Annual Report
2018-19





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

माकृअनुप
ICAR

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PREFACE

Hill farming systems, over centuries, have operated with the recyclable natural resources available within and around the systems. In India, these systems and the farmers within are the guardians of the most valued and important landscape and ecological resources like water, carbon, hydro power and a variety of high-quality foods. Yet, these farming systems are under increasing threat from climate, social and economic changes. Apart from marginality and subsistence, one of the most alarming facts is the higher average age of hill farmers and ever-increasing dependence on women.

Abandoned agricultural lands are facing threat of rewilding. Allowing rewilding of abandoned farmland may cause ecological imbalance and detract tourists from traditional landscapes. It may take centuries for these rewilded areas to become forests. Meanwhile, all the beneficial flora and fauna that survive in managed lands will disappear giving way to multiple known and unknown diseases and pests that thrive in the uncontrolled wild. As a proportion, farming may not be the most significant direct contributor to hill economy, but it is crucial for survival of other businesses like tourism, hospitality and handicraft. People visit the so called 'places of emancipation' in the hills because they are framed either in crop fields or orchards. Furthermore, the expectation of enjoying healthy and organic local food attracts visitors. All these contribute to increased off-farm income as part of the hill economy.

Many would argue that these ancillary businesses could be sustained by converting the farmers to 'resort keepers' where food production would be a secondary activity. However, it should be kept in mind that, over centuries, these exceptionally beautiful areas survived on the existence of agricultural production systems that not only satisfied the food sovereignty of hill people but also nurtured the bountiful flora and fauna of hill ecology/ecosystem. Also, during natural disasters these local food systems have traditionally provided means of survival to the people living in hills.

Considering the diversified need of hill agriculture, the institute worked on various aspects of crop improvement, management and processing. Additionally, the institute engaged in the scientific planning and creation of new climate resilient genotypes with a complete assessment of their nutritional value. Vigilance over threats led to a great win over the dreaded tomato pinworm in the Kumaun region of Uttarakhand. Being aware of the fact, drudgery and malnutrition are among the serious problems of women farmers, the institute developed new implements with increased efficiency and comfort and nutri-garden packages for hills.

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: June 30, 2018

(A. Pattanayak)
Director

Unity of Life in the words of Padma Bhushan Professor Boshi Sen

Padma Bhushan Professor Boshi Sen
Founder Director
1887 to 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, nine varieties of different crops were notified. These include two centrally released hybrids of maize - Vivek Maize Hybrid 57 (10,347 kg/ha green cob) and VL Sweet Corn Hybrid 2 (6,766 kg/ha); three varieties of wheat for Uttarakhand - VL *Gehun* 967 (1,988 kg/ha) (timely soon organic rainfed); VL *Gehun* 2014 (5, 207 kg/ha) and VL *Gehun* 3004 (4,388 kg/ha) in the main cereals group. In millets, finger millet variety VL *Mandua* 379 (3,100 kg/ha) was notified for north west and north east hills, eastern and central India. Another genotype, VL *Mandua* 378 (2,290 kg/ha) was identified for rainfed organic conditions of Uttarakhand hills. Likewise, in soybean VL *Soya* 89 (2,324 kg/ha) was notified for northern hill zone. In garden pea, VL *Sabji Matar* 13 (11,500 kg/ha) and VL *Sabji Matar* 15 (12,800 kg/ha) were notified for organic conditions of Uttarakhand state. To popularize newly notified varieties, front line demonstrations (FLDs) were conducted in a total of 42.1 ha area across the state. The newly released hybrids and varieties recorded a yield advantage of 66.3, 22.3, 12.0, 3.7 and 40.5% in maize, small millets, soybean, rice and wheat respectively over the ruling varieties in farmers field. In 2018-19, 278.30 q seeds of various categories were produced and 268.3 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. One hundred and twenty-nine confirmed doubled haploids were produced during the year. These lines showed significant variations in agronomic traits like plant stature, anthesis-silking-interval, ear placement, tassel shape and size, cob size and kernel rows/ear. Doubled haploids from Vivek QPM 9 were confirmed for their QPM trait through molecular markers. In addition, putative haploids from five new induction crosses were obtained.

Experiments on nitrogen scheduling in wheat cultivation showed that application of N @ 153 kg/ha through four different splitting (15, 20, 35 and 30% of the level at basal, tillering, jointing and booting, respectively) increased grain yield of wheat by 5.4%, saved 103 kg urea/ha and reduced the emission of 226 kg of CO_2/ha compared to the maximum grain yield achieved with application of 200 kg N/ha though three equal spliting. Application of Phosphorous-enriched compost (PEC) @ 100% of recommended P through SSP increased acid and alkaline phosphatase activity by 43 and 48%, respectively, compared to SSP (100% P) treated plot under different soybean-based cropping systems (soybean-wheat, soybean-lentil and soybean-toria cropping systems). However, the best effect (52 and 69%, respectively) was seen when P through PEC was increased to 125%. Experiments on the use of bio-fertilizers indicated that inoculation of 'P' solubilizing bacterial strain *P.* sp. CS11RP1 enhanced finger millet grain yield by 1.23-fold compared to uninoculated control (1,511 kg/ha). Bacterization of finger millet seeds with bacterial consortium C4 enhanced grain yield by 23.5% compared to uninoculated control. Bacterization with cold tolerant PGP *Pseudomonas* sp. PPERs23 recorded higher grain yield of 3,379 and 3,103 kg/ha for VL *Gehun* 953 and VL *Gehun* 907, respectively. However, VL *Gehun* 804 provided higher yield (3,200 kg/ha) with *Pseudomonas* sp. NARs9. Bacterization with cold tolerant PGP consortium of PGRs4, PPERs23 and PCRs4 recorded higher grain yield of 3,520 and 3,232 kg/ha for VL *Gehun* 953 and VL *Gehun* 907, respectively. However, VL *Gehun* 804 recorded higher yield (3,334 kg/ha) with consortium of PPRs4, PCRs4 and PGRs1. The above results indicated that VL *Gehun* 804 is an interesting genotype for studying plant microbe interactions.

Research on cultivation methods showed that application of green mulch in finger millet recorded 14% higher grain yield in the main crop (compared to no mulch) and 23% higher yield in the succeeding wheat crop. Grain yield of wheat under zero tillage with limited irrigation was 15% higher than conventional tillage (2,519 kg/ha), while it was just reverse in case of rice. In the *rabi* season, in open field, the highest onion yield (18.2 t/ha) was obtained under drip irrigation scheduled at 1.2 IW: CPE ratio. In case of garlic, the highest yield (9.25 t/ha) was obtained under drip irrigation scheduled at 1.0 IW:CPE ratio. Among different grass plantation systems in slopy land (43%), love grass and hybrid *Napier* were found to be the most effective in controlling runoff (57 and 56%) and soil loss (14.85 and 16.12 t/ha/yr).

Several fodder crops were tested during the year. Entries S-25 (Setaria), NB-21 (bajra napier hybrid), AVT-RG-1 (ryegrass), VTWC-1 (white clover) and VTRC-7 (red clover) were promising. In the agroforestry system, grain yield of wheat and finger millet were reduced by 22.0 and 5.8% respectively under peach plantation compared to open (without peach), respectively. The most suitable variety of wheat and finger millet for growing under peach crop was VL *Gehun* 804 and VL *Mandua* 149, respectively. Better turmeric yield (5.58 t/ha) was recorded under chir pine (*Pinus roxburghii)* forest compared to open condition (3.04 t/ha) on sloping lands (<23%).

During the year, moderate incidence of leaf and neck blast in rice and yellow rust in wheat was noticed whereas the false smut infestation in rice was high. Turcicum leaf blight, banded leaf and sheath blight and maydis leaf blight of maize were moderate in intensity. Leaf blast of finger millet and grain smut of barnyard millet showed high incidence. The South American pinworm (*Tuta absoluta)* was noticed for the first time in Uttarakhand during May 2018 and the damage was found up to 15%. The infestation was controlled within 40 days by joint efforts of the institute and line departments. Race profiling of blast pathogen (10 isolates) in rice showed that among the 24 'R genes' in monogenic blast differentials against *Magnaporthe oryzae*, *Pita2, Piz5, Pizt, Pita* and *Pi9* were found to exhibit high degree of resistance. Out of 206 hill germplasm collections of finger millet, VHC 3637, VHC 4085, VRB-MF-1817, VRB-MF-1819, VHC 4180 and VHC 4087 were immune to neck blast and showed high degree of resistance to finger blast and moderate resistant to leaf blast. Amongst 55 maize inbred lines evaluated under artificial epiphytotic conditions against banded leaf and sheath blight disease, identified tolerant sources were V334, V335, V372, V 406, V 407, VSL-4 and CM 141.

A study was conducted to find the compatibility of bacterial entomopathogens with insecticides in managing tomato borer and cabbage aphids. The joint action of four potent chitinolytic bacteria with seven selected insecticides against *Brevicoryne brassicae* revealed that out of total 28 interactions, additive, antagonistic and synergistic effects were in the ratio of 15, 10 and 3, respectively. Synergistic interactions were seen in profenophos with VLBt38 and VLBt109 and imidacloprid with VLBt27. Against *Helicoverpa armigera,* a total of 16 interactions were tested of which 13 and 3 were synergistic and additive, respectively and no antagonistic interactions were found. In majority of the synergistic interactions, the co-toxicity factor was more than 50 representing high levels of synergism.

Out of 12 siderophore producing Pseudomonad tested for production of *Agaricus bisporus* mushroom, casing application of strain PCRs4 (14.13 kg/q), strain PGRs1 (13.34 kg/q), strain PBRs5 (13.22 kg/q) and strain NPRp15 (13.09 kg/q) were found promising and gave significantly higher yield than control (11.3 kg/q compost). Amongst fourteen 'P' solubilizing *Pseudomonas* strains, strain CS11RP1 (15.4 kg/q compost wt.), *Pseudomonas fragi* CS11RH1 (14.4 kg/q compost wt.) gave 23.2% and 15.2% higher yield of *Agaricus bisporus* in comparison to control (12.5 kg/q compost wt), respectively.

Macrocybe gigantea mushroom cap contained higher polyphenols (9.72 mg GAE/100g dry wt.), total flavonoids (5.54 quercitin equi/g) and ferric reducing antioxidant power (234.94 mM trolox equi/g) than other parts tested, which indicated that the mushroom is a good antioxidant food where its cap contributes the most.

Vegetable value chain was studied in Nainital district of Uttarakhand. Marketing channel comprising of Producer—Wholesaler/ Commission agent (local market)—Retailer—Consumer was the most prominent followed by almost 70 per cent of the farmers. The study revealed that 80% of the tomato produced in the area was sold through this channel with a cost of marketing of Rs 187.45 per quintal. Marketing cost was the lowest (Rs 55.40 per quintal) in channel comprising of only producer and consumer, but only 5% of the produce was being sold through this channel. Drudgery of farm women in various activities in finger millet cultivation was studied. Rapid Entire Body Analysis (REBA) technique showed that carrying load, decortication and weeding activities as risky for farmers and required to be intervened.

The extent of malnutrition in farm women was assessed by computing the Body Mass Index (BMI). It was found that 26.0% of farm women studied were chronic energy deficient. Majority of women received medium dietary diversity score with 4-5 food groups only. Average vegetable consumption by women farmers was found to be 163.6 g/day, which is 45 per cent less than ICMR recommendation. Consumption of roots and tubers was 119% higher than recommended whereas consumption of green leafy vegetables and other vegetables were 42.4% and 87.3% less than recommended, respectively. Therefore, the concept of "nutri-garden" was introduced to promote consumption of nutritious food by cultivating suitable crops and vegetables locally.

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 the m-Kisan portal and 700 farmers are enrolled in the 'Need-based SMS Service' of the institute. Information provided by different divisions 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. The institute also runs two Farmers Producer Organizations (FPOs) in Uttarakhand.

INTRODUCTION

ICAR-VPKAS, Almora Campus

Experimental Farm, ICAR-VPKAS, Hawalbagh Campus

1. VPKAS: A Profile

ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan (ICAR-VPKAS), Almora is a premier institution conducting agricultural research mainly for the hilly region of North-Western (NW) Himalayan states of India, *viz*., Jammu and Kashmir, Himachal Pradesh and Uttarakhand. However, it also extends its technological support to other hilly regions of the country. The growth and development of the institute over the years has been phenomenal. Established by Padma Bhusan 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, at an altitude 1,600 m amsl) in Uttarakhand. The Research Farm is located at Hawalbagh, 13 km away from Almora on Kausani/ Ranikhet Road at an altitude of 1,250 m amsl (29°56' N and 79°40' E).

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

The ICAR-VPKAS, in the last 95 years of service to the nation, has several pioneering achievements to its credit. The most notable ones are:

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

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

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

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

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.

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 158 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 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. The institute has also developed matching production and protection technologies for these varieties.

Since 2015-16, 27 improved varieties of various crops like, wheat (VL *Gehun* 953), maize (Vivek Maize Hybrid 45, Vivek Maize Hybrid 47, Vivek Maize Hybrid 51, Vivek Maize Hybrid 53, Central VL Maize Sweet Corn 1), barley (VL *Jau* 118, VLB 94), rice (VL *Dhan* 68, VL *Dhan* 157, VL 7620), millets (VL *Mandua* 352, VL *Mandua* 348), oilseeds (VL Soya 77, VL *Bhat* 201) and vegetable (Vivek *Matar* 12, VL Shimla *Mirch* 3), Ricebean [Him Shakti (VRB3)] were released for cultivation. Among them nine were central releases and 18 were state releases. During the last five years, 907.77 q of breeder, 68.55 q of nucleus and 84.02 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 babycorn, high calcium grain millet) were done through these varieties. Working towards quality improvement, two inbreds (CM 212 and V 373) were converted to QPM and sweet corn 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 beta carotene (<10 ppm), 10 inbreds for high Fe content (<50 ppm) and 20 inbreds for low phytate (phy 55-63% of total P) have been developed. In wheat, *Yr10* and *LR24* genes have been pyramided in VL *Gehun* 907 and VL *Gehun* 892. More than 14,000 native and exotic accessions of different crops are being maintained at the institute.

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

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 has been introduced.

Low-cost polyhouse technology has been developed for protected cultivation. Crops and seedlings can successfully be grown during winter in the polyhouses, which, otherwise, is not possible outside due to prevailing low temperature. Package and practices for growing vegetables under low-cost polyhouse have been developed and standardized. 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. 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 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 devastates several rainfed *kharif* crops, is the most menacing insect of the region. More than 75 species of this insect have been recorded in Uttarakhand. Insect trap (Patented: IN290170) and the entomopathogenic *Bacillus cereus* WGPSB2 are the potential alternatives to insecticides 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 3800 field demonstrations were conducted to demonstrate the benefits of latest agro-technology in the villages adopted under various programmes.

A survey of the economics of off-season vegetables indicated that producer receives only 13-21% of consumer's money in different vegetables and the lion's share is siphoned to the middlemen in the prevailing marketing system, which indicates the need to develop marketing system by the farmers themselves, e.g., by forming a cooperative marketing society. 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 Purashkar** 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 Research 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 was selected for the "**Best Performing Centre Award" for the year 2017-18 for small millets research**. Institute also published "Inventory of ICAR-VPKAS Technologies" during 2018-19.

1.4 Insitute Facilities

Laboratories and Research Farm

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

Research Farm

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

Fabrication Workshop Cum Training Centre

During 2018-19, the Institute has established one workshop-cum-training centre under the Scheduled Cast 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 4202 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 4000 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). 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 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 was 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.

Staff

The staff position of the Institute as on 31.3.2019 is given below

Staff position	Sanctioned	Filled	Vacant
RMP	01	01	-
Scientific	60	41	19
Technical	44	33	11
Administrative	24	15	09
Supporting	49	43	06
Total	178	133	45

Finance

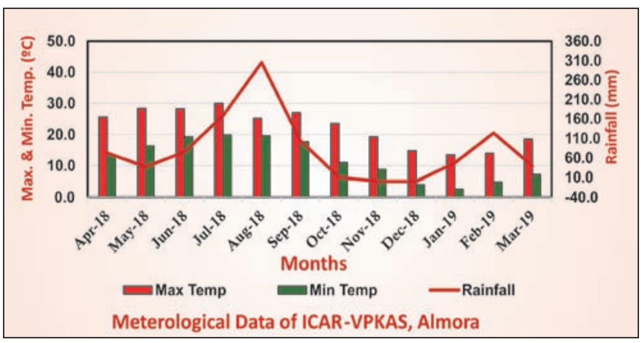
The budget outlay for 2018-19 (Rs. in lakhs) is given hereunder

Item	Allocation	Expenditure
Grant-in-General	2997.25	2997.18

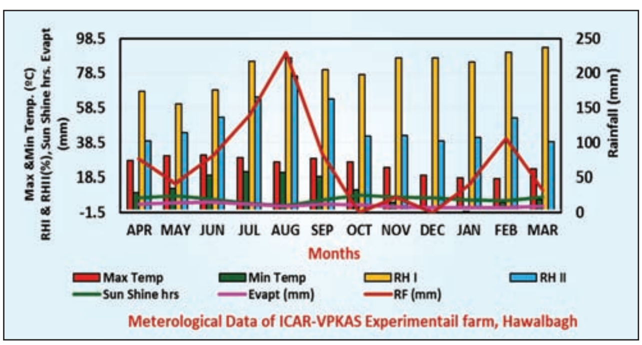
1.5 Weather and Crop Season

At Almora, the mean maximum daily temperature during *kharif* season (May to October) ranged from 23.5°C (October) to 30.0°C (July) and mean minimum daily temperature varied from 11.0°C (October) to 19.8°C (July). During *kharif*, about 699.9 mm rainfall was received. The maximum rainfall was received during August (305.0 mm) followed by July (168.3 mm). The mean maximum daily temperature during *rabi* season (November to April) ranged from 13.5°C (January) to 25.6°C (April) and the mean minimum daily temperature from 2.6°C (January) to 13.5°C (April). During *rabi*, about 283.0 mm of rainfall was received with no rainfall in the month of November. The total rainfall for entire year was 982.9 mm.

However, at the Experiemntal farm Hawalbagh, the mean maximum daily temperature during *kharif* season (May to October) ranged from 27.3°C (October) to 31.4°C (June) and mean minimum daily temperature varied from 11.4°C (October) to 21.7°C (July). During *kharif* about 572.9 mm rainfall was received. The maximum rainfall was received during August (230.0 mm) followed by July (138.6 mm). The mean maximum daily temperature during *rabi* season (November to April) ranged from 17.6°C (February) to 28.0°C (April) and the mean minimum daily temperature from -1.10°C (Decmber) to 10.0°C (April). During *rabi*, about 276.7 mm of rainfall was received with no rainfall in the month of December. The total rainfall for entire year was 849.6 mm.



