologies
95 Years of Science and Technology for Hill Regions of India
ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan
(An ISO 9001:2015 Certified Institute)
Almora - 263 601, Uttarakhand, India
www.vpkas.icar.gov.in


Integrated Pest Management in Major Crops
MANAGEMENT
OBSERVATION
IDENTIFICATION
RECORD KEEPING
SURVEILLANCE
FORECASTING
THRESHOLD
IPM
J. Stanley, K.K. Mishra, A.R.N.S. Subbanna
Rajashekara, H and A. Pattanayak
ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan
(An ISO 9001:2015 Certified Institute)
Almora - 263 601, Uttarakhand, India
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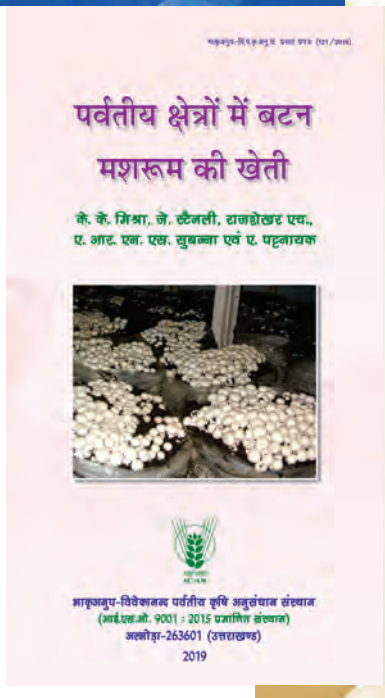
पोषण एवं खाद्य सुरक्षा में पोषण वाटिका का महत्व
राष्ट्रीय हिमालयी अध्ययन मिशन
(पर्यावरण वन एवं जलवायु परिवर्तन मंत्रालय, भारत सरकार)
भाकृअनुप-विवेकानन्द पर्वतीय कृषि अनुसंधान संस्थान
(आईएसओ 9001:2015 प्रमाणित संस्थान)
अल्मोड़ा-263601, उत्तराखण्ड (भारत)
www.vpkas.icar.gov.in


पर्वतीय क्षेत्रों में बटन मशरूम की खेती
के. के. मिश्रा, जे. स्टैनली, राजशेखर एच.,
ए. आर. एन. एस. सुबन्ना एवं ए. पट्टनायक
भाकृअनुप-विवेकानन्द पर्वतीय कृषि अनुसंधान संस्थान
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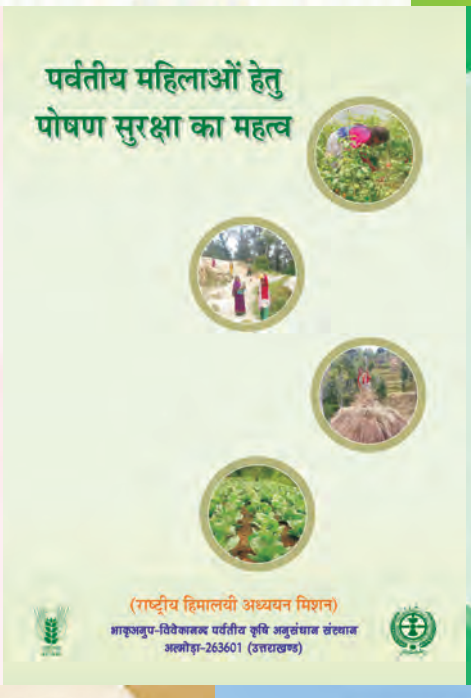
अल्मोड़ा-263601 (उत्तराखण्ड)
2019


पर्वतीय महिलाओं हेतु पोषण सुरक्षा का महत्व
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अल्मोड़ा-263601 (उत्तराखण्ड)


पोषण सुरक्षा हेतु पोषण वाटिका निर्माण
भाकृअनुप-विवेकानन्द पर्वतीय कृषि अनुसंधान संस्थान
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सम्पर्क समय - प्रत्येक कार्य दिवस (प्रातः 10.00 बजे से सांय 5.00 बजे तक)