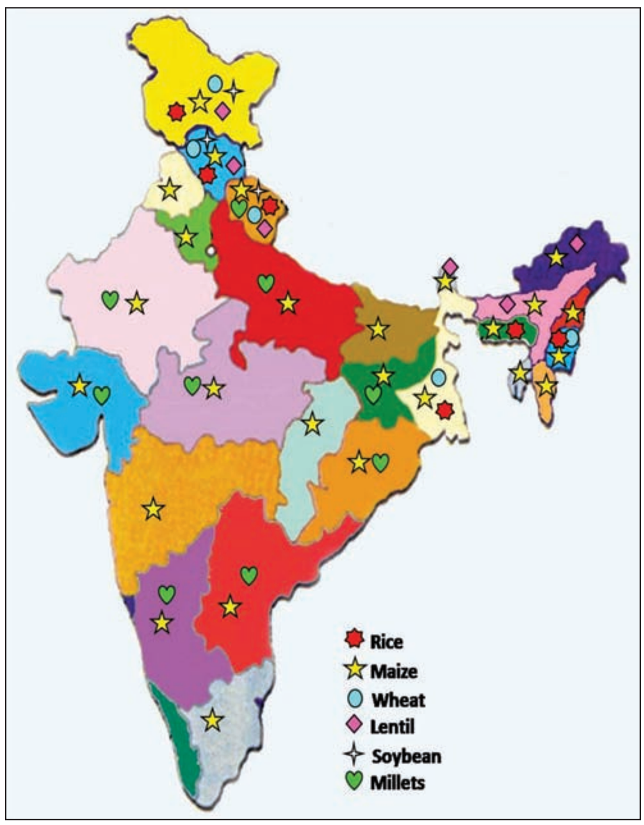
Meteorological Data of Almora (2018-19)



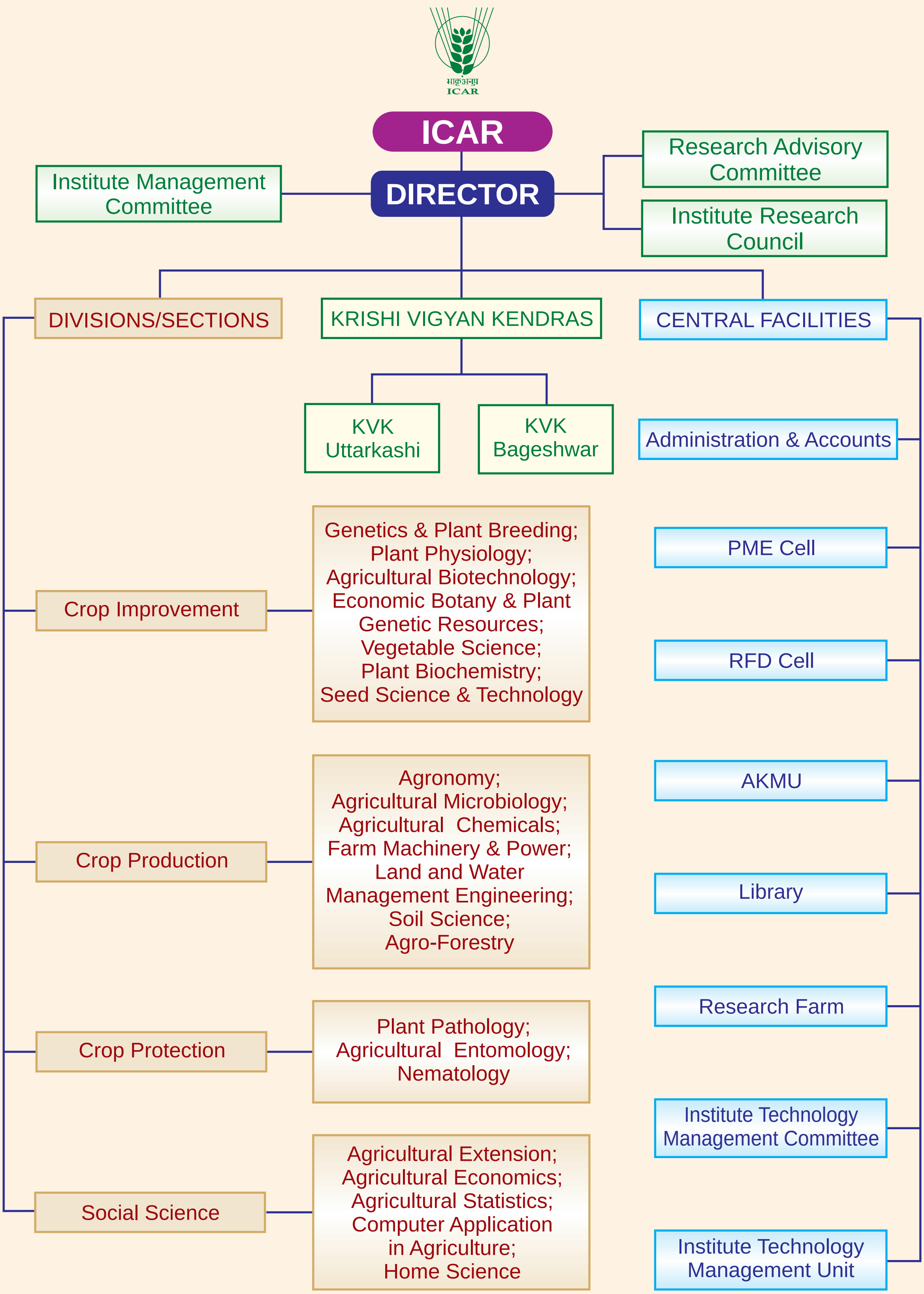
Meteorological Data of Hawalbagh Farm, Hawalbagh (2018-19)

Recommendation Domain of the Varieties Developed during Last Five Years

Since 2015-16, 27 improved varieties of various crops were developed. Among them nine were released through CSCSNRV and 18 were released through SVRC. The recommendation domain of these varieties includes the states beyond the mandate area of the institute as 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 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

Vivek Maize Hybrid 57

VL *Sabji Matar* 13

VL *Mandua* 378

Zinc solubilizing bacteria

Crop of *Macrocybe gigantea*

Vivek Wheat Thresher

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, Rajashekara, H., R.S. Pal, Rakesh Bhowmick (on study leave) & 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., Nov 30, 2018 to May 28, 2019) & Vijay Singh Meena]*
- Genetic Improvement of Wheat and Barley for Higher Productivity, Quality Traits, Abiotic and Biotic Stresses *[Drs. L. Kant, K.K. Mishra & D. Mahanta]*
- Trait Mining and Genetic Improvement of Small Millets and Potential Crops in the Context of Climate Change *[Drs. D.C. Joshi, Rajashekara, H. & B.M. Pandey]*
- 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., Nov 30, 2018 to May 28, 2019), K.K. Mishra, Sher Singh, A.R.N.S. Subanna, J.P. Aditya, & R.S. Pal]*
- Enhancement of Genetic Potency in Important Vegetables 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]*
- 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., Nov 30, 2018 to May 28, 2019), J.P. Aditya & Manoj Parihar]*
- 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 conditions in the North-Western Hills. The states of Jammu & Kashmir, Himachal Pradesh and Uttarakhand (Hills) with a total area of 625 thousand ha and production of 1189 thousand tonnes account for 7.2 and 5.5% of the national area and production, respectively. The productivity is 1902 kg/ha compared to the national average of 2509 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. The accomplishments in maize research during the year 2018 are presented hereunder.

2.1.1. Varietal Improvement

2.1.1.1. Hybrid Released

VL Sweet Corn Hybrid 2

VL Sweet Corn Hybrid 2 (FSCH 75) is a high yielding single-cross sweet corn hybrid. It exhibited an average yield of 10,347 kg/ha in Zone I (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura), exhibiting yield superiority of 41.6 per cent over the check Madhuri (7,309 kg/ha) in All India Coordinated Trials during 2015-17. The harvestable maturity (green cob) of the hybrid is 75-77 days in mid-hills. It is moderately resistant to turcicum and maydis leaf blight, banded leaf & sheath blight and curvularia leaf spot. TSS of the corn is 14.5-15.3%.

Vivek Maize Hybrid 57 (FH 3754) is a high yielding single-cross normal corn hybrid. It exhibited an average yield of 6,766 kg/ha in Zone I, exhibiting yield superiority of 13.5 per cent over the check PMH 5 (5,962 kg/ha) in All India Coordinated Trials during 2015-17. Maturity of the hybrid is 95-100 days in mid-hills. It has yellow flint and bold grains (test weight 280 g) and is moderately resistant to turcicum and maydis leaf blight.

Vivek Maize Hybrid 57

2.1.1.2. Elite Lines under All India Coordinated Maize Improvement Programme

In NIVT (Extra-early and Early), FH 3875 (8,166 kg/ha) exhibited numerical superiority over the check BIO 605 (8,138 kg/ha) in NHZ. FH 3861 (6,497 kg/ha) and FH 3879 (6,908 kg/ha) out-yielded the check BIO 605 (6,457 kg/ha) in NEPZ. FH 3879 with yield of 8,553 kg/ha and 5,918 kg/ha also out-yielded the check BIO 605 in PZ (8,298 kg/ha) and DKC 7074 (5,328 kg/ha) in CWZ. FH 3861 (5,722 kg/ha) also exhibited superiority over DKC 7074 in CWZ. In AVT-I (Extra-early and Early), FH 3823 (6,256 kg/ha) yielded 10.4% higher than the check DKC 7074 (5,669 kg/ha) in CWZ. In QPM trial, FQH 148 (5,555 kg/ha) was numerically superior to the check Pratap QPM Hybrid 1 (5,531 kg/ha).

2.1.1.3. Elite Lines under State Maize Varietal Trials

In SVT (Hills), QPM hybrids FQH 106 (3,779 kg/ha), FQH 148 (4,491 kg/ha), FQH 140 (4,528 kg/ha) and QPM composite VL QPM composite 2 (3,293 kg/ha) were superior to the respective checks Vivek QPM 9 (3,297 kg/ha) and Vivek *Sankul Makka* 35 (3,413 kg/ha). Normal corn hybrids FH 3878 (4,327 kg/ha) and FH 3895 (3,824 kg/ha) were superior to the best check (3,083 kg/ha).

2.1.1.4. Breeding Materials/Development of New Strains

Development of composites

QPM: 203 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 *viz.,* 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 14 promising open pollinated populations and 10 double cross combinations each from two heterotic pools developed during *kharif* 2017. Forty-five progenies possessing early maturity (52-56 days to 50% silking), shorter plant height (200-215 cm) and tolerant 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 fifty eight progenies of different homozygosity levels (23 S_1, 40 S_2, 103 S_3, 46 S_4, 62 S_5, 51 S_6, 28 S_7 and 5 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 *H. 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 146 (8 S_2,15 S_3 and 123 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.
- Advance generation progenies of two BC_2F_9 populations generated by crossing QPM versions of CM 212 and V373 with two sweet corn donors were evaluated. Promising progenies from each population were identified, maintained and used in hybridization programme.

Development of new single-cross hybrids

- Twenty new normal corn hybrid combinations were generated involving 12 existing elite lines and 8 new promising lines (V 509-V 516) identified during the season.
- Fifteen new sweet corn hybrid combinations and sixteen new QPM hybrid combinations were also generated using elite VL lines and new promising lines.

Doubled haploid breeding programme

Out of seed of putative 139 doubled haploid plants harvested during *kharif* 2017, 129 doubled haploid lines were obtained during *kharif* 2018. The details are as given below:

- Significant variation for important agronomic traits like plant stature, anthesis-silking interval, ear placement, cob size, ear aspects, tassel shape and size, grain size and kernel rows/ column were observed among the DH lines as given below.
- Out of 129 lines, 123 exhibited complete within line uniformity indicating their doubled haploid constitution. The remaining 6 lines exhibited variable degree of within line differences. These lines will be investigated further to establish the cause of variation. The DH status of these lines

Variation for days to flowering and tassel type among DH lines

Mature cobs of QPM DH lines

will be further confirmed on the basis of cob and seed characteristics.

- The QPM DH lines derived from QPM hybrids Vivek QPM 9 were screened with *opaque-2* marker umc1066 and 48 out of 50 progenies were observed to show presence of only one parental allele (VQL 1 or VQL 2) (Fig. 2.1.1).

Fig. 2.1.1. Molecular screening of Vivek QPM 9 DH lines with *opaque-2 markers umc*1066

Promising lines were used as parents for generation of new hybrid combinations. Putative haploid seeds of six induction crosses generated during *kharif* 2017 by crossing haploid inducer line EC 805127 with hybrids Vivek QPM 9, FQH 106, CMVL 55, FSCH 41 and VMH 45 were propagated during *kharif* 2018 following standard protocol. New induction crosses involving Vivek QPM 9, Pusa Improved VQPM 9, VMH 27, VH 43 and VMH 45 were also generated.

2.1.2. Germplasm Resource: Evaluation and Maintenance

- Three hundred and ten maize accessions from NEH region were evaluated and maintained
- Fifty-six accessions and six composites received from SKUAST-K were maintained
- Six accessions of local maize from Uttarakhand and four from NEH region were evaluated and maintained
- One hundred and one institute gene bank accessions were rejuvenated

2.1.3. Details of Germplasm Shared

Seed of early maturity inbreds was shared with various NARS institutes for strengthening their early maturity maize breeding programme. The details of inbreds shared are as given in Table 2.1.1.

Table 2.1.1. Details of maize inbreds shared with NARS institutes

Sl. No.	Institute	Germplasm
1.	GBPUAT, Pantnagar	V 334, V 336, V 351 and CM 212
2.	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
3.	Indian Institute of Maize Research, Ludhiana (for evaluation of nutritionally important traits)	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
4.	Indian Institute of Maize Research, Ludhiana (for AICMIP Pathology trial)	V 351, CM 141, V 440 and VSL 27
5.	SKUAST-K, Srinagar	V 492, V 496, V 502, V 503, V 506 and V 351
6.	SKUAST-J, Jammu	VQL 1 and VQL 2
7.	ICAR RC for NEH, Umiam, Meghalaya	V 373 and V 390

2.1.4. Plant Protection Investigations

During *kharif* 2018, total of 637 maize genotypes from coordinated entries were evaluated for Turcicum blight (*Exserohilum turcicum*). Plants were inoculated with pathogen in whorl after 30 days of sowing and allowed for symptoms expression and disease data were taken in 1-9 scale. Identified resistance sources in maize are given in Table 2.1.2.

Table 2.1.2. Identified resistance sources in maize

Trial name	No of entries	Highly resistant entries
Rainfed AVT-I-II	17	LM 13 (C)/FILLER, Bio 9544 (C), LMH 1016, DKC7173 (1Q7802), INDAM 1122, NMH-4053, JKMH15303 and CMH-08-292 (C)
NIVT-Medium	30	DKC 9198 and LMH 3417
NIVT 63-64 (Early-extra early maturity)	24	AH8181, AH 8106, LMH 3917, FH 3864 and FH 3879
QPM-I-II-III	16	HQPM 7 (Check), EHQ 64, APQH 1, LQPMH 118, Vivek QPM 9 (Check), APQH 5 and HQPM 1 (Check)
Sweet corn trial I-II-III	09	BSCH416078, CMVL SC 1 (Check), Misthi (Check), NUZI 205 and BSCH416086
Baby corn-I-II-III	08	PAC 321, CMVL BC2 (Check), AH 7204 and AH 7043
Pop corn	07	APCH 3, DPCH 306 and APCH 2
Trap nursery	12	CM501, BML6, BML7, LM 14, IIMR SBT POOL and V373
OPV	09	RCM 1-76, Vijay (Check), MS 4-1, Hemant (S Check), L300, MS 8-1, RCM 1-61 and L 315
Germplasm	505	91 entries were found highly resistant

2.1.5 Agronomic Investigations

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

One genotype of sweet-corn (AKSH1) was evaluated against three checks (Madhuri, Priya & Win orange) with two planting densities (60 x 30 cm and 60 x 25 cm) and two fertilizer levels (150-60-60 and 225-90-90 kg/ha N-P_2O_5-K_2O). The new genotype AKSH1 produced (17,862 kg/ha) significantly higher cob yield than the rest of the genotypes, except Madhuri (16,948 kg/ha). But the new genotype AKSH1 produced significantly higher cob yield compared to Madhuri under higher plant densities (60 x 25 cm). The fertilizer level of

225-90-90 kg/ha N-P_2O_5-K_2O provided significantly higher cob yield (16%) compared to 150-60-60 kg/ha N-P_2O_5-K_2O (14,220 kg/ha). The planting density of 60 x 25 cm (18,032 kg/ha) provided 42% more cob yield than 60 x 30 cm (12,657 kg/ha). The B:C ratio with planting geometry of 60 x 25 cm and nutrient level of 225-90-90 kg/ha N-P_2O_5-K_2O (4.67) was considerably higher (69%) than 60 x 30 cm planting geometry and 150-60-60 kg/ha N-P_2O_5-K_2O nutrient level (2.76).

Relative performance of pre-release QPM genotype at different nutrient levels

One new QPM genotype (FQH 106) was evaluated against three checks (VQPM 9, VMH 39 and VMH 53) with two fertilizer levels (150-60-60 and 200-65-80 kg/ha N-P_2O_5-K_2O). There was no significant difference for grain yield, neither among genotypes nor between nutrient levels.

2.2. Rice

Rice is a major *kharif* crop of the hill regions of India. In North-Western Himalayan hills, it is grown in 0.61 million hectares with production of about 1.34 million tonnes and productivity 2,179 kg/ha. Jammu & Kashmir covers highest area of rice (0.28 m ha), whereas production (0.63 mt) and productivity (2,414 kg/ha) were highest in Uttarakhand. In North-Eastern Himalayan states *viz.*, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizorum, Nagaland, Sikkim, Tripura the annual rice production is around 6.81 million tonnes from an area of about 3.48 million hectares with average productivity 1,955 kg/ha during 2016-17. The average productivity of rice in NW and NE Himalayan states is far behind the average national productivity

2.2.1. Varietal Improvement

2.2.1.1. Elite Lines under All India Coordinated Rice Improvement Programme

In irrigated early duration, entry VL 32224 was repeated for one more year as it has shown consistent performance for two years in lower hill (≤ 950 m amsl) and in third year under medium hill (≤ 950-1500 m amsl). Three entries *viz.*, VL 32292 (3,454 kg/ha), VL 32308 (2,935 kg/ha), VL 32303 (3,120 kg/ha) were promoted to second year of testing under medium hill and one entry VL 32300 (4,745 kg/ha) was promoted under low elevated hill condition based on their performance over the best check. Entry VL 32237 (4,068 kg/ha) was found promising for medium hills of Uttarakhand after three years of testing in irrigated medium duration trial, whereas three entries VL 32131 (4,630 kg/ha), VL 40387 (4,617 kg/ha) and VL 32130 (4,266 kg/ha) recorded significant yield advantage over the best check and hence promoted to third year of testing in medium hill condition. Entry VL 32329 was promoted to second year of testing in irrigated medium duration. In rainfed upland trial, entry VL 20073 (2,564 kg/ha) outperformed all the checks with yield advantage of 7.73% over the best check and hence promoted to third year of testing. However, entry VL 20254 (2,706 kg/ha) showed yield superiority of 13.7% over the best check and promoted to second year of testing.

2.2.1.2. Elite Lines under State Rice Varietial Trials

State Varietal Trials (SVT) were conducted under organic conditions. FYM @ 40, 30 and 20 t/ha were applied for irrigated early and medium for rainfed upland June sown and rainfed upland spring sown trial, respectively. In SVT multi-locational trials, four trials *viz.,* Spring sown rainfed upland, June sown rainfed upland, irrigated early duration and irrigated medium duration were conducted. Two entries, *viz.*, VL 11364 (1,900 kg/ha) and VL 11574 (2,088 kg/ha) were identified for release in spring sown rice after three years of testing for its superior performance over the checks VL *Dhan* 207 and VL *Dhan* 209. Entries VL 11638 (1,978 kg/ha), VL 11634 (1,785 kg/ha) and VL 11743 (1,979 kg/ha) provided superior performance over the checks VL *Dhan* 207 and VL *Dhan* 209 after two years of testing. In June sown rainfed upland rice, two entries VL 20073 (1,964 kg/ha) and VL 20083 (1,730 kg/ha) completed three years of testing and found significantly superior over the checks Vivek *Dhan* 154 (1,371 kg/ha), VL *Dhan* 221 (1,613 kg/

ha) and VL *Dhan* 156 (1,456 kg/ha) and identified for release. Entries VL 20254 and VL 20229 were promoted to second year of testing. Irrigated early duration trial VL 32110 (3,511 kg/ha) and VL 32112 (3,616 kg/ha) were promoted to third year of testing, whereas VL 32303 (3,563 kg/ha) was promoted to second year of testing based on their yield superiority over the best checks Vivek *Dhan* 82 (3,398 kg/ha). VL 32094 (3,927 kg/ha) was found promising in irrigated medium duration trial and promoted to third year of testing.

2.2.1.3. Breeding Materials/Development of New Strains

Two station trials each in spring sown rainfed upland, June sown rainfed upland and irrigated rice were conducted. Station trials were conducted to evaluate selected breeding lines against check for grain yield, resistance to major diseases like blast and brown spot and to identify promising lines. Promising lines selected from advance station trials includes VL 20432 (2,437 kg/ha) and VL 20541 (2,429 kg/ha) in rainfed upland June sown against best check VL *Dhan* 157 (1,799 kg/ha); VL 32434 (4,370 kg/ha) and VL 32465 (4,167 kg/ha) in irrigated early duration in comparison with check VL *Dhan* 86 (3,489 kg/ha) and VL 32470 (4,677 kg/ha) and VL 32471 (4,328 kg/ha) in irrigated medium duration conditions over check VL *Dhan* 68 (3,917 kg/ha). Selected lines were resistant to blast (1-3 score), brown spot (1-5 score) and showed desirable plant height (semi dwarf irrigated <110 cm, upland <90 cm to intermediate irrigated 110-130 cm and upland 90-125 cm) with different days to maturity (early 100-120 days in irrigated & rainfed upland June sown), medium (125-140 days in irrigated) and very late (>160 days in rainfed upland spring sown).

Segregating breeding materials

On the basis of desired characters like early (100-120 days) and medium (121-140 days) maturity, semi dwarf (irrigated <110 cm and upland <90 cm) to intermediate (irrigated 110-130 cm and upland 90-125 cm) plant height, drought tolerance (0-3 score of leaf drying), disease (0-5 score) and insect resistance (0-3 score), a total of 3,209 progenies derived from 635 crosses were selected in F_2 to F_5 generations under rainfed upland and irrigated transplanted ecosystem. The details are mentioned in Fig. 2.2.1.

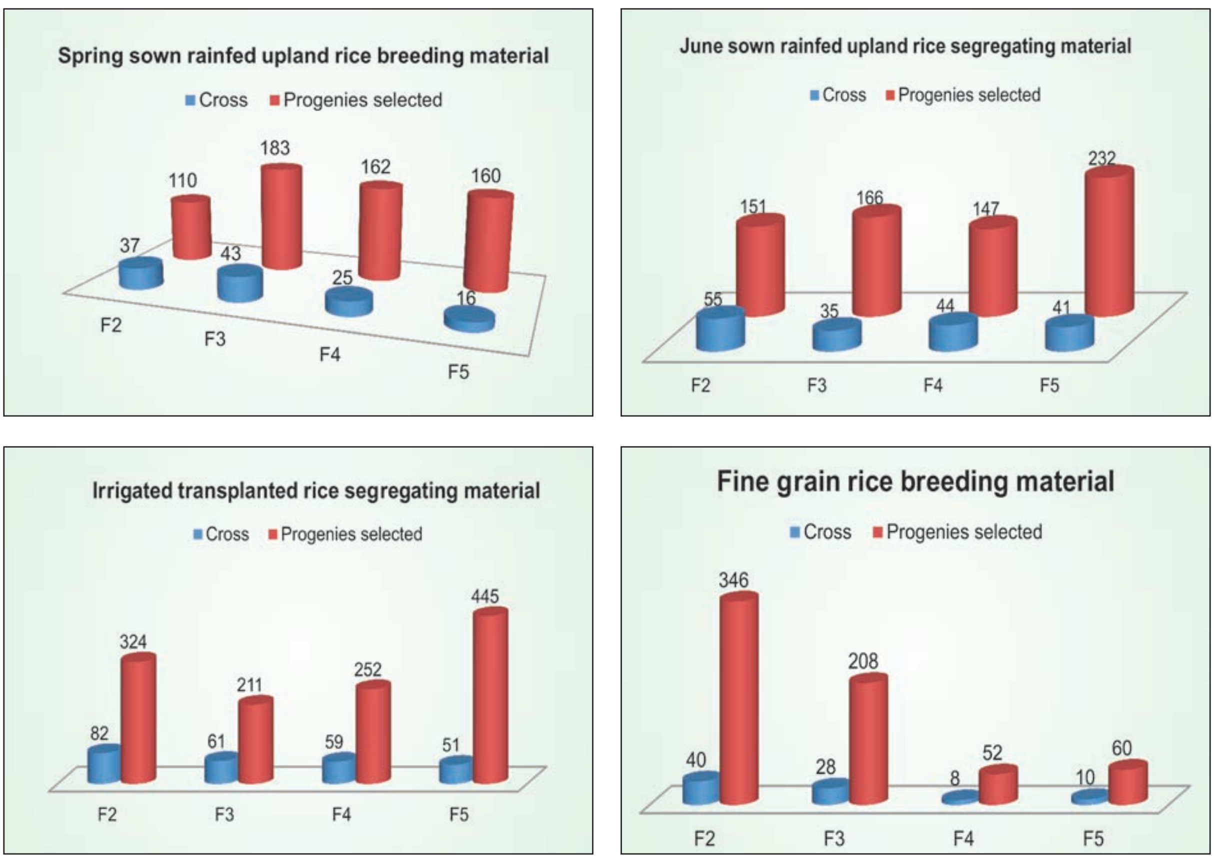


Fig. 2.2.1. Details of breeding materials under rainfed and irrigated ecosystem

2.2.2. Crop Protection Investigations

Plant pathological experiments were carried out during *kharif* 2018 for disease resistance evaluation in rice lines received from rice breeder (station entries) and AICRIP entries and screened under uniform blast nursery (UBN) for blast disease and brown leaf spot disease and the results are summarized as follows

- In advance station trial for spring rice, 18 lines were tested for brown leaf spot resistance. None of the entry was found highly resistant.
- In advance station trial for June sown rainfed condition, 22 entries were evaluated for leaf and neck blast disease, entries like VL 20432 and VL 8657 were resistant to leaf blast and Vivek 154, VL 157, VL 20432, VL 20433, VL 20434, VL 20441, VL 20444, VL 20464, VL 20466, VL 20468, VL 20541, VL 20549, VL 20554, VL 20559, VL 20561, VL 20568 and VL 8657 were found highly resistant to neck blast disease.
- In advance station trial for transplanted rice, 22 lines were tested. Out of which, 8 entries (VL 32376, VL 32441, VL 32456, VL 32468, VL 32469, VL 32396, VL 32470 and VL 8657) were resistant to leaf blast and 17 entries (VL 32430, VL 32434, VL 32441, VL 32456, VL 32462, VL 32465, VL 32468, VL 32469, VL 32428, VL 32432, VL 32433, VL 32454, VL 32455, VL 32470, VL 32471, VL 32472 and VL 8657) were resistant to neck blast disease.
- In VL rice blast screening nursery, 82 genotypes were evaluated for brown, leaf and neck blast disease resistance. None of the genotypes was highly resistant to brown leaf spot disease. Three genotypes (VL 31997, VL 32197 and VL 8657) were found resistant to leaf blast and fifty-nine entries showed highly resistant reaction (1 score) to neck blast disease.
- In National Screening Nursery for Hills (NSNH), 101 entries were tested for leaf and neck blast resistance, none of the entry was found highly resistant to leaf blast disease and entries like 2908, 2909, 2910, 2919, 2920, 2921, 2606, 2612, 2613, 2803, 2804, 2806, 2817, 2701, 2707, 3008 and 3017 showed highly resistant reaction with 1 score to neck blast disease.
- In National Hybrid Screening Nursery (NHSN), 108 entries were evaluated for brown leaf spot, leaf blast and neck blast disease. None of the entry was found resistant to brown leaf spot disease. Entries like 3201, 3203, 3207, 3213, 3233, 3304, 3308, 3405, 3410, 3414, 3103, 3104, 3108, 3111, 3115, 3117, 3118, 3119, Swarnadhan and Tetep were found resistant to leaf blast disease and entries 3201, 3203, 3205, 3213, 3214, 3216, 3217, 3218, 3220, 3221, 3222, 3224, 3226, 3228, 3231, 3233, 3302, 3305, 3308, 3313, 3322, 3101, 3103, 3106, 3109, 3111, 3112, 3117, 3119, 3120, IR 64, Swarnadhan and Tetep were resistant to neck blast disease.
- In Donor Screening Nursery (DSN), 129 entries were evaluated for leaf and neck blast resistance. Out of which RDN-RIL-77, Tetep and RNR 23605 were highly resistant to leaf blast disease and none of the entry was highly resistant to neck blast disease.
- In National Screening Nursery (NSN-1), 398 entries were evaluated for leaf blast disease under UBN system, entries like 2021, 2023, 3612, 1311, 1101, 1102, 1103, 1109, 1112, 4109, 118, 803, 808, 1014, 1015, 1016, 1420, Tetep, 4416, 4469, 5004, 5010 and 5012 were highly resistant to leaf blast disease.
- In National Screening Nursery (NSN-2), 682 entries were tested for leaf blast disease. Out of which, entries like 606, 615, 618, 624, 631 (1 score), 401, 411, 1905, 1908, 3910 (1), 3912, 1704, 1708, 1742, 1761, 4204, 4201 (1), 4250, 1201, 1208, 1212, 1215, 1240, 1245, 1254, 205, 216, 218 (1), 222, 2331, 915 (1), 943 (1), 952, 962, 1526 (1), 1554, Tetep (1), 4301, 4302, 1817, 3706, 3720, 3726 and 3733 were highly resistant to leaf blast disease.

2.2.3. Agronomic Investigations

Nitrogen response of various rice entries (transplanted) under high and low input management

In the AVT-2 Early Hill (EH), one new genotype (IET 25819) was evaluated against VL *Dhan* 85 and VL *Dhan* 86 under two nitrogen levels (low input-50% RDN and medium input-100% RDN). It was observed that grain yield of different entries of rice increased with the increasing levels of the nitrogen. The mean maximum grain yield of 3.98 and 4.15 t/ha was recorded for low and medium input, respectively with IET 25819 (Fig. 2.2.2.). IET 25819 was significantly superior compared the VL *Dhan* 85 and 86 under both nitrogen levels.

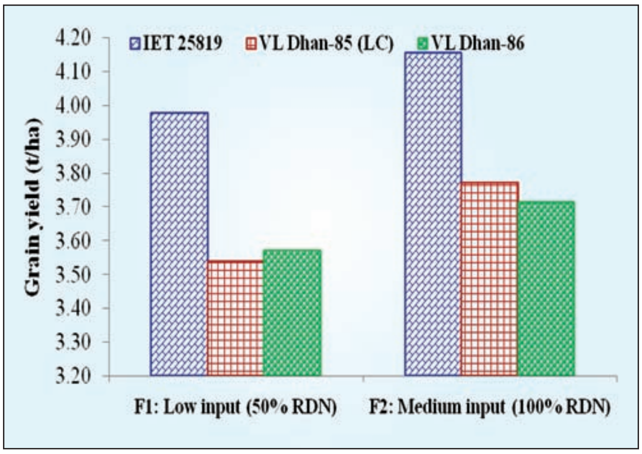


Fig. 2.2.2. Effect of nitrogen levels on grain yield of different early hill rice cultivars under transplanted conditions

In the AVT-2 Medium Hill (MH) one new genotype (IET 25830) was evaluated against VL *Dhan* 62, VL *Dhan* 65 and VL *Dhan* 61 under two nitrogen levels (100% RDN and 150% RDN). Results showed that grain yield of different entries of rice increased with the increasing levels of nitrogen. IET 25830 recorded significantly higher grain yield under both low (4.44 t/ha) and medium (4049 t/ha) input compared to the rest of the genotypes (Fig. 2.2.3.).

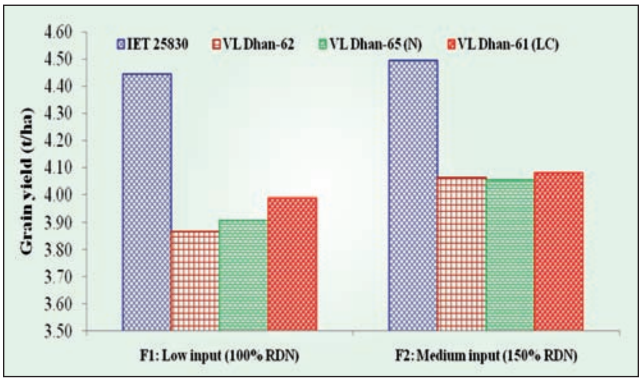


Fig. 2.2.3. Effect of nitrogen levels on grain yield of different medium hill rice cultivars under transplanted conditions

2.3. Wheat

Wheat is grown over an area of 0.96 million ha in N-W Himalayas with an average productivity of 1,958, 1,947 and 2,258 kg/ha in the states of Himachal Pradesh, Jammu & Kashmir and Uttarakhand, respectively. Its average productivity of 2,054 kg/ha is much below the national productivity of 3,034 kg/ha in 2015-16. 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 Notified

VL *Gehun* 967 (SHARP/3/PRL/SARAJ/TSIA/EE#5/5/VEE/LIRNIBOWI3IBCNI 4IKAUZ#4) is notified for rainfed timely sown organic conditions of Uttarakhand hills and has an average yield potential of 1,988 kg/ha compared to 1,762 and 1,668 kg/ha for the checks VL *Gehun* 907 and UP 2572, respectively. Besides high yield, VL *Gehun* 967 possesses high degree of resistance to yellow and brown rust under field conditions.

VL *Gehun* 967: Newly notified variety for Uttarakhand hills

VL *Gehun* 2014 (Raj 4132/AKAW 4006) is an indigenously bred wheat strain. It has been notified for irrigated timely sown conditions of Uttarakhand plains. It has an average yield potential of 5,207 kg/ha compared to 4,375 kg/ha for the best check UP 2628 during testing from 2014-15 to 2016-17. Besides high yield, VL *Gehun* 2014 possesses high degree of resistance to yellow and brown rust under both natural as well as artificial conditions.

VL *Gehun* 2014: Newly notified variety for Uttarakhand plains

VL *Gehun* 3004 (HD 2844/PBW 486) is an indigenously bred wheat strain. It is notified on 19.2.2019 for irrigated late sown conditions of Uttarakhand plains. It has an average yield potential of 4,388 kg/ha compared to 3,721 kg/ha for the best check UP 2565 during testing from 2013-14 to 2015-16. Besides high yield, VL *Gehun* 953 possesses high degree of resistance to yellow and brown rust under both hill as well as plain conditions.

VL *Gehun* 3004: Newly notified variety for Uttarakhand plains

2.3.1.2. Elite Lines under All India Coordinated Wheat Improvement Programme

The adaptability evaluation of new wheat strains with respect to grain yield, disease resistance and other desirable attributes under the rainfed early sown, rainfed as well as irrigated timely sown and restricted irrigation late sown conditions was done in eleven yield evaluation trials.

Rainfed conditions

The early sown IVT/AVT trial included 12 entries. The trial average yield was 3,400 kg/ha and the trial failed due to severe drought like conditions. Seven entries were tested in AVT timely sown trial. The average yield of trial was 760 kg/ha, which was quite low (due to drought) and the trial was considered as failed. In timely sown IVT trial, among 16 entries VL 2034 (2,690 kg/ha), UP 3014 (2,680 kg/ha) and HS 453 (2,060 kg/ha) were found superior to the best check HS 562 (2,560 kg/ha). Ten entries were evaluated in the late sown restricted irrigation IVT/AVT (pre-sown irrigation only) trial, and two entries VL 3018 (1,170 kg/ha) and VL 3016 (1,160 kg/ha) yielded better than the best check HS 490 (1,090 kg/ha).

Irrigated conditions

Seven entries were evaluated under AVT timely sown trial and the check HS 562 (5,550 kg/ha) was the top yielder.

2.3.1.3. Elite Lines under State Wheat Varietal Trials

Rainfed organic conditions

Under SVT organic timely sown trial, 12 entries were tested, in which VL 2015 (3,667 kg/ha) and VL 2029 (3,533 kg/ha) recorded a yield advantage of 33.0% and 21.9% over the best check VL *Gehun* 907 (2,757 kg/ha).

Irrigated organic conditions

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

2.3.1.4. Elite Lines under Station Trials

In initial station yield evaluation trials, one trial each under rainfed early sown, rainfed timely sown, irrigated timely sown and restricted irrigation late sown conditions was conducted to assess the adaptability of new wheat strains with respect to grain yield and disease resistance. In early sown rainfed trial, 16 entries were evaluated and VW 1712 (5,950 kg/ha) was found significantly superior to the best check HS 542 (3,090 kg/ha). Under timely sown rainfed trial, 30 entries were tested and VW 1715 (1,507 kg/ha) and VW 1117 (1,368 kg/ha) were found superior to the best check HS 507 (1,319 kg/ha). Fourteen entries were evaluated under the late sown restricted irrigation (pre-sown irrigation only) trial and VW 1752 (1,574 kg/ha) was at par with the best check HS 490 (1,692 kg/ha). Thirty entries were evaluated under irrigated timely sown trial and VW 1720 (7,104 kg/ha), VW 1715 (6,868 kg/ha), VW 1738 (6,750 kg/ha) and VW 1721 (6,500 kg/ha) were significantly better than the best check, VL *Gehun* 907 (6,472 kg/ha).

Sixty new bulks were evaluated in different station trials under the rainfed as well as irrigated conditions and 9 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 and brown rust and loose smut) genotypes suitable for rainfed early sown, rainfed and irrigated timely sown and restricted irrigation late sown conditions of northern hill zone are the major objectives of the programme. Two hundred and ninety-seven fresh crosses [97 spring × 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 58 S×S and 155 W×S were identified after evaluation of 319 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. One hundred thirty seven F_2's (*i.e.* 79 S×S and 59 W×S) and 336 bulk progenies of 336 crosses (187 W×S and 149 S×S) in F_3 to F_5 generations and 241 single plant progenies (170 S×S) and (456 W×S) of 253 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, 362 bulk and 440 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

High protein content, high micro-nutrients, 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. BWL 1660, BWL 1664, BWL 991 and QLD 11 (protein >16%), QLD 70, BN 959, QLD 71 and QLD 85 (protein yield 45-52 g), VL 858 (*chapati* quality), HD 3216 and UP 2927 (sedimentation value) and 8th EBWYT 510 were used as donors for the respective traits and were crossed with well adapted genotypes. Twenty fresh crosses were attempted during *rabi* 2016-17. Quality analysis of 72 F_6 bulks derived from such crosses was completed. The quality parameters of promising F_6 bulks are given in Table 2.3.1.

Table 2.3.1. Promising F_6 bulks with desirable quality parameters

Breeding No.	Pedigree	Protein (%)	Fat (%)	Starch (%)
BN-767	CHINA84-400022/VL 907//SS64/2*SUNCO (CROSS #254)#7	11.16	3.19	56.64
BN-575	VL 892/PHS 822	11.43	3.38	53.69
BN-569	VL 858/VL 892	11.03	3.45	51.43
BN-771	CHINA 84-400022/MACS 6240//QLD31	10.97	3.31	57.68
BN-615	TAM 200/KAUZ//Ltg164/PHS822	10.94	3.41	61.31
BN-766	CHINA 84-400022/VL914//VL920	10.91	3.05	61.34
BN-745	AGRI/NAC//ATTILLA/PBW599//Yr10/5*DATATINE	10.89	3.36	56.67
BN-695	RL6043/4*NAC//PASTOR/3/BABAX/VL 892	10.88	3.18	58.67

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

Winter and facultative wheat donors (40) 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. The selected ones were crossed to spring wheat known for their high yield potential, disease resistance (rust resistance in particular) and adaptation to the major wheat growing regions of the country. Three-way cross was also attempted with the F_1 of the last year and selected spring wheat. During rabi 2017-18, 98 crosses were successfully attempted.

Ninety F_1s made during *rabi* 2016-17 were evaluated and 68 were found promising and retained for growing their F_2 generation during next crop season. In adidition, 80 F_2s retained during last season, were evaluated during *rabi* 2017-18. High incidence of yellow and brown rust were artificially created, which facilitated the selection. Only negative selection was practised in these materials. Fifty-eight F_2s was bulked.

During *rabi* 2017-18, 51 F_2 bulks were supplied to IIWBR, Karnal for further distribution to different coordinating & cooperating centers.

These 51 F_2 bulks were shared with 7 cooperators in three major wheat growing zones (Northern Hills 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 6.9 to 95% at different cooperating centers.

2.3.1.7. Genetic Resources - Evaluation and Maintenance

Two national nurseries comprising of 184 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* 2018, for screening against yellow and brown rust, respectively. Heavy yellow rust epiphytotic facilitated the screening and yellow rust severity upto 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. Plant Pathological Investigations

More than one thousand wheat entries of different coordinated and station nurseries were screened under natural and artificial epiphytotic conditions. These include Trap Nursery, SAARC, Loose Smut Expression Nursery (LSEN), 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). Identified promising lines of wheat are given in Table 2.3.2.

Table 2.3.2. Promising lines of wheat in different disease screening nurseries

Nursery	Promising lines (disease reaction)
TRAP	C 306, RNB 1001, HPW 349, HS 507 against yellow rust (0 to 5S); Agra local-60S
SAARC	WH 1562, HD 2189, PBW 660 and Bakhtawar 94 against yellow rust (0 to 5S); Susceptible check-40S
Loose smut expression nursery (LSEN)	VL 1013, WH 1202, HI 8791, UAS 462, DDK 1052, DDK 1053, MACS 5047, MACS 5049, DBW 90, HD 3086, WH 1124, MACS 4028, UAS 446, VW 20105, VW 20125, VW 20166, VW 1433 (0%)
VL rust screening nursery	VW 1725, VW 1726, VW 1727, VW 1753 (0S to yellow and brown rust; 01score for powdery mildew)
Powdery mildew screening nursery (PMSN)	VW 1537, VW 1557, VW 1629, VW 1630, VW 1632, VW 1702, VW 1703, VW 1718 (0-1 score)

Elite plant pathological screening nursery (EPPSN)	HI 1612, DBW 251, TL 3012, TL 3013, TL 3014, VL 1011, VL 1012, VL 1013, HPW 448, HS 645, PBW 750 (0-5S for yellow rust & 0-1 score for powdery mildew)
Multiple disease screening nursery (MDSN)	VL 3002, VL 3012, HS 627, DBW 217, VL 3011, HD 2967 (0S for yellow rust & 0-1 score for powdery mildew)
Hill Bunt Screening Nursery Coordinated (HBSN)	NHESZ 1709, VW 1225, VW 1231, VW 1245, VW 1250, VW 1260, VW 1333, VW 1518, VW 1556, VW 1630 (0%)

2.3.3. Agronomic Investigations

Performance of new wheat genotypes at different dates of sowing under irrigated conditions

Three new genotypes (VL 2014, VL 2015 and VL 3004) were evaluated against VL *Gehun* 953 and VL *Gehun* 892 under different dates of sowing (Normal - November 7 and Late - November 27) for higher productivity. VL 2015 (6,283 kg/ha) and VL 2014 (6,014 kg/ha) produced significantly higher grain yield compared to rest of the genotypes under late sowing condition. The grain yield of VL 2015 (6,389 kg/ha) was significantly higher than the rest of the genotypes. Normal sowing time (6,399 kg/ha) provided 9% higher grain yield than late sowing.