ढिंगरी मशरूम उत्पादन तकनीकी
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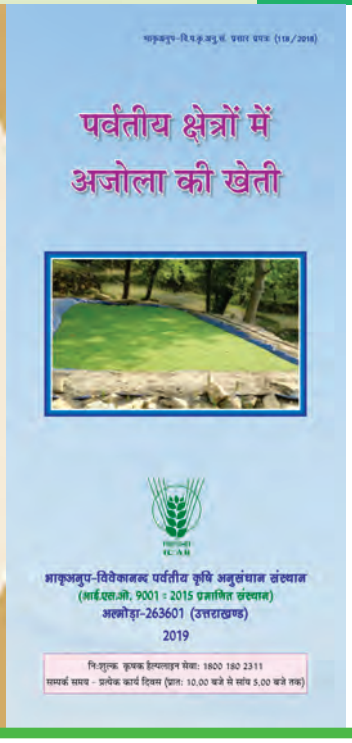
पर्वतीय क्षेत्रों में अजोला की खेती
भाकृअनुप-विवेकानन्द पर्वतीय कृषि अनुसंधान संस्थान
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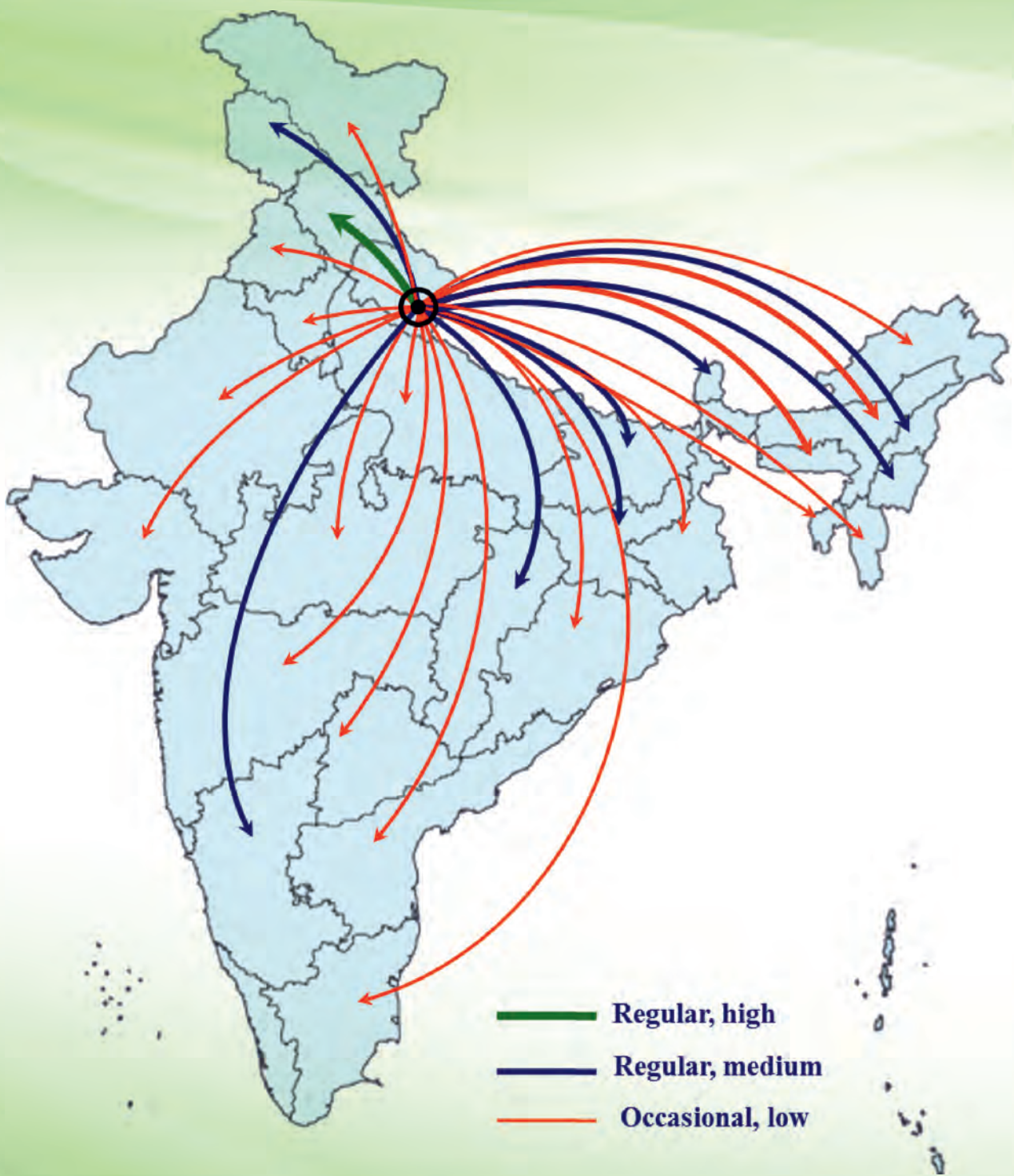
Technology Delivery Map of ICAR-VPKAS



भाकृअनुप
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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