2.4. Barley

Barley is being cultivated to some of the traditional areas of North-Western Hills. It has a coverage of 44.8 thousand ha with an average productivity of 1,130 kg/ha (2015-16). Barley improvement work is focused 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

Sixty new barley strains were evaluated in 4 different trials, to identify high yielding disease resistant genotypes. AVT timely sown rainfed trial failed due to drought conditions. VLB 160 (2,029 kg/ ha) entry surpassed the best check VLB 56 (2,000 kg/ha) in SVT (organic) timely sown rainfed trial. Thirty-two new bulks generated through institute breeding programme were evaluated in station trials under rainfed condition. Five promising strains having yield potential from 1,713 to 1,865 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, 128 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

Dual purpose barley genotypes (17) were evaluated against two checks (BHS 380 and HBL 276) under rainfed condition. VLB 156 (1,487 kg/ha) produced highest grain yield, which provided 33% higher grain yield than the best check, HBL 276. VLB 155 provided the highest green fodder yield (3,686 kg/ha), which was significantly higher than most genotypes, except VLB 157 (3,601 kg/ha), BHS 380 (3,559 kg/ha) and UPB 1072 (3,418 kg/ha).

2.5. Small Millets & Potential Crops

Small millets and potential crops are the integral part of hill and tribal farming in drylands all 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) (Directorate of Economics and Statistics, Ministry of Agriculture, GOI, 2014-15). 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. Varieties Notified

Central Finger millet VL *Mandua* 379 was notified for cultivation in rainfed *kharif* ecology of Uttarakhand, Bihar, Jharkhand, NE states and Madhya Pradesh in the year 2018. It was developed from the cross GEC440 x VL *Ragi* 149. It exhibited average yield of 3,100 kg/ha in coordinated trails. It has a medium plant height (95-102 cm) and early maturity (103-111 days). This variety is characterized by semi-compact ear heads with top incurved fingers with 1000 seed weight of 3.05 g and dark copper colour grains (CVRCS.O. 1379(E). dated 27 March, 2018).

2.5.1.2. Varieties Identified for Release

VL *Mandua* 378 was identified for the rainfed organic conditions of Uttarakhand. It was developed from a cross between GEC 440 (early maturing core collection germplasm line) and VL *Ragi* 149 (blast resistant finger millet variety). This variety has compact earheads and moderate resistance to finger and neck blast. It recorded an average grain yield of 2,290 kg/ha with a yield advantage of 23.4% over the check variety VL *Mandua* 324 (1,850 kg/ha).

Field view of VL *Mandua* 379

Field view of VL *Mandua* 378

Seeds of VL *Mandua* 379

Seeds of VL *Mandua* 378

2.5.1.3. Elite Lines under All India Coordinated Small Millets Improvement Programme

Finger millet

In two yield evaluation trials, total thirty-five elite entries were evaluated for yield and yield contributing traits. In initial varietal trial (north zone, early and medium maturity) of finger millet, the best performing entry in terms of grain yield was RAUF 17 (4,773 kg/ha) followed by VR 1110 (4,497 kg/ha). Similarly, in advanced varietal trial (north zone, early and medium duration) a total of ten entries were evaluated for yield parameters. Out of the ten tested entries, BR-14-3 1(4,784 kg/ha), KOPN 9422 (4,196 kg/ha) and VL 387 (3,382 kg/ha) were the best performing entries compared to the local check VL *Mandua* 324 (3,234 kg/ha).

Barnyard Millet

Barnyard millet yield evaluation trial comprising both initial and advanced entries (BIAVT) was evaluated for yield and yield contributing traits in rainfed *kharif* season. Out of the total thirteen entries evaluated, genotype VL 254 recorded the highest grain yield (3,323 kg/ha) followed by VL 207 12 (2,987 kg/ha).

2.5.1.4. Elite Lines under State Varietal Trials

Finger millet

In the state varietal trial (SVT) under organic conditions, VL 391 (2,995 kg/ha), VL 398 (2,660 kg/ha) and VL 392 (2,630 kg/ha) were the top-ranking entries in terms of grain yield.

Barnyard millet

In barnyard millet SVT trial, entry VL 254 was the top yielder (2,082 kg/ha) followed by VL 253 (1,956 kg/ha).

2.5.1.5. Breeding Materials/ Development of New Strains

Yield evaluation of superior bulks in station trial

An initial station trial (IST) was laid down under rainfed *kharif* ecology of Experimental Farm Hawalbagh, Almora. The IST comprised of sixty-four phenotypically superior F6 bulks evaluated in two replications along with two national checks (VL 376 and VL 352). Genotypes VR-18-1 (3232.8 kg/ha), VR-18-4 (2987.5 kg/ha), VR-18-21 (3789.6 kg/ha), VR-13-31-1 (3,222.2 kg/ha) and VR-13-31-6 (3,589.7 kg/ha) were the best performing entries in terms of grain yield compared to the check variety VL 352 (2,671.3 kg/ha) and VL 376 (2,279.8 kg/ha).

Development of new strains

Twenty-two new cross combinations were attempted involving parental genotypes with diverse genetic background. This included high yielding blast resistant released cultivars (VL *Mandua* 379, VL *Mandua* 376, GPU 45, GPU 48 and GPU 28); early maturing locally adapted genotypes of Uttarakhand (VL *Mandua* 149, VL 340, VL *Mandua* 347 and VL *Mandua* 352) and white grain entry of Tamil Nadu (TNEC 1234). Additionally, local promising collections (VHC 3581, VHC 36610, VHC 3618, GPHCPB 52) identified from two years rigorous evaluation of hill gene pool of finger millet along with a promising ICRISAT core germplasm genotype (IE 4673) were also deployed in hybridization programme.

Out of the total twenty-two crosses attempted during the *kharif* 2017, sixteen crosses were identified as true F_1 hybrid during *kharif* 2018. The anthocyanin coloration in nodes and panicle was utilized as a phenotypic marker for the identification of true hybrids. The segregating generations (F_2, F_3, F_4 and F_5) were evaluated and selections were made utilizing selected bulk pedigree method. Plant progenies of different segregating generations were subjected to rigorous selection for blast. The infector rows for neck and finger blast were planted in and around the breeding materials and screening was done under natural disease pressure. The detail of the breeding material is depicted in Fig. 2.5.1.

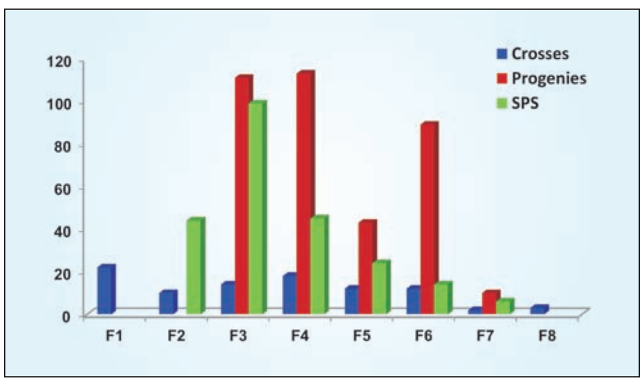


Fig. 2.5.1. Details of finger millet breeding material generated and evaluated during the year

Barnyard Millet

Yield evaluation of superior bulks in station trial

An initial station trial of barnyard millet was laid down in rainfed *kharif* ecology. The IST comprised of fifty-two phenotypically superior F_6 and F_7 bulks evaluated in two replications along with national checks VL *Madira* 172 and VL *Madira* 207. None of the entry has shown yield superiority over the checks. Entries VB 17-4 (2,919.2 kg/ha), VB 17-9 (2,835.0 kg/ha) and VB 16-20 (2,591.2 kg/ha) in station trial were at par with best check VL *Madira* 207 (2,669.2 kg/ha).

Development of new strains

A total of nineteen crosses were attempted utilizing the parents with diverse genetic background. The parental genotypes included, locally adapted genotypes (VL 172, VL 29, VL 207, VL 234 and VL 137), superior performing genotypes selected from national barnyard germplasm nursery (GECH 127, GECH 1, GECH 13, GECH 271, GECH 388, GECH 768, GECH 746, TNEF 206 and ACM 333); promising lines picked from ICRISAT core collection (IEc 552 and IEc 566) and genotypes picked from advanced breeding material based on yield components (DHBM 93-3, VB 410 and VB 464). In addition, the *E. esculenta/E. esculenta* cross (PRJ1/IEc 552 and PRJ-1/PRB 903) were also attempted for exploiting their high yield potential and grain smut resistance. The F_4 progenies of *E. esculenta/E. esculenta* cross were having large panicle, more number of branches, medium plant height and smut resistance. Out of the twenty-two crosses attempted in *kharif* 2017, sixteen were identified as true hybrids based on the pigmentation and panicle morphology of hybrids and male parent.

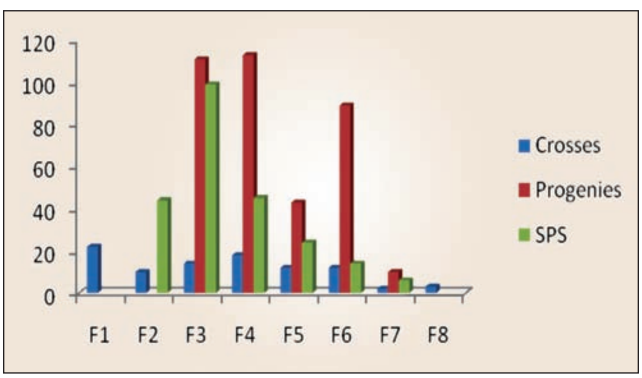


Fig. 2.5.2. Details of barnyard millet breeding material generated and evaluted during the year

The details of segregating breeding materials are presented in Fig. 2.5.2.

Promising segregating F_4 progenies of *E. esculenta* × *E. esculenta* cross (PRB 903× PRJ-1)

2.5.2. Potential Crops (Amaranth and Buckwheat)

2.5.2.1. Elite Strains in Coordinated and State Varietal Trials

In advanced varietal and state varietal trials of amaranth and buckwheat, a total of thirty-five entries were evaluated for grain yield and yield contributing traits. In amaranth AVT, highest yield was exhibited by entry VL 110 (1,654 kg/ha) followed by check variety Durga (1,166 kg/ha). Likewise, in SVT, genotype VL110 (2,235 kg/ha) was the best performing genotype followed by VL 115 (2,085.6 kg/ha) in terms of grain yield. In advanced varietal trial of buckwheat, check variety VL *Ugal 7* (1,423.4 kg/ha) was the best performing genotype and none of the test entry out yielded it in terms of grain yield.

2.5.2.2. Development of New Strains and Breeding Material

During *kharif* 2018, 8 new cross combinations were attempted involving locally adapted genotypes (VL 44, VL 101 and VL 115), high yielding national genotypes (Durga and PLP 1) and promising accessions selected from germplasm evaluation (IC 95250 and IC 42407). In amaranth, 4 out of 6 crosses attempted during 2017 are expected to be true hybrids based on panicle pigmentation. The details of breeding material are depicted in Fig. 2.5.3.

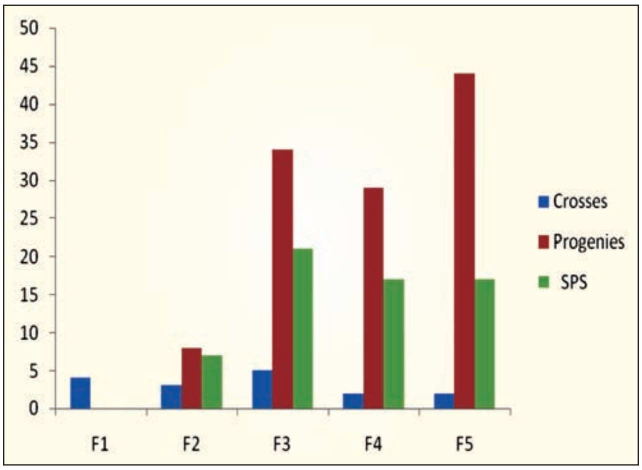


Fig. 2.5.3. Development of new strains and breeding material

2.5.3. Crop Protection Investigations

During *kharif* 2018, 117 entries of finger millet and 110 entries of barnyard millet of both station and coordinated trials were evaluated for disease resistance to blast and grain smut diseases, respectively. The resistant sources identified were summarized in Table 2.5.1.

2.5.4. Agronomic Investigations

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

Three pre released finger millet varieties (FMV 1102, FMV 1104 and FMV 1106) were evaluated against two checks (VL *Mandua* 352 and VL *Mandua* 376) with different nutrient levels (75, 100 and 125% NPK) under rainfed conditions. The variety FMV 1106 recorded higher yield (3,262 kg/ha) compared to all other varieties. The same variety recorded the highest grain yield with 75 per cent NPK (3,768 kg/ha). However, there was no difference due to different nutrient levels.

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

One pre release variety of barnyard millet, *i.e.* BMV 582 was evaluated aginst three checks (VL *Madira* 207, DHBM 93-3 and VL *Madira* 29) with different nutrient levels (75, 100 and 125% NPK) under rainfed conditions. The variety VL *Madira* 207 recorded the highest yield (2,362 kg/ha) among all varieties. However, there was no difference due to different nutrient levels.

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

Two pre release varieties of proso millet (PMV 441 and PMV 442) were evaluated against two checks

Table 2.5.1. Identified resistant sources in finger millet & barnyard millet

Crop	Nurseries	Entries	Disease	Highly resistant entries
Finger millet	VL Disease screening nursery (VLDSN)	64	Leaf, neck and finger blast	VR-18-1, VR-18-2, VR-18-3, VR-18-5, VR-18-6, VR-18-7, VR-18-8, VR-18-11, VR-18-12, VR-18-16, VR-18-17, VR-18-19, VR-18-35, VR-18-36, VR-18-40, VR-18-43, VR-13-15, VR-15-4-1 and VR-15-5
	Advanced Varietal Trial (AVT-I & II)	11	Leaf, neck and finger blast	VR1101, PR 202, GPU 67 and GE 4449 (R check)
	Initial Varietal Trial (IVT)	26	Leaf, neck and finger blast	WN 550, OEB 601, KPON 1059, IIMRFM-8011-17 and GPU67
	National Screening Nursery (NSN)	16	Leaf, neck and finger blast	NSN-2 and NSN-14
Barnyard millet	Station trial	84	Grain smut disease	VB-18- 5, VB-18-34, VB-18-36, VB-18-43, VB-18-44, VB-18-52 and VB-18-54
	Barnyard advanced varietal trial (BAVT)	14	Grain smut disease	DHBM 33, BYNDL-1, TNEf 307, and PRB-903 (R check)
	National Screening Nursery (NSN)	12	Grain smut disease	NSN-1, NSN-2, NSN-3, NSN-4 and PRB-903 (R check)

(TNAU 164 and TNAU 202) with nutrient levels (75, 100 and 125% NPK) under rainfed conditions. There was no difference for different varieties and different nutrient levels. The yield levels were very low due to rat damage and shattering.

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 111 thousand hectares with 101 thousand tonnes production whereas, the total oilseed production is 60.8 thousand tonnes from 95.4 thousand hectares in North-Western Himalayas (DAC 2016-17). Development of nutritionally superior high yielding, disease and insect-pest resistant varieties suitable for hill agro-ecosystem with matching production technology are the thrust areas in research programme for improving pulse and oilseed production in hills.

2.6.1. *Kharif* Legumes (Horse gram, Rajmash and *Bhat*)

2.6.1.1. Elite lines under All India Coordinated Programme

A total of 14 horsegram entries were evaluated for yield and yield contributing characters in IVT and AVT2 (North) trial. In this trial, two entries *viz.*, VLG 47 and VLG 48 were tested and recorded grain yield of 627 and 662 kg/ha, respectively. Only one entry BSP 17-2 (1029 kg/ha) was found at par to the best check CRHG 22 (1030 kg/ha) in combined IVT + AVT2 (North) trial.

2.6.1.2. Elite Lines under State Varietal Trials

Under organic conditions, out of the nine entries tested in SVT, two entries, *viz.*, VLG 47 and VLG 48 were tested during *kharif* 2018 for yield and yield contributing characters. VLG 47 and VLG 48 recorded grain yield of 703 kg/ha and 652 kg/ha, respectively in this trial.

2.6.1.3. Elite Lines under Station Trials

During the *kharif* 2018, 29 superior bulks identified in F_6 generations of different crosses were evaluated in Initial Station Trial (IST) for yield and yield components along with two national checks (VL *Gahat* 15 & VL *Gahat* 19). Entries, *viz.,* VLG 2017-20 (1185 kg/ha), VLG 2017-2 (1037 kg/ha) and VLG 2017-1 (1019 kg/ha) were found superior to the best check VL Gahat 15 (833 kg/ha) with resistance against anthracnose disease (score 1) under natural conditions. Among 15 entries evaluated in Advance Station Trial (AST) entries, *viz.*, VLG 2016-11 (992 kg/ha) and VLG 2016-2 (957 kg/ha) were found superior to the best check VL Gahat 15 (863 kg/ha).

Breeding materials/Development of new strains

During *Kharif* 2018, seventeen new cross combinations were attempted involving high yielding anthracnose resistant released varieties (VLG 15, VLG 19, VLG 8, HPK 2, HPK 4 & VLG 10); early maturing (<100 days) variety (AK 42); local blackish brown grained lines *viz.*, VLG 31 and VLG 37 were also included in the crossing programme. Out of 62 crosses attempted during *Kharif* 2017, 60 cross combinations were advanced to F_2 generation, whereas, different segregating generations were subjected to rigorous selection for traits, *viz.*, yield components, earliness, anthracnose resistance and semi-spreading plant type and 177 (F_2 to F_5 generation) crosses were selected and advanced to subsequent generations following pedigree method.

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

2.6.2.1. Elite Lines under All India Coordinated Programme

In lentil, 3 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 AICRP, entries *viz.*, VL 529 and VL 530 were evaluated in IVT (large seed), whereas VL 154 and VL 155 were evaluated in IVT (small seed). But none of the entry could surpass the best check. The AVT I & II (small seed) comprising the entry of VL 152 were repeated for r*abi* 2018-19.

In field pea, a total of 4 yield evaluation trials were conducted under AICRP comprising IVT (tall), IVT (dwarf), AVT I (tall) and AVT I (Dwarf). In IVT (tall), two field pea entries *viz.*, VL 66 and VL 67 were tested and the entry VL 66 (1324 kg/ha) yielded better than best check Rachna (999 kg/ha) and has been promoted to AVT II (NHZ).

2.6.2.2. Elite Lines under State Varietal Trial

In SVT, lentil entries VL 154, VL 153, VL 152, VL 150 VL 527 & VL 528 were tested under organic condition and small seeded lentil entry VL 152 (854 kg/ha) was promoted to third year of testing, respectively. Lentil entry VL 152 produced 11.6% higher grain yield than the best check VL *Masoor* 133 (765 kg/ha), whereas, among large seeded lentil entry VL 527 (893 kg/ha) was promoted to third year of testing as it produced 16.9% higher grain yield than over the best check VL *Masoor* 514 (764 kg/ha) under organic conditions.

In SVT, field pea entries *viz.*, VL 64, VL 66 and VL67 were tested. Among them, entry VL 64 (1,026 kg/ha) was found 16.5% superior to the best check VL *Matar* 42 (881 kg/ha) and was promoted to third year of testing under organic condition.

2.6.2.3. Elite Lines under Station Trials

During the *rabi* season 2017-18, out of 16 entries in initial station trial (small) entries, *viz.*, VLM 2017-10 (399 kg/ha), VLM 2017-15 (362 kg/ha) and VLM 2017-12 (344 kg/ha) were found best performing compared to best check VL *Masoor* 129 (290 kg/ha), whereas in initial station trial (large) entries, *viz.*, VLM 2017-110 (784 kg/ha), VLM 2017-109 (712 kg/ha) and VLM 2017-107 (688 kg/ha) were best performing entries as compared to the best check VL *Masoor* 507 (507 kg/ha). Similarly, in advanced station trial (large) entries, *viz.*, VL 531 (932 kg/ha) and VL 532 (916 kg/ha) performed better than the best check VL *Masoor* 507 (825 kg/ha) and in advanced station trial (small) entries, *viz.*, VL 156 (1091 kg/ha) and VL 157 (1009 kg/ha) performed better than the best check VL *Masoor* 129 (993 kg/ha).

In initial station trial of field pea, entries, *viz.*, VP 2017-9 (1,333 kg/ha), VP 2017-19 (1,222 kg/ha) and VP 2017-12 (1,194 kg/ha) were best performing entries and found superior to the best check VL *Matar* 42 (875 kg/ha) whereas entries, *viz.*, VL 68 (1392 kg/ha) and VL 69 (1382 kg/ha) were superior to the best check VL *Matar* 42 (1,169 kg/ha) in advance station trial.

Breeding materials/Development of new strains

During *rabi* 2017-18, seventy three 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 programme. Out of 86 crosses attempted during *rabi* 2017-18, 62 cross combinations were advanced to F_2 generation whereas, different segregating generations were subjected to rigorous selection for traits viz., yield components, biomass and wilt resistance and 238 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, 35 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). Out of 41 crosses attempted during *rabi* 2017-18, 39 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 131 crosses were selected in F_2 to F_6 generations. Fourteen uniform bulks selected for further evaluation of yield, component traits and quality characters.

Agronomic Investigations

In a study on response of lentil genotypes to fertility levels, VL *Masoor* 150 provided the highest average seed yield (901 kg/ha), which was 5.5 and 8.8% higher than VL *Masoor* 133 and VL *Masoor* 129, respectively. Among fertility levels, 150% of recommended dose (30:60:30 kg NPK/ha) recorded highest average seed yield (895 kg/ha) followed by 100% NPK (20:40:20 kg NPK/ha) and at 5 t FYM/ha. Across the fertility levels, VL *Masoor* 150 produced highest seed yield (935 kg/ha) at 150% of recommended dose (30:60:30 kg NPK/ha).

2.6.3. Oilseed Crops - Soybean

2.6.3.1. Variety Notified

VL *Soya* 89 (VLS 89) variety has been notified by Central Variety Release Committee for timely sown rainfed condition of Northern Hill Zone (Uttarakhand and Himachal Pradesh). It has been developed from the cross "VLS 47/EC 361364". VLS 89 showed significant yield superiority of 12.0% over the best check VL Soya 59. Its average yield is 2,324 kg/ha with 115-120 days maturity duration. It has 19.1% oil content compared to the best check VL *Soya* 59 (19.0%) with moderate resistance against frog eye leaf spot (<11.1%), pod blight diseases (3), *Chauliops* (10-30%) and resistance against defoliators.

VL *Soya* 89

2.6.3.2. Elite Lines under All India Coordinated Programme

A total of 46 soybean entries were evaluated for yield and yield contributing characters in three coordinated trials (IVT, IVT-Vegetable soybean & AVT I). In IVT, entry namely VLS 97 (1737 kg/ha) was tested but none of the entry from all the AICRP centres could exhibit significant yield superiority over the best check VL *Soya* 59 (2148 kg/ha). Similarly in AVT I, VL *Soya* 59 (1830 kg/ha) provided the highest yield.

2.6.3.3. Elite Lines under State Varietal Trial

In SVT, soybean entries namely VLS 96, VLS 97, VLB 214, VLB 215 and VLB 216 were tested during *kharif* 2018. Among all tested entries, VLB 215 (1,995 kg/ha) exhibited significant yield superiority of 11.2% over the best check VL *Bhat* 201 (19.29 kg/ha).

2.6.3.4. Elite Lines under Station Trials

During the *kharif* 2018, a total of 4 station trials were conducted comprising initial station trials, Advance Station Trials for soybean, Station Trial for *Bhat* and Early Station Trial. In Initial Station Trial of soybean entries *viz.*, VS 2017-9 (3152 kg/ha), VS 2017-1 (3333 kg/ha) and VS 2017-6 (2963 kg/ha) were found superior to the best check VL *Soya* 47 (2778 kg/ha) and in Station Trial (Bhat) entries *viz.*, VS 2016-103 (2491 kg/ha), VS 2017-101 (2220 kg/ha) and VS 2017-103 (2220 kg/ha) were top performing entries found superior to the best check VL *Bhat* 201 (1973 kg/ha). In Advance Station Trial of soybean entries, *viz.*, VS 2015-20 (2765 kg/ha), VS 2015-60 (2598 kg/ha) and VS 2015-55 (2593 kg/ha) were found superior to best check VL *Soya* 77 (2232 kg/ha). In Early Station Trial entries, *viz.*, VS 2015-40 (2370 kg/ha), VS 2015-43 (2202 kg/ha) and VS 2015-4 (2074 kg/ha) surpassed the best check JS 95-60 (1835 kg/ha).

Breeding materials/Development of new strains

During *kharif* 2018, 41 new cross combinations were attempted involving 24 diverse parents. These 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) received from IISR, Indore. Evaluation and rigrous selection were made for desirable traits in 142 crosses (F_2 to F_6 generation) of soybean based on desirable phenotypic traits like yield and component traits, diseases (frog eye leaf spot and pod blight) and insect-pests (*Chauliops* and defoliators) resistance.

Crop protection investigation

In the *kharif* 2018, major diseases observed at Hawalbagh (Almora) and in farmers' villages in Almora district were frogeye leaf spot (FLS), bacterial pustules and pod blight (Ct). FLS appeared during first week of August. 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-moderate intensity.

In soybean trap nursery for disease monitoring, out of 16 entries evaluated against frog eye leaf spot disease, KHSb 2 and NRC 7 showed resistant reaction (11.1% infection index). Out of 70 soybean entries previously found resistant against FLS, 50 maintained their resistance, however, NRC 88, VS 2005-40, VS 2006-17, JS 9, Himso 1685, MACS 1407 and Shalimar showed immune reaction (0 score on 0-9 scale). In advance station trial of soybean, VS 2015-12 and VS 2016-14 showed resistant reaction against FLS (1 score on 0-9 scale) and in black soybean advance trial, VB 2014-101, VB 2015-108, VB 2017-102, and VB 2017-103 were found resistant to FLS (0-1 score on 0-9 scale).

2.7. Vegetable Crops

Predominantly, off-season vegetable cultivation and temperate ones are recognized as money-spinning venture as compared to cereals, due to niche potentials of hills. Acreage under vegetable cultivation in Uttarakhand is around 90 thousand ha with an average productivity of 10.51 t/ha, which is much lower than the national productivity of 17.01 t/ha (NHB, 2017). Development of high-yielding varieties/hybrids, resistant to biotic stress and with specific quality as per the market demands along with package of practices are important area of research activity for the augmentation of vegetable scenario in NWH region.

2.7.1. French Bean

2.7.1.1. Varietal Improvement

Five varietal evaluation trials were conducted with 66 genotypes to evaluate their green pod yield performance against checks (Pant Anupama, Arka Suvidha, Swarn Priya, Lakshmi and VL *Bean* 2). Entries, 2016/FBBVAR 2 (9,420 kg/ha), VLFB 1707 (9,970 kg/ha) and VLFB 1630 (10,510 kg/ha) were found best with respect to green pod yield in AVT-I, SVT and station trial, respectively.

Development of new strains

Importance was given to develop high yielding dwarf genotypes with smooth-flashy stringless pod and resistance to rust. In this effort, 7 fresh F_1s were developed using diverse parents. Three hundred and thirty-two progenies derived from 42 crosses were advanced from F_2 to F_6 generations. Thirty-three new bulks were also obtained based on phenotypic uniformity for evaluation in subsequent crop season.

2.7.2. Tomato

2.7.2.1. Varietal Improvement

Eight varietal evaluation trials were conducted to assess 57 entries against suitable checks to identify high yielding genotype in determinate and indeterminate group. Maximum fruit yield was recorded with entries, *viz.*, 2017/TODVAR-6 (21,060 kg/ha), 2016/TODVAR-2 (21,590 kg/ha), 2017/TODHYB-1 (25,050 kg/ha), 2016/TODHYB-7 (24,030 kg/ha), 2015/TODHYB-4 (26,08 kg/ha), 2015/TOINDVAR-2 (23,020 kg/ha), 2016/TOCVAR-6 (17,000 kg/ha), 2015/TOCVAR-1 (19,070 kg/ha) in IET Det., AVT-I Det., IET Det. Hyb, AVT-I Det. Hyb., AVT-II Det. Hyb., AVT-II Indet., AVT-I Cherry and AVT-II Cherry, respectively.

Development of new strains

Developing high yielding varieties/hybrids having market acceptability regarding size, shape and pericarp thickness are the main focus points. Twelve F_1s were made using diverse parents with respect to desirable horticultural traits. Five F_1 crosses were advanced.

2.7.3. Capsicum

2.7.3.1. Varietal Improvement

Two varietal evaluation trials were conducted to evaluate 9 entries against suitable checks to identify early maturing, high yielding genotype. Kt-1 with 20,300 and 21,300 kg/ha recorded maximum fruit yield in AVT II and AVT II Hyb., respectively.

Development of new strains

In capsicum, importance was given for development of high yielding varieties/hybrids with medium dark green fruits, thick skin and other important traits, suitable for protected cultivation and open field, especially under organic conditions. Twenty

F_1s were developed involving diverse parents. Nine progenies derived from 9 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 (7,030 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).

Development of new strains

Three F_1s were developed involving diverse parents. Twenty F_5 progenies of a cross between *Vigna unguiculata*/*Vigna unguiculata subsp. sesquipedalis* were advanced and selections for important horticultural traits were practised.

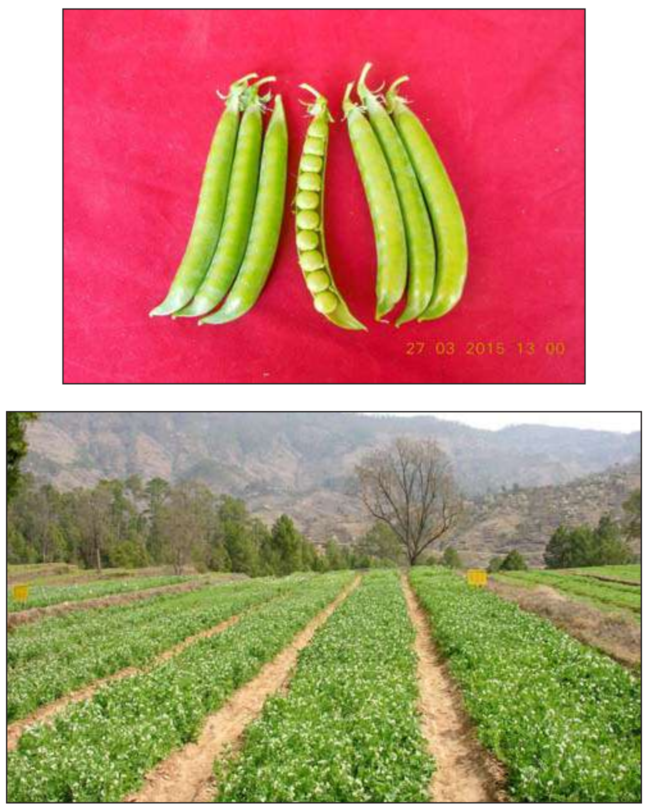
2.7.5. Garden Pea

2.7.5.1. Vareity Notified

VL *Sabji Matar* 13 (VP 907) is an early maturing variety notified by Central Sub-committee on Crop Standards, Notification and Release of Varieties for Horticultural Crops for cultivation in Uttarakhand state. It is developed through hybridization between VP 272 and Arkel, subsequently typical pedigree method was followed. It has shown 19.3% mean green pod yield superiority over the best check VL *Ageti Matar* 7. VL *Sabji Matar* 13 takes around 124-125 days for first green pod harvest in the mid hill conditions (November sown crop). The average green pod yield is 11,500 kg/ha. Besides yield potential, it is being early in maturity escapes incidence of powdery mildew disease. It possesses long pod length with 8-9 seeds/pod and high shelling percent (>48).

VL *Sabji Matar* 15 (VP 1208) is a medium maturing variety notified by Central Sub-committee on Crop Standards, Notification and Release of Varieties for Horticultural Crops for Uttarakhand state. It has shown 23.5% mean green pod yield superiority over the check Vivek *Matar* 11. VL *Sabji Matar* 15 takes around 126-130 days for first green pod harvest in mid hill conditions (November sown crop). The average green pod yield is 12,800 kg/ha. Besides the high yield potential, this entry is moderately resistant against powdery mildew disease. The pods are long with high shelling percent (>50).

VL *Sabji Matar* 13



VL *Sabji Matar* 15

2.7.5.2. Varietal Improvement

Eight yield evaluation trials were conducted to assess 84 entries with suitable checks to identify high yielding early and medium maturing genotypes. 2017/PEVAR-5 (8,300 kg/ha), 2016/PEVAR-4 (11,820 kg/ha), 2015/PMVAR-3 (9,240 kg/ha), 2017/PMVAR-4 (11,590 kg/ha) and 2016/PEVAR-4 (11,110 kg/ha) recorded maximum green pod yield in IET (Early), AVT-I (Early), AVT-II (Early), IET (Medium) and AVT-I (Medium), respectively. VP 1335 (13,720 kg/ha) gave highest green pod yield in state varietal trials. In pea AST I, VP 1702 (14,030 kg/ha), VP 1701 (12,640 kg/ha), and in AST II, VP 1601 (10,770 kg/ha) and VP 1345 (9,930 kg/ha) were found promising.

Development of new strains

Development of early and medium duration genotypes with high green pod yield and resistance to powdery mildew were the main objectives of garden pea breeding programme. In this effort, 40 fresh F_1s were made among selected parents to combine different horticultural traits like earliness, high green pod yield, high shelling percent, attractive pod color and shape as well as disease resistance *etc*. Promising 56 F_1s were advanced for growing their F_2 generation in next season. Besides, selection was practised in the segregating materials derived from 33 F_2s, 12 F_3s, 02 F_4s, 02 F_5s and 03 F_6s crosses. Based on important traits, 204 progenies derived from 19 crosses were advanced in F_3 to F_6 generations and three new bulks were obtained based on phenotypic uniformity for evaluation in subsequent crop season in early and medium maturity group.

2.7.6. Onion

2.7.6.1. Varietal Improvement

In long day onion, three AINRP and one station trial (Onion Hyb.) were conducted with 52 genotypes to evaluate their yield performance against checks. Maximum bulb yield was recorded with entries, *viz*., ON17-85 (40.24 t/ha), ON16-37 (38.25 t/ha), ON15-39 (40,600 kg/ha) and VL In. 31-1A /ON 12-73 (40,980 kg/ha) in IET, AVT I, AVT II and AST (Hybrid), respectively.

Development of new hybrids

In heterosis breeding programme of long day onion, 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 (VL In. 31-1A) was maintained with the help of their maintainer line VL In. 31-1B.

2.7.7. Garlic

2.7.7.1. Varietal Improvement

For long day conditions, two AINRP trials were conducted with 19 genotypes to evaluate their yield performance against checks. GN 17-21 (15,330 kg/ha) in IET and GN 15-78 (18,850 kg/ha) in AVT I recorded maximum bulb yield with big clove size.

2.7.8. Genetic Resources – Evaluation & Maintenance

Total 573 accessions in different vegetable crops were maintained during *rabi* 2017-18 and *kharif* 2018.

Crop	Accessions
Garlic	64
Ginger	06
Turmeric	24
French bean	125
Chilli	86
Capsicum	63
Tomato	115
Colocasia	33
Turmeric	23
Garden pea	30
Vegetable type mustard	04
Total	573

2.8. Germplasm Evaluation for Nutritional and Physiological Parameters

ICAR-VPKAS involves in 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 nutraceutical security of the vulnerable populations. 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.

Method development for robust phenotyping of non-structural carbohydrate and cell wall components in rice through FT-NIR

Non-structural carbohydrates (NSC) reserves are stored in the vegetative parts of perennial grasses. The remobilization of NSC stored in reserve in the stem prior to heading that can later be mobilized to supplement photosynthate production during grain-filling. However, the mechanism that regulates the NSC reserve in the stem pre-anthesis on grain filling of grains of rice remains unclear.

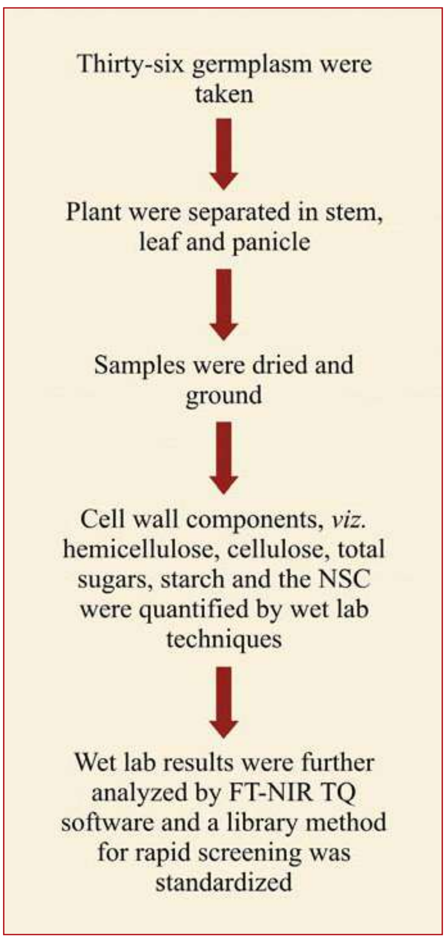


Fig. 2.7.1. Flow chart for phenotyping of carbohydrate through FT-NIR

To understand the dynamics of NSC accumulation and remobilization large number of samples have to go through the screening for NSC. The effort involved in traditional wet laboratory techniques may be prohibitively laborious for such larger-scale studies. In present investigation, the FT-NIR spectroscopy spectrum of each dried sample of rice was obtained by scanning with a Thermo-fisher FT-Near Infra red spectroscopy system. It is necessary that the sample cuvette should be at least 50% filled with sample for better representation of plant sample. The spectrum data range was 4000–10, 000 cm^{-1}, number of scans was 64, and the resolution was 4 cm^{-1} (Fig. 2.7.1).

The calibrated graph from FT-NIR TQ software for Non-structural carbohydrates (NSC) showed a highly significant correlation (R^2=0.9399) 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 rice (Fig. 2.7.2).

Effect of seed soaking and cooking on tryptophan and phytate content

Eleven maize genotypes (VQL-1, V-345, V-335, VQL-2, CM-212, CM-145, VQL 17, QPM-9, V-409, V-405 and VQL-3) frequently used by maize breeder in their breeding programme were selected for soaking and cooking. Samples were tested for their tryptophan and phytate P (mg/g) contents before and after soaking and cooking. Legume seeds were soaked in tap water for 24 and 48 hrs; and to get uniform soft mass seed were cooked in a beaker (1:5 seed water ratio). Maximum reduction of phytate P (33.0 %) was found in V345 after soaking (48 hrs), while through cooking maximum reduced phytate P content by 28.0% in VQL-1 (Fig. 2.7.3).

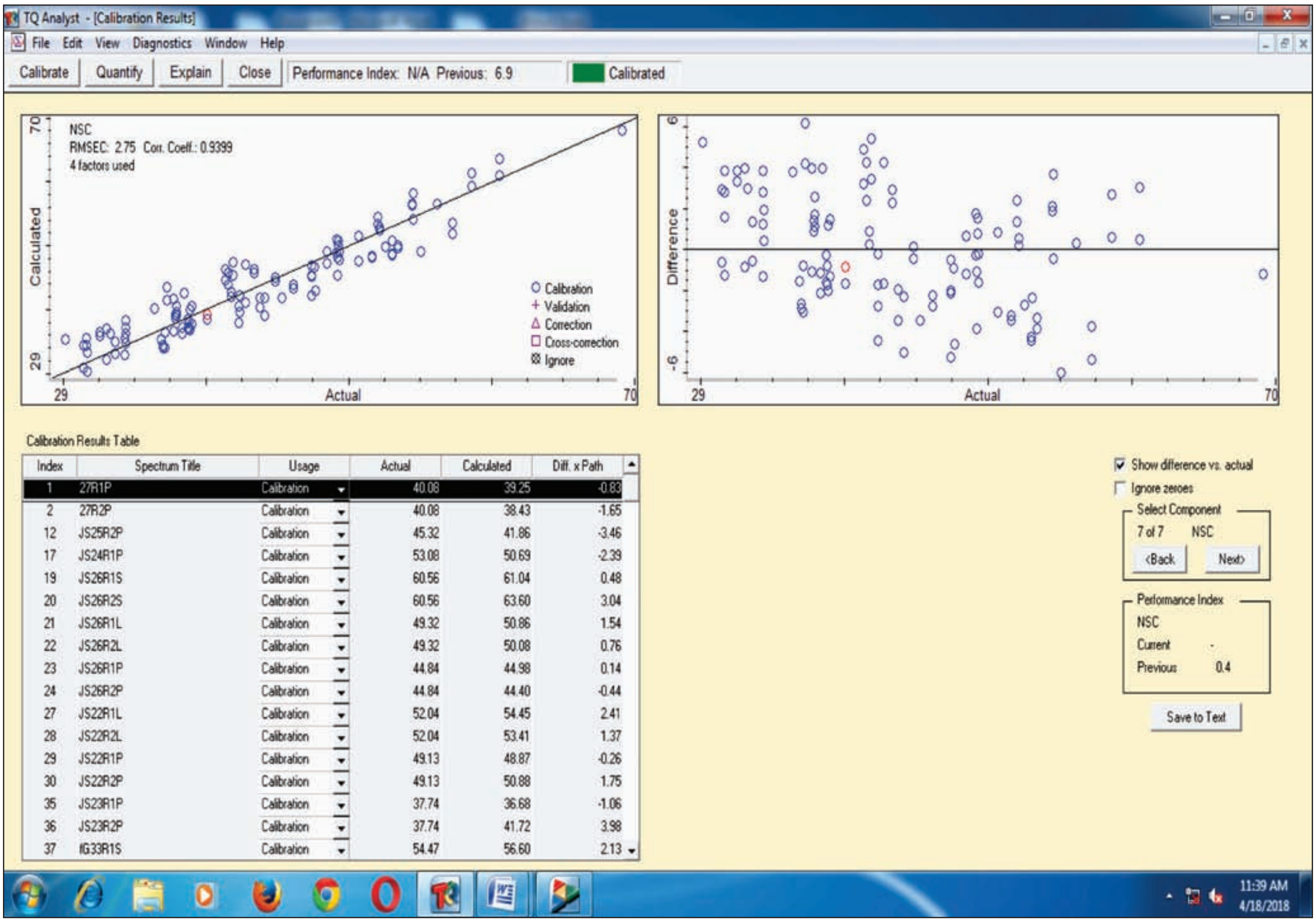


Fig. 2.7.2. Calibrated graph from FT-NIR TQ software for Non-structural carbohydrates (NSC)

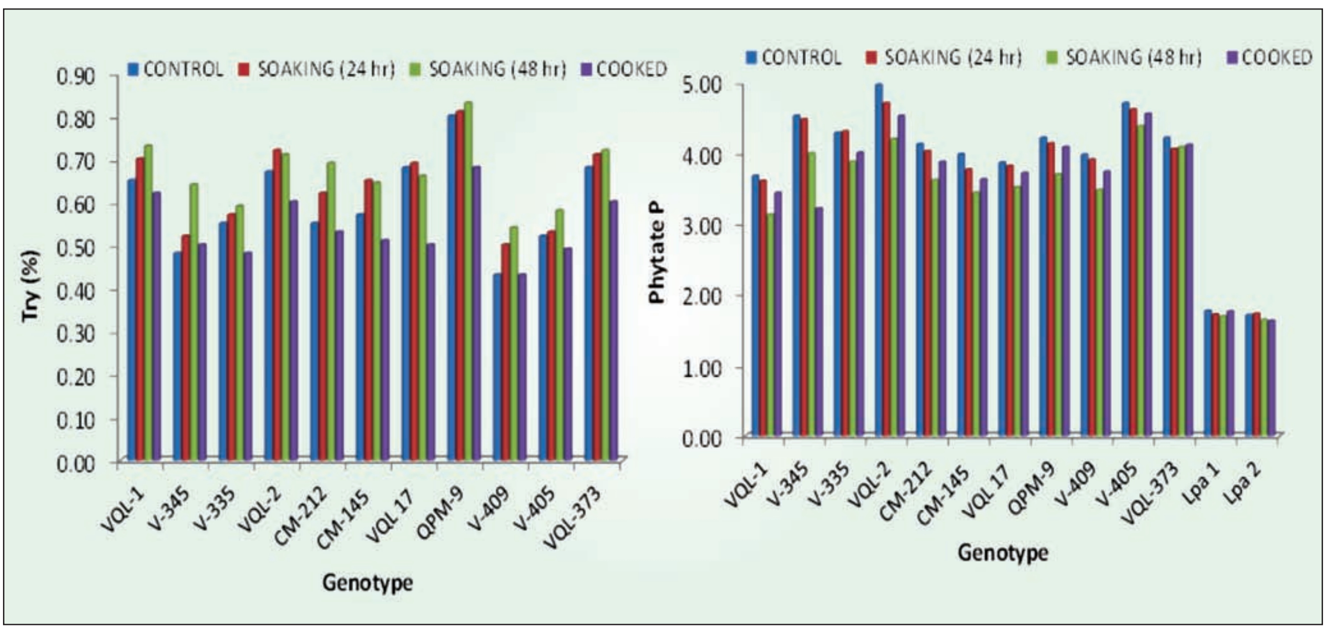


Fig. 2.7.3. Effect of seed soaking and cooking on tryptophan and phytate content

Evaluation of micronutrient content in maize genotypes

Fifty-five (55) genotypes of maize were evaluated for grain Fe and Zn concentrations to identify those with improved Fe and Zn concentrations. The ranges were 25.40 (LP49) – 54.60 (LP11) ppm for Fe and 22.15 (LP21) – 36.65 (LP48) ppm for Zn.

2.8. 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.

During the period under report, 139 q breeder seed of 23 released varieties/inbreds was produced. A total of 107.97 q breeder seed of 31 released varieties/inbreds (including carryover stock) was supplied to different seed producing agencies to take up further multiplication.

Around 11.65 q nucleus seed of 37 released varieties was also produced following standard methods of maintaining genetic purity. In addition, 8.63 q of Truthfully labelled seed was produed during *kharif* 2017 (Table 2.8.1). A total of 11.35 q Truthfully Labelled seed (*kharif* & *rabi*) of 20 varieties were produced and a total of 15.04 q TL seed was supplied (including carryover stock). A total of 7.74 q of nucleus seed was produced during *rabi* 2017-18 (Table 2.8.2). Under farmer participatory seed production programme, 113.48 q TL seed of wheat (VL *Gehun* 907, VL *Gehun* 829, VL 804, VL *Gehun* 953), 1.44 q TL seed of Lentil (VL *Masoor* 126 and VL *Masoor* 133), 0.58 q TL seed of Paddy (VL *Dhan* 68) and 0.65 q TL seed of finger millet (VL *Mandua* 352) was produced, and a total of 141.38 q TL seed was supplied from the seed procured (Table 2.8.3).

Table 2.8.1. Seed production *kharif 2017* and supply *kharif* 2018

Crops	Breeder Seed (q)		Truthfully Labelled Seed (q)		Nucleus Seed (q)
	Production	Supply	Production	Supply	Production
Rice	2.50	2.00	0.10	3.65	1.20
Maize	-	4.29*	0.70	0.53	0.25
Finger Millet	2.10	3.08*	0.60	0.31	0.08
Barnyard Millet	2.30	2.13	1.00	0.32	0.02
Soybean	-	-	3.10	4.91	1.90
Horsegram	-	1.51*	2.80	3.04	0.15
Pigeonpea	-	1.74*	-	0.03	0.15
Buckwheat	-	0.02*	-	0.05	0.05
Amaranth	-	0.25*	0.05	0.06	0.01
Rajma	-	-	-	0.01	0.05
French bean	-	0.07*	0.06	0.09	0.05
Okra	-	-	0.20	0.06	-
Summer squash	-	-	0.02	0.01	-
TOTAL	6.90	14.91	8.63	13.07	3.91

Table 2.8.2 Seed production *rabi* 2017-18 and supply during *rabi* 2018-19

Crop	Breeder Seed (q)		Truthfully Labelled Seed (q)		Nucleus Seed (q)
	Production	Supply	Production	Supply	Production
Wheat	116.00	84.78	1.00	1.00	6.00
Barley	-	0.92	-	-	0.50
Field pea	0.40	0.01	-	-	0.10
Garden pea	2.20	0.14	-	-	0.22

Lentil	8.00	5.96	0.50	0.05	0.40
Onion	0.40	0.29	-	-	0.01
Garlic	4.50	0.90	-	-	0.50
Toria	0.60	0.06	-	0.41	0.005
Radish	-	-	0.10	0.106	-
Coriander	-	-	0.19	0.066	-
Lahi	-	-	0.30	0.14	-
Fenugreek	-	-	0.48	0.105	-
Palak	-	-	0.15	0.095	-
TOTAL	132.10	93.06	2.72	1.97	7.74

Table 2.8.3. Farmers' participatory seed production

Crop	Variety	Seed produced (q)	Seed supplied (q)
Rice	VL *Dhan* 86	0.58	-
Finger millet	VL *Mandua* 352	0.65	-
Wheat	VL *Gehun* 829	21.50	18.15
	VL *Gehun* 907	9.96	13.76
	VL *Gehun* 953	78.72	74.50
	VL *Gehun* 804	23.30	34.45*
Lentil	VL *Masoor* 126	0.87	0.52
	VL *Masoor* 133	0.57	-
	TOTAL	136.15	141.38

*Including carryover seed

3. Natural Resource Management for Sustainable Productivity

Research Projects

- Crop Management for Higher Soil Quality and Sustainability in Indian Himalayas *[Drs. Dibakar Mahanta, P. K. Mishra, V.S. Meena, Manoj Parihar & R.P. Meena]*
- 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]*
- 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]*
- 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]*

3. Natural Resource Management for Enhancing Productivity

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

3.1. Crop Management for Higher Soil Quality and Sustainability

Evaluation of N level and scheduling on wheat grain yield

The estimated optimum wheat grain yield of 7569, 7429, 7263 and 7182 kg/ha could be achieved through four different splitting (15, 20, 35 and 30% of the level at basal, tillering, jointing and booting, respectively), four equal splitting, three different splitting (15, 25 and 60% of the level at basal, tillering and jointing, respectively) and three equal splitting of 153, 170, 193 and 200 kg N /ha, which provided 17, 15, 12 and 11% higher grain yield than the recommended N application (3 equal split of 120 kg/ha), respectively (Fig. 3.1.1). The application of N @ 153 kg/ha through four different splitting saved 103 kg urea/ha and reduced the emission of 226 kg of CO_2/ha compared to the maximum grain yield achieved with application of 200 kg/ha though three equal splitting.

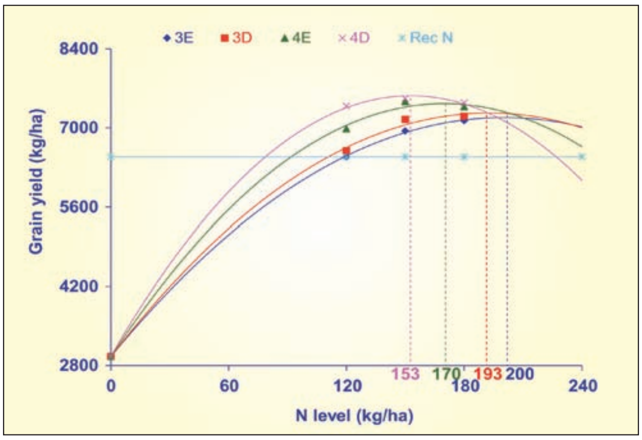


Fig. 3.1.1. Response of N level and scheduling on wheat grain yield

Evaluation of P-enriched compost and biofertilizer on monophosphatase activity and their response to soil available P under soybean based cropping systems

Different levels of P-enriched compost (PEC) were evaluated against the recommended dose of P through SSP for the activity of different enzymes related to P availability. Application of PEC @ 125% of the recommended P provided 52 and 69% higher acid phosphatase (401 µg PNP/g soil/hr) and alkaline phosphatase activity (238 µg PNP/g soil/hr) compared to SSP treated plot (264 and 140 µg PNP/g soil/hr, respectively) under different soybean based cropping systems (mean of soybean-wheat, soybean-lentil and soybean-*toria* cropping systems), respectively. Application of PEC @ 100% of the recommended P provided 43 and 48% higher acid phosphatase and alkaline phosphatase activity compared to SSP treated plot respectively. The highest and lowest acid and alkaline phosphatase activities were recorded under soybean-wheat (370 and 207 µg PNP/g soil/hr, respectively) and soybean-*toria* (292 and 158 µg PNP/g soil/h, respectively) cropping systems, respectively. The higher acid and alkaline phosphatase activity were finally reflected in higher soil available P, which was clearly proved through higher and significant correlation coefficient (R^2 = 0.880 and 0.868) between them (Fig. 3.1.2).

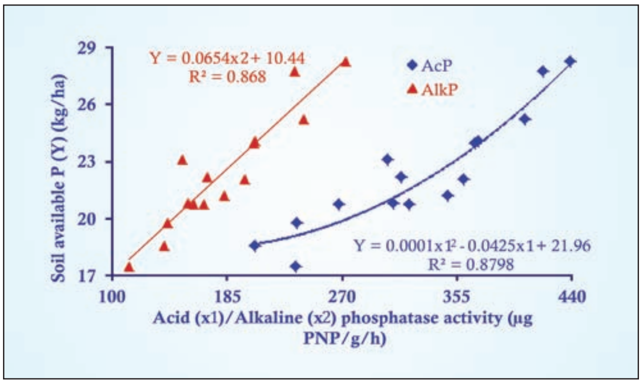


Fig. 3.1.2. Response of phosphatase activity to soil available P under different soybean-based cropping systems

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

The analysis of grain yield data after 45 years of experimentation under rainfed soybean (cultivar:

Bragg, VLS 2 before 2009 and VL Soya 63 since 2009)-wheat (cultivar: Sonalika, VL 421, VL 616 before 2008-09 and VL *Gehun* 829 since 2008-09) system confirmed that the addition of FYM to the inorganic treated plots provided an increase in the wheat equivalent grain yield (Fig. 3.1.3). The average wheat equivalent grain yield from the system and sustainable yield index with application of 10 t/ha FYM along with the recommended NPK (6,737 kg/ha and 0.625, respectively) recorded 105 and 156% higher compared to the recommended NPK (3,287 kg/ha and 0.244, respectively), which confirmed that the application of chemical fertilizer only is not sustainable.

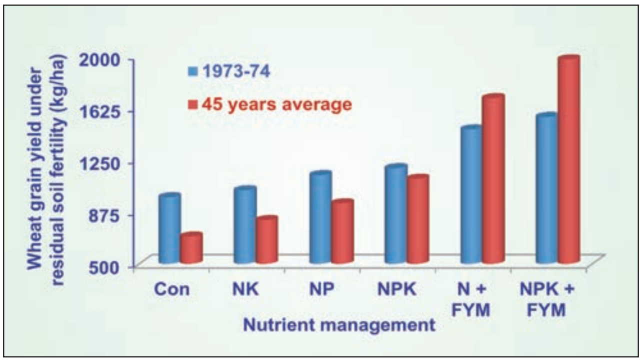


Fig. 3.1.3. Comparative wheat equivalent yield of rainfed soybean-wheat system

The root colonization of arbuscular mycorrhizal fungi (AMF) was estimated after 45 cycles of soybean-wheat cropping system. Application of FYM @ 10 t/ha along with N (N + FYM) provided 125% higher spore density compared to recommended NPK plots. The colonization was highest under N + FYM (60%) followed by control (47%) and lowest value was recorded under NPK (27%) (Fig. 3.1.4). The AMF infection to wheat root

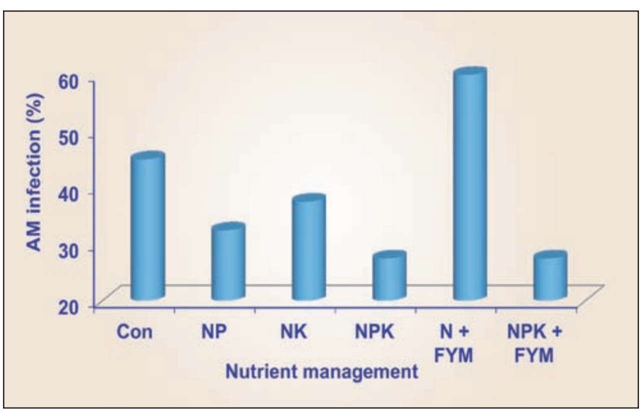


Fig. 3.1.4. Arbuscular mycorrhizal infection to wheat root with different nutrient management practices

is very poor under inorganic fertilizer treatment, especially P fertilizer. Even the infection was significantly higher under control plot compared to chemical fertilized plots. Soil organic carbon greatly influences the infection without inorganic nutrient application (Fig. 3.1.5). In conclusion, long-term fertilization, especially amendments with FYM are beneficial for root colonization of AMF, while continuous applications of inorganics counteract these benefits.

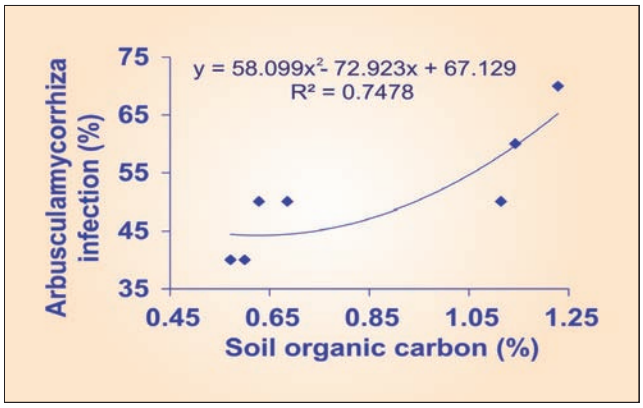


Fig. 3.1.5. Response of arbuscular mycorrhiza infection in wheat root to soil organic carbon

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

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 for wheat and soybean) for rainfed wheat-soybean cropping system during the second year of the transition phase for conversion to organic. The potential wheat equivalent yield of wheat-soybean cropping system (includes the drought season of *rabi* 2017-18) through FYM and VC were 9,384 and 9,813 kg/ha, which could be achieved with application of 56 and 51 kg P/ha, respectively. These yield levels were 35 and 41% higher than the recommended NPK, respectively (Fig. 3.1.6). From the quadratic response curve, it was estimated that the level of P required from FYM and VC to achieve the same yield level as recommended NPK for wheat-soybean cropping system were only 14.0 and 11.7 kg P/ha, respectively, which were very less compared to 24.0 kg P/ha (mean of 34.9 and 13.1 kg P/ha under recommended P through inorganic (SSP) for soybean and wheat crop, respectively). The level of N required from FYM and VC to achieve the same yield level as recommended NPK for wheat-soybean cropping system were only 51 and 50 kg N/ha, respectively.

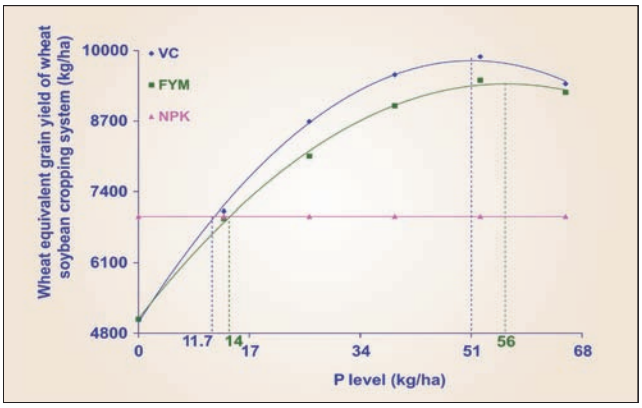


Fig. 3.1.6. Response of wheat equivalent grain yield of wheat-soybean cropping system to P application through farmyard manure and vermicompost

Comparative influence of organic and chemical amendments on maize

Farmyard manure (FYM) and vermicompost (VC) were evaluated against the recommended NPK (120-60-40 and 150-60-60 kg N-P_2O_5-K_2O/ha for wheat and maize, respectively) under irrigated wheat (VL *Gehun* 907)–maize (Vivek Maize Hybrid 45) cropping system. It was estimated that the level of N required from FYM and VC to achieve the same yield level as the recommended NPK (11,615 kg/ha) was 293 and 268 kg N/ha, which were quite high compared to the inorganic production system (cereal–cereal system) during the transition phase for conversion to organic (Fig 3.1.7).

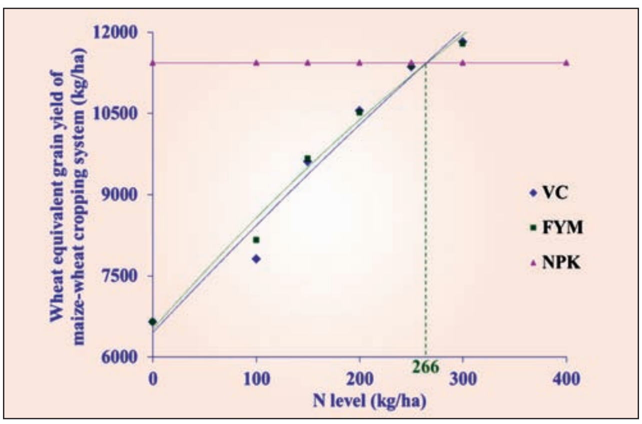


Fig. 3.1.7. Response of wheat-maize cropping system to N application through farmyard manure and vermicompost

Validation of nutrient expert in wheat–maize cropping system

The nutrient application by estimating the level of nutrients through nutrient expert was compared with recommended NPK (120-60-40 and 150-60-60 kg/ha N-P_2O_5-K_2O) and nutrient omission plots under wheat (VL *Gehun* 907)–maize (Vivek Maize Hybrid 45) cropping system. The nutrient expert treatment provided 16 and 23% higher grain yield of wheat and maize compared to the recommended NPK (4,872 and 7,076 kg/ha for wheat and maize, respectively), respectively. The N, P and K use efficiency of applied Urea, SSP and MOP estimated with help of nutrient omission plots for wheat was 19.6, 2.2 and 1.8 kg grain per kg of applied nutrients, respectively. The N, P and K use efficiency of applied Urea, SSP and MOP estimated with help of nutrient omission plots for maize was 16.7, 4.3 and 6.8 kg grain per kg of applied nutrients, respectively.

Effect of Phosphate solubilizing bacterial strains to enhance P uptake, growth and yield of finger millet

Eight 'P' solubilizing bacterial strains having multiple traits at 28ºC were evaluated under field conditions on P uptake, growth and yield of finger millet (VL *Mandua* 347). Single inoculation of cold tolerant bacterial strains *P. fragi* CS11RH1 recorded maximum (1.74 fold) total chlorophyll and 1.66-fold physiological available iron in comparison to un-inoculated control (1.72 and 15.3/g tissue, respectively) at 60DAS under field conditions. Single inoculation of cold tolerant bacterial strains *Pseudomonas* sp. RT5RP(2) recorded 1.26 and 1.29 fold higher FDA enzyme activity at 30 and 60DAS, respectively as compared to control (5.49 and 5.10 fluorescein produced/g dry weight) in finger millet. Inoculation with 'P' solubilizing bacterial strain *Pseudomonas* sp. RT6RP recorded 1.49 fold higher followed by *Pseudomonas* sp. RT5RP(2) recorded 1.38 fold total phosphomonoesterase enzyme activity at 60DAS over the control (215.2 µgNP/g^{-1}dm/hr). Inoculation with 'P' solubilizing bacterial strain *P. fragi* CS11RH4 and *Pseudomonas* sp. PCRP7(2) significantly improved percent total 'P' content (seed+stover) by 1.54 and 1.46-fold, respectively over un-inoculated control (0.83%) at 60DAS under field conditions. Inoculation with 'P' solubilizing bacterial strain *P. fragi* CS11RH4 recorded highest microbial carbon and nitrogen ratio (C_{mic}:N_{mic} ratio) (1.55 fold) over un-inoculated control (4.95 µg/g of fresh rhizospheric soil) in finger millet under field conditions. Single inoculation of 'P' solubilizing bacterial strain *P. sp.* RTSRP(2) and *P.* sp. CS11RP1 & *P. fragi* CS11RP4 enhanced Finger millet grain yield by 1.23 and 1.19-fold over uninoculated control (1,511 kg/ha) under field conditions (Fig. 3.1.8).

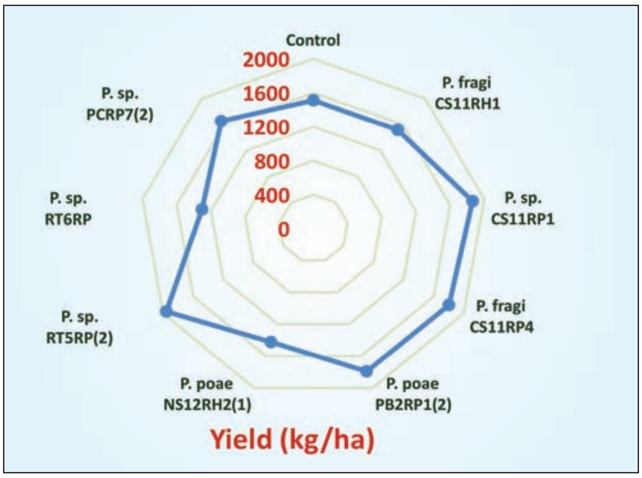


Fig. 3.1.8. Effect of P solubilizing bacterial strains on yield of finger millet (VL *Mandua* 347)

Effect of phosphate solubilizing bacterial consortium to enhance P uptake, growth and yield of finger millet

Eight phosphate solubilizing bacterial consortium having multiple traits at 28ºC were evaluated by seed treatment under field conditions on P uptake, growth and yield of finger millet (VL *Mandua* 347). Inoculation with 'P' solubilizing bacterial consortium C8 recorded 1.41-fold higher total phosphomonoesterase enzyme activity followed by C7 (1.39 fold) at 60DAS over the control (264.8 μgNP/g^{-1}dm/hr). Consortia C8 and C7 significantly improved percent 'P' content in shoot by 1.36 and 1.31-fold, respectively over uninoculated control (0.72%) at 60DAS. However, at final harvesting bacterization with consortium C8 and C7 significantly improved total (seed+stover) percent 'P' content by 1.62 and 1.54-fold, respectively over uninoculated control (1.92%). Consortium C6 recorded maximum (1.97-fold) total chlorophyll in comparison to un-inoculated control (1.67/g tissue) at 60DAS under field condition. Phosphorous solubilizing bacterial consortium C5 recorded maximum 1.54-fold physiological available iron in comparison to un-inoculated control 16.8/g tissue at 60DAS under field condition. Phosphorous solubilizing bacterial consortium C7 and C4 recorded 1.29 and 1.22-fold higher FDA enzyme activity at 30 and 60DAS, respectively as compared to control (4.9 and 5.4 fluorescein produced/ gm dry weight) in finger millet. Inoculation with 'P' solubilizing bacterial consortium C8 recorded highest rhizospheric soil microbial carbon and nitrogen ratio (C_{mic}:N_{mic} ratio) (1.60-fold) followed by C4 (1.41-fold) over uninoculated control (4.9 μg/g of fresh finger millet rhizospheric soil) under field conditions. Bacterization of finger millet (VL *Mandua* 347) seeds with bacterial consortium C4 significantly enhanced grain yield by 23.5% followed by C1 (14.5%) over uninoculated control (1,806 kg/ha) (Fig. 3.1.9).

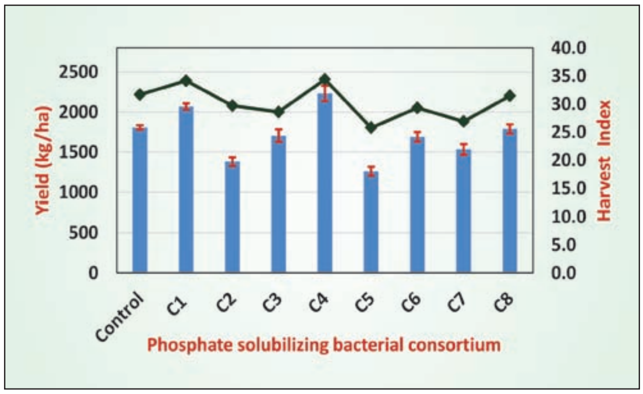


Fig. 3.1.9. Effect of P solubilizing bacterial consortium on yield of finger millet (VL *Mandua* 347)

Management of lodging and yield maximization in wheat

Two growth regulators, namely lihocin and folicur were applied individually and together to manage the lodging of wheat. Two sprays of folicur @ 0.1% at first node and flag leaf stage (6,216 kg/ha) provided 9% higher grain yield compared to without application. There was no lodging in wheat crop with or without application of growth regulators. But, application of lihocin, folicur and both lihocin and folicur reduced 6.7, 1.0 and 5.4 cm plant height of wheat crop, respectively. Application of folicur provided significantly higher effective tiller/m^2 (404 tiller/m^2) than other growth regulators, which enhanced 20 number of tiller/m^2 compared to without 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 conditions. Transplantation of finger millet provided 23 and 35% higher grain yield than the direct line sowing (1,853 kg/ha) and the traditional broadcasting method of sowing (1,684 kg/ ha), respectively. The improvement in wheat yield with seed drill sowing was of 9 and 27% compared to manual line sowing (1,548 kg/ha) and broadcasting method (1,320 kg/ha), respectively. Application of mulch in finger millet proved beneficial and recorded 14% higher yield compared to no mulch (1,929 kg/ha). Moreover, the mulch conserved soil moisture for the succeeding wheat crop, where one hoeing after winter rains in the mulched plots resulted into 23% higher wheat yield compared to no mulch (1,451 kg/ha). The effect of zero and conventional tillage was almost identical in finger millet, but zero tillage provided 6% more grain yield compared to the conventional tillage (1,569 kg/ha) under wheat. Transplanting with mulch under zero tillage in finger millet recorded the B:C ratio of 2.17 and seed drill sowing under zero tillage conditions in mulched plots provided the B:C ratio of 1.83.

Evaluation of herbicides for control of broadleaved weeds in wheat

The herbicide efficiency index for broad-leaved weed with application of 2,4-D Na (400 g a.i./ ha)+Carfentrazone (20 g a.i./ha) at 35 days after sowing under irrigated wheat was 148, which was highest among other herbicides (Halauxifen-methyl Ester+Florasulam 40.85% W+Surfactant, Metsulfuron methyl 20 WG+Surfactant, Carfentrazone 40DF, 2,4-D Na (80 WP), 2,4-D E 38 EC, Metsulfuron+carfen trazone+Surfactant, 2,4-D Na+Carfentrazone, 2,4-D E+Carfentrazone, Halauxifen methyl+florasulam+ carfentrazone+Surfactant, Pendimethalin(PE)+Isoproturon+2,4-D (PoE), Sulfosulfuron+Metsulfuron). It also provided highest grain yield (6,319 kg/ha) among different herbicides, which was 13% higher than weedy check plot. The weed control efficiency for application of 2,4-D Na+Carfentrazone, Pendimethalin (PE) + Isoproturon and Sulfosulfuron+Metsulfuron were 91, 92 and 90%, respectively.

Effect of Sesbania mulching on productivity of finger millet –wheat rotation

An experiment was conducted for eight years to know the effect of *Sesbania* mulching in finger millet-wheat rotation along with 4 levels of fertilizers [FYM (5.0 t ha^{-1} in finger millet and 10.0 t/ha in wheat); FYM (50%) + RDF (50%); RDF (100%) i.e. 40:20:20 and 60:30:20 NPK/ha, in finger millet and wheat, respectively; and Control] on yield of finger millet and succeeding wheat crop under rainfed condition. There was no significant difference in grain yield of finger millet and wheat due to *Sesbania* mulching under finger millet. Among various fertilizer levels, highest grain yield of finger millet was recorded with 5.0 t/ha FYM (1,529 kg/ha), however highest grain yield of wheat was recorded with 50% FYM+50% RDF (1476 kg/ha).

Response of cold tolerant PGP Pseudomonas strains on nutrient uptake, growth and yield of different varieties 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 nutrient uptake, growth and yield of different varieties of wheat. 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 grain yield of 3,379 and 3,103 kg/ha for VL *Gehun* 953 and VL *Gehun* 907, respectively. However, VL *Gehun* 804 provided higher yield (3,200 kg/ha) with *Pseudomonas* sp. NARs9. The effect of two PGP consortium on yield of three wheat varieties is depicted in Fig. 3.2.1.

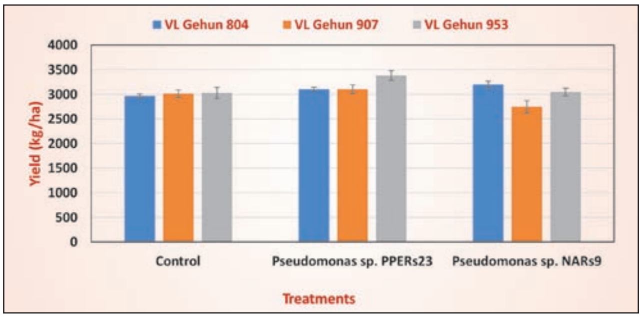


Fig. 3.2.1. Effect of cold tolerant PGP Pseudomonas strains on yield of three wheat varieties

Response of cold tolerant PGP consortium on nutrient uptake, growth and yield of different varieties of wheat

Two elite cold tolerant PGP consortium [Consortium 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 nutrient uptake, growth and yield of different varieties 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 main effects for varieties yielded $F\,(2,18) = 214.6$, $p<0.05$ indicating a significant difference between varieties. Bacterization with cold tolerant PGP consortium C2 recorded higher grain yield of 3,520 and 3,232 kg/ha for VL *Gehun* 953 and VL *Gehun* 907, respectively. However, VL *Gehun* 804 recorded higher yield (3,334 kg/ha) with consortium C4. The interaction effect was significant $F\,(4,18) = 173.3$, $p<0.05$. The effect of two PGP consortium on yield of three wheat varieties is depicted in Fig. 3.2.2.

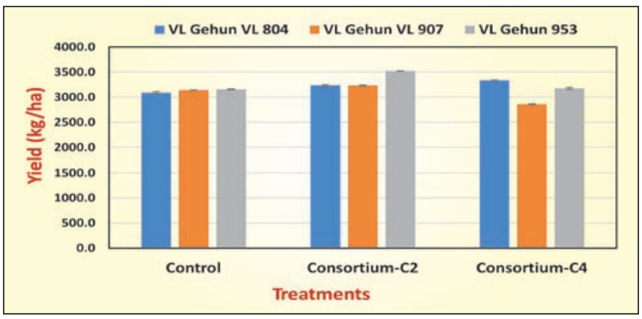


Fig. 3.2.2. Effect of cold tolerant PGP *Pseudomonas* strains on yield of three wheat varieties

Effect of plant growth promoting Pseudomonad on yield of finger millet

Eight PGP *Pseudomonas* strains having multiple traits at 28ºC were evaluated under field conditions on P uptake, growth and yield of finger millet (VL *Mandua* 347). *Pseudomonas* sp. PPERs4 recorded maximum (2.29-fold) total chlorophyll in comparison to uninoculated control (1.11 mg/g tissue). All the strains showed enhancement in physiological available iron ranged from 1.17 to 1.70-fold at 60DAS. Inoculation with *P. fluorescens* PPRs4 recorded maximum FDA enzyme activity (1.23-fold) at 30DAS and *P. putida* PBRs5 (1.18-fold) at 60DAS compared to control (5.22 and 5.24 fluorecein produced/g dry weight) in finger millet. Inoculation with *P. fluorescens* PPRs4 recorded 1.85 times higher total phosphomonoesterase enzyme activity at 60DAS compared to the control (185 μgNP/g^{-1}.dm/h). Bacterization of finger millet (VL *Mandua* 347) seeds with *P. putida* PBRs5, *P. fluorescens* PPRs4 and *P. lurida* NPRs3 enhanced grain yield by 1.5, 1.4 and 1.3-fold, respectively compared to uninoculated control (983 kg/ha) (Fig. 3.2.3).

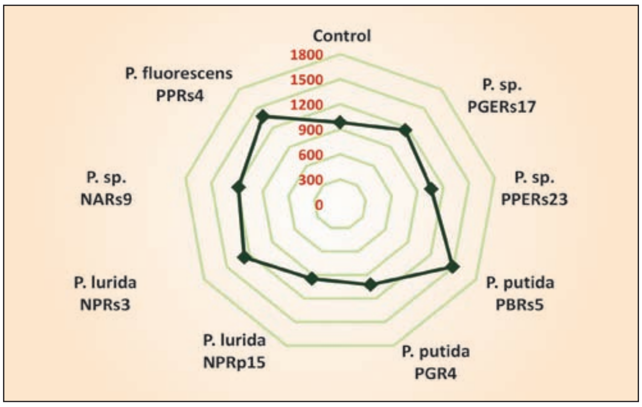


Fig. 3.2.3. Effect of PGP *Pseudomonas* strains on yield (kg/ha) of finger millet (VL *Mandua* 347)

Effect of plant growth promoting (PGP) bacterial consortia in enhanceing yield of finger millet

Eight PGP bacterial consortium having multiple traits at 28ºC were evaluated under field conditions on P uptake, growth and yield of finger millet (VL *Mandua* 347). Consortium C3 recorded maximum (2.55-fold) total chlorophyll in comparison to un-inoculated control (1.88 mg/g tissue). All the consortia showed enhancement in physiological available iron ranged from 1.85 to 1.26-fold at 60DAS under field condition. Consortium C4 and C7 recorded 1.25 and 1.20-fold respectively, higher FDA enzyme activity at 30DAS and 60DAS, respectively as compared to uninoculated control (5.47 and 5.58 fluorescein produced/g dry weight) in finger millet. Bacterial consortium C4 recorded 1.33-fold higher total phosphomonoesterase enzyme activities at 60DAS over the uninoculated control (257.3 μgNP/g^{-1}.dm/hr). Bacterial consortium C5 recorded highest C_{mic}:N_{mic} ratio (9.84) over un-inoculated control (4.61) in finger millet under field conditions at 60DAS. Treatment of finger millet (VL *Mandua* 347) seeds with bacterial consortium C5 numerically enhanced grain yield by 5.0% followed by C4 (4.0%) over uninoculated control (1,389 kg/ha) (Fig. 3.2.4).

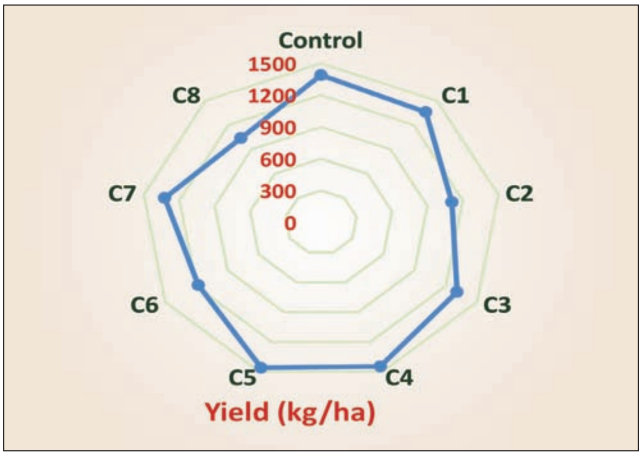


Fig. 3.2.4. Effect of PGP bacterial consortium on yield (kg/ha) of finger millet (VL *Mandua* 347)

Evaluation of herbicides for control of weeds in maize

The grain yield with the spray of tembotrione @ 120 g/ha (11,445 kg/ha) was little higher compared to recommended Atrazine + 2,4-D Amine (11,288 kg/ha). Tembotrione can substitute the recommended Atrazine + 2,4-D Amine for weed control in maize. The crop resistance index of tembotrione under maize was 3.9, which was 6% higher 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.

Response of nitrogen levels to grain amaranth varieties

One pre released variety of Amaranth (VL 110) was evaluated against two checks (VL *Chua* 44 and VL 101) with different nitrogen levels (0, 30, 60, and 90 kg N/ha) under rainfed conditions. No significant difference was found among all three varieties. Among various N levels, 90 kg N/ha recorded the maximum grain yield (1317 kg/ ha) compared to the grain yield with 60 (1206 kg/ ha) and 30 kg N/ha (878 kg/ ha). The highest grain yield was recorded by VL 110 with application of 90 kg N/ha (1393 kg/ha), which was at par with other N levels except control.

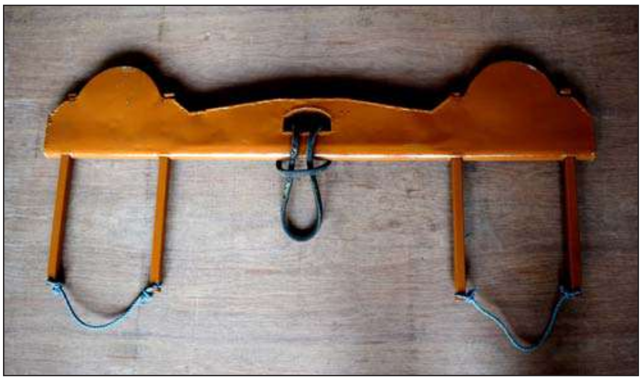
Tillage and phosphorus management in wheat-soybean cropping system

Different levels of P along with phosphate solubilizing bacteria (PSB) provided 17 to 31% higher wheat grain yield compared to control, while the corresponding increase in soybean yield was in the range of 23 to 49%. The tillage effect was non-significant in both the crops with zero tillage having little bit edge over conventional tillage with 4 and 8% higher grain yield of wheat and soybean, respectively. The application of 150% P + PSB under zero tillage recorded highest grain yield of wheat (4297 kg/ha) and soybean (3125 kg/ha).

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

Development of Metallic Yoke (Zua)

A light weight (5.8 kg) metallic yoke has been developed to supplement the VL Shyai Hal, which will be helpful in reducing deforestation and C sequestration.



Designed metallic yoke

Vermicompost strainer for small farmers

Pulley and belt system were opted for the power transmission than the existing gear and chain mechanism in solar-cum-manual operated continuous vermi-compost strainer with no mortality and minimum damage to the earthworms during the process.

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

Evaluation of Grasses & Clovers

Setaria: Out of six entries of *Setaria* grass, entry S-25 produced significantly higher green fodder (37,958 kg/ha) than entries S-18 and S-6. Entry S-25 produced significantly higher dry matter (3,941 kg/ha) than entries S-4 and S-18.

Bajra Napier hybrid: Out of five entries of *Bajra Napier* hybrid grass, entry NB-21 produced significantly higher green and dry fodder (48,000 and 10,910 kg/ha, respectively) followed by entry BNH-11 (34,074 & 7,837 kg/ha) than rest of the entries.

Rye Grass: In AVT on rye grass, out of four entries, entry AVT-RG-1 produced significantly higher green forage (13.63 t/ha) and dry fodder (2.28 t/ha) than rest of the entries, except entry AVT-RG-2 for dry fodder.

White Clover: In white clover initial varietal trial, out of six entries significantly higher green fodder (6.90 t/ha) and dry fodder (1.52 t/ha) was obtained from entry VTWC-1 than entries VTWC-3 and VTWC-4.

Red Clover: Out of seven entries in red clover, entry VTRC-7 produced significantly higher green fodder (5,334 kg/ha) than entries VTRC-1 and VTRC-3. It also produced significantly higher dry fodder (961 kg/ha) compared to the remaining entries, except VTRC-4 and VTRC-6.

Evaluation of cultivated fodder

Oat: Out of nine entries, entry IVTO MC-8 produced significantly higher green fodder (23.45 t/ha) than entry IVTO MC-9. It also produced significantly higher dry fodder (6.23 t/ha) compared to IVTO MC-9 and IVTO MC-7.

Maize: In IVT on maize, significantly higher green forage (35,185 kg/ha) was obtained from entry PFM-9 compared to the rest of the entries, except TNFM-131-9, HPFM-9, COHM-8, J-1006, AH8071R, MF-2018, Star-111, TSFM-16-10, African Tall, IMHBG-18KF-2 and CMVLBC-2. Significantly higher dry fodder (9,717 kg/ha) was also recorded for PFM-9 compared to the rest of the entries.

Cowpea: In IVT on cowpea, entry UPC-622 produced significantly higher green forage (24,444 kg/ha) and dry fodder (4,755 kg/ha) than rest of the entries, except MFC-16-4 for green fodder (21,975 kg/ha).

Cutting management of trees

Effect of different lopping treatments on tree canopy management of *Kachnar (Bauhinia retusa*) grown on field terrace risers were studied. Seven different lopping techniques were applied. These lopping treatments were: C1 - pollarding (tree cut back nearly to the trunk to produce a dense mass of branches) at 1 m height, C2 - pollarding at 2 m height leaving main shoot intact, C3 - pollarding at 1 m height + LMSI (leaving main shoot intact), C4 - local practices (removal of leaves and tender twigs at random just above the bifurcation of the branches), C5 - lopping leaves and tender twigs twice in a year, C6 - lopping leaves and tender twigs once in a year, C7 - lopping of lower 1/2 part of tree keeping top 1/2 undisturbed. The mean yield of three years showed that the highest green forage yield (5.89 kg/tree) was recorded in lopping leaves and tender twigs twice in a year (C5) followed by pollarding at 1 m height + LMSI (leaving main shoot intact) (Fig. 3.4.1). The highest mean fuel wood yield was recorded under treatment C2.

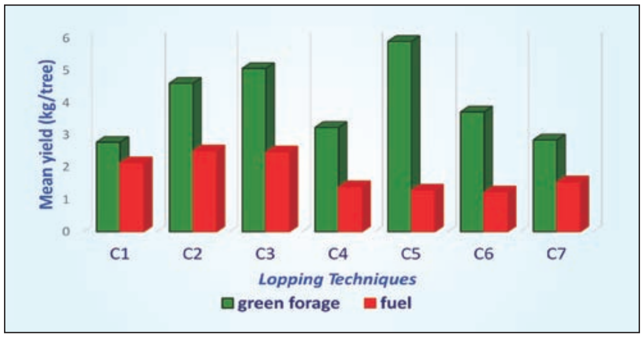


Fig. 3.4.1. Effect of lopping methods on forage and fuel wood yield of *Kachnar* grown on field terrace risers (mean of three years)

Estimation of runoff and soil loss under different grass planting systems in sloping land

An experiment was conducted to evaluate the effect of five different four-year-old grass planting systems (*Kudzu* vine, *Bajra* napier, Hybrid *napier*, Love grass and Lemon grass) on runoff and soil loss in the sloping land compared to control treatment (no grass plantation only natural grasses). The runoff plot in sloping land was divided into six sub-plots of 10×10m each under different grass planting systems. The effect of different planting system was found significant in reducing runoff and soil loss compared to control. The runoff and soil loss under different grassland plantation systems in sloping land (43% slope) having annual 1000 mm rainfall were 55-66% and 15-26 t/ha/yr, respectively. Among the different grass systems, love grass and hybrid napier were found to be the most effective in controlling runoff (57 and 56%) and soil loss (14.85 and 16.12 t/ha/yr). The love grass also produced the highest biomass (Fig. 3.4.2).

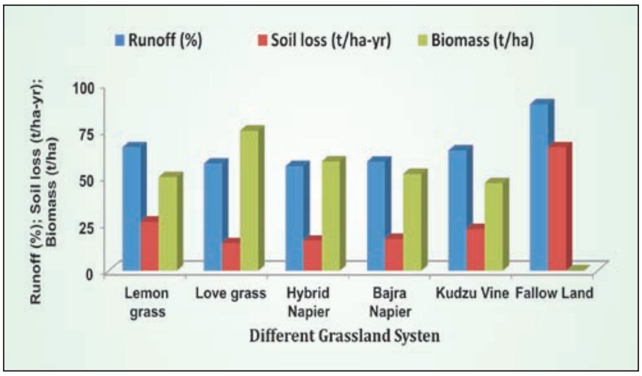


Fig. 3.4.2. Runoff and soil loss under different grass planting systems in sloping land

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 (>8 yrs) years, no significant effect on green fodder and grain yield of wheat was observed with the presence of different fruit trees, however, during *kharif*, presence of tree affected significantly the grain yield of soybean. Due to leaf fall of deciduous fruit trees during *rabi*, undergrown crop got full light. During *kharif*, fruit plants are having full leaves and thus there was less light for under grown crops, which affects the photosynthesis resulting into less yield in comparison with open fields. 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 5,500 and 7,900 kg/ha.

Peach-based

In peach-based agri-horti system, four varieties of wheat, i.e. VL *Gehun* 804, 892, 829 and 907 during *rabi* and four varieties of finger millet viz., VL *Mandua* 149, 324, 315 and 347 during *kharif* season were evaluated. Under peach, grain and straw yield of wheat were reduced by 22 and 4%, respectively compared to open (without peach). But there was significant reduction in grain yield only. There was no significant difference among wheat varieties. The highest grain yield was recorded from *VL Gehun* 804 followed by VL *Gehun* 892, VL *Gehun* 829 and VL *Gehun* 907. However, straw yield varied significantly among different varieties and ranged from 3424 kg/ha in VL *Gehun* 907 to 4753 kg/ha in VL *Gehun* 829. In *kharif* season, average yield of finger millet was significantly higher (6% higher) under open (without peach) compared to under peach. Among varieties, VL *Mandua* 149 produced maximum grain yield (1.93 t/ha), which was significantly higher than the rest of the varieties (Fig. 3.4.3).

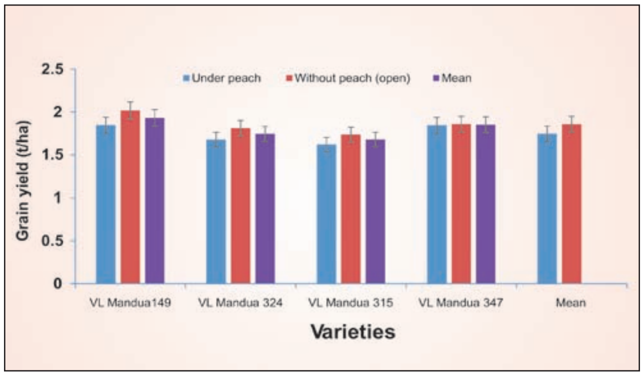


Fig. 3.4.3. Performance of different varieties of finger millet in peach-based agri-horti system

In another experiment, the inter-row spaces in peach tree was utilized for forage production by integration of *kharif* grasses such as *S. sphacelata*, hybrid napier, broad-leaved paspalum and congosignal and *rabi* grasses viz., perennial rye, tall fescue, Hima-14 and grassland manava. The results revealed that pooled green forage (*kharif* + *rabi*) of grasses under open condition (without peach) was 2.5% higher than with peach tree, and it is non-significant. However, *kharif* grasses produced significantly higher green forage compared to *rabi* grasses by 33.49% under peach and 56.6% without peach (open) situation. Among different grasses, *S. sphacelata*, perennial rye and their combination produced significantly higher green forage than rest of the grasses. The gross return was two to five times more under peach compared to without peach situation (Fig. 3.4.4).

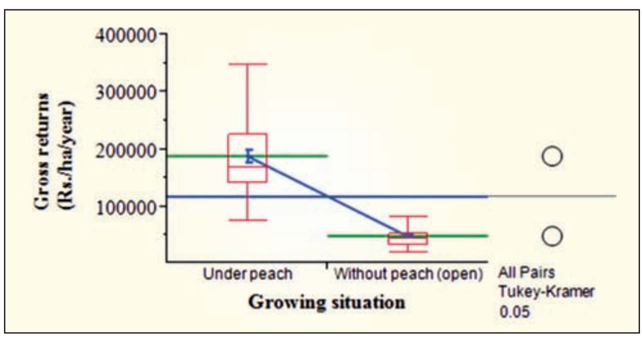


Fig. 3.4.4. Gross returns from grass species combinations in horti-pastoral system

Silvi-horti system

Fodder-based on sloping land

On sloping land, turmeric yield of *RCT-1* in open (without trees) and under fodder trees varied between 6.48 to 10.53 t/ha (Fig. 3.3.5). Maximum green forage (3.49 kg/tree) and fuel wood (1.85 kg/tree) was obtained from *Alnus nepalensis* followed by *Quercus glauca*, *Melia azedarach* and *Bauhinia retusa*. In case of planting technique, the difference was non-significant for green forage and fuel wood, which ranged from 1.34 to 2.57 kg/tree and 0.65 to 1.59 kg/tree, respectively.

Fodder-based on flat land

In silvi-horti system, turmeric yield of variety *RCT-1* did not vary significantly under fodder trees and open (without trees) on flat marginal land. Turmeric yield ranged between 8.95 and 13.97 t/ha (Fig. 3.4.5). *Celtis australis* gave highest green forage (13.90 kg/tree) and fuel wood (13.79 kg/tree) followed by *Quercus leucotrichophora*, *Bauhinia retusa* and *Grewia optiva*.

Forest-based on sloping land

In hilly areas of Himalayas, huge area is under the chirpine on sloping land. To utilize the under-space of chirpine (*Pinus roxburghii)*, turmeric *RCT-1* was grown on sloping land of the forest floor. The turmeric yield of 5.58 t/ha was recorded under chirpine compared to open condition (3.04 t/ha) on sloping land (<23%) (Fig. 3.4.5).

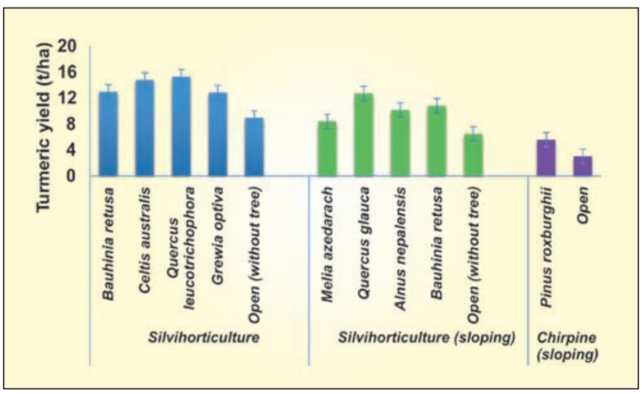


Fig. 3.4.5. Rhizome yield of turmeric under different trees in silvi-horti systems

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 m height, pollarding at 2 m height and pollarding at 3 m height with *Setaria kazungula* under these trees were tested under silvi-pastoral system. During winter season, *Morus alba* yielded the highest green biomass (4,150 kg/ha) followed by *Quercus leucotrichophora*. In case of cutting management, pollarding at 3 m height produced the highest green forage (3,525 kg/ha). In *kharif* season, *Setaria sphacelata* (cv. Kajungula) under *Quercus leucotrichophora* produced the highest green fodder (5,239 kg/ha). Among lopping management, the highest green forage yield was obtained with cutting at 1 m height (4,774 kg/ha) followed by cutting at 2 m, 3 m and coppicing.

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

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

The direct sown rice-wheat rotation was evaluated with limited irrigation under zero and conventional tillage. The higher wheat yield (2,897 kg/ha) was recorded under zero tilled plots in comparison with conventional plots (2,519 kg/ha). However, the trend was reverse for rice. The water productivity followed the similar trend as that of grain yield (Fig. 3.5.1). The highest yield of wheat (3,224 kg/ha) and rice (2,095 kg/ha) was recorded with four irrigations. The highest water productivity was recorded with one irrigation followed by two and three irrigations. Lowest water productivity was recorded with four irrigations (Fig. 3.5.1).

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

Wheat was grown under fertilized condition and the succeeding crop soybean was grown on the residual fertility, except one treatment, where recommended NPK was applied to both crops (20-80-40 and 120-60-40 kg N-P_2O_5-K_2O/ha for wheat and soybean, respectively). Application of recommended NPK + 10 t FYM/ha (NPK + FYM) during *rabi* season only recorded significantly higher wheat grain yield (5,189 kg/ha) as compared to control. Application of FYM @ 10t/ha (FYM) during *rabi* season only provided higher yield (2,873 kg/ha) compared to application of N @ 120 kg/ha (2,582 kg/ha). The lowest grain yield was obtained in control (1,919 kg/ha) (Fig. 3.5.2). The water productivity

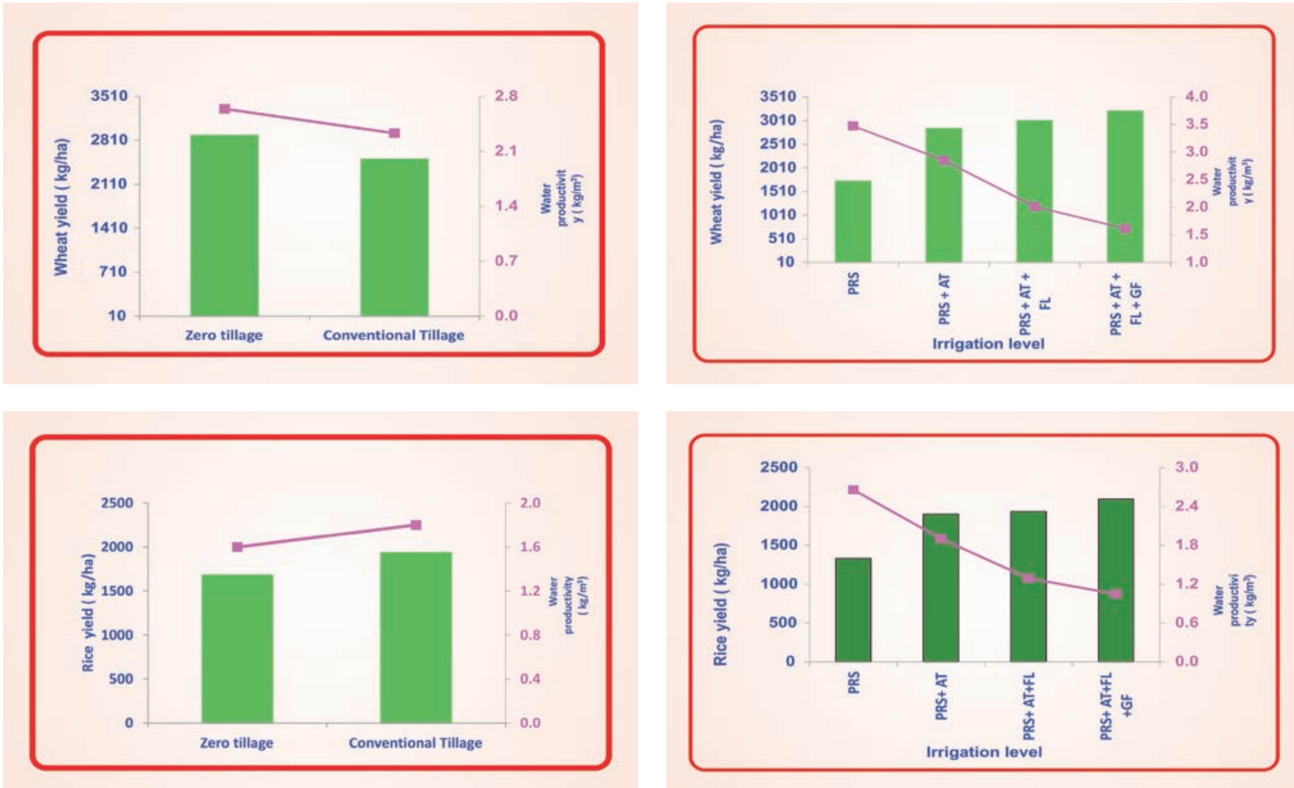


Fig. 3.5.1. Grain yield and water productivity of wheat and rice as influenced by tillage and irrigation (PRS- Pres sowing irrigation; PRS+AT-Pres sowing irrigation+at tillering/ CRI; PRS+AT+FL- Pres sowing irrigation+at tillering/ CRI+Flowring; PRS+AT+FL+GF - Pres sowing irrigation+at tillering/ CRI+Flowring+Grain filling)

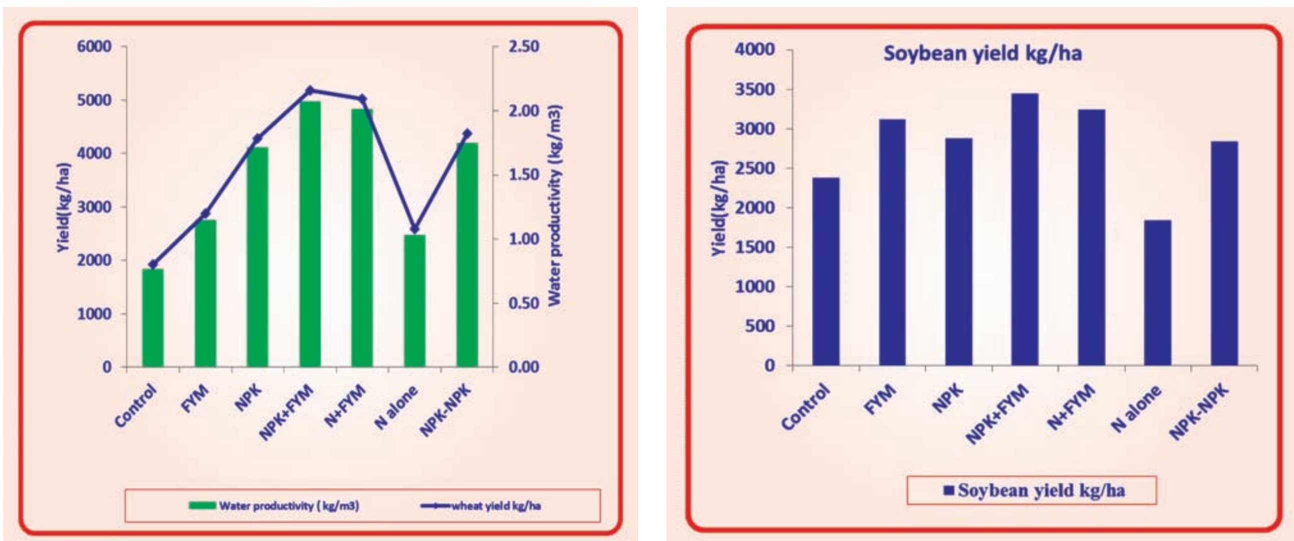


Fig. 3.5.2. Wheat and soybean yield under different level of nutrients

followed the same trend as that of grain yield. The yield trend of soybean was similar to wheat under residual fertility. Application of the recommended NPK to both seasons produced lower yield than the NPK+FYM, N+FYM and FYM treated plots under residual fertility (Fig. 3.5.2).

Recharging techniques for hill springs

The roof and surface water were harvested in trenches. Trees have been planted on trenches for enhancing the recharging of ground water. Although, the five-yearly mean annual rainfall was lower by 19.4, 13.5, 15.5, 13.6, 12.5, 24.2, 26.5, 27.1 and 32.5% during 2006-2010, 2007-2011, 2008-

2012, 2009-2013, 2010-2014, 2011-2015, 2012-2016, 2013- 2017 and 2014-2018, but the five year mean annual discharge of the spring was 73, 101, 114, 136, 149, 146, 138, 143 and 136% higher during 2006-2010, 2007-2011, 2008-2012 2009-2013, 2010-2014, 2011-2015, 2012-2016, 2013-2017 and 2014-2018, respectively compared to annual discharge recorded during 2000 before the inception of the treatments. The annual discharge was 147% higher during 2018 compared to the discharge recorded before treatment inception in 2000. The discharge of spring greatly increased during lean period in comparison with discharge recorded in 2000 (Fig. 3.5.3).

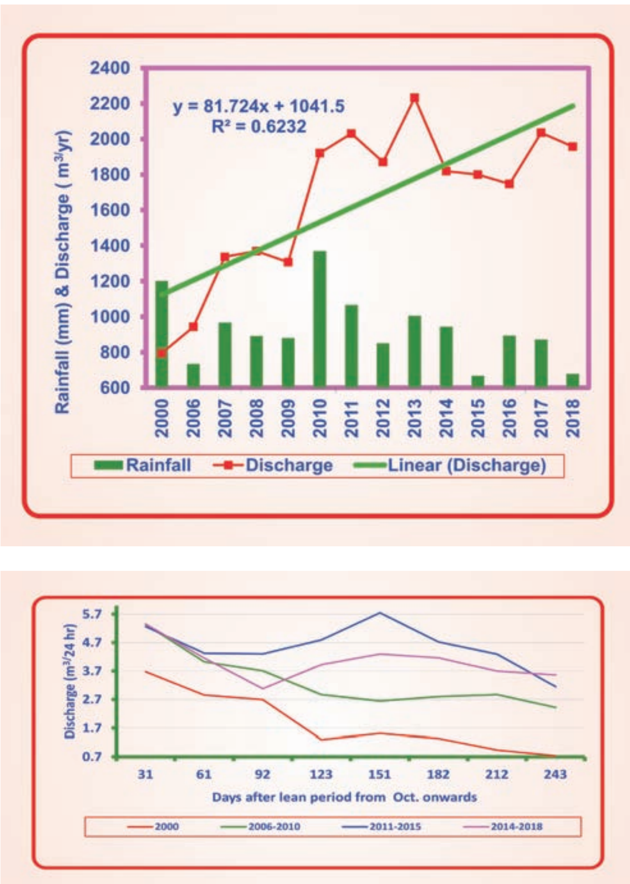


Fig. 3.5.3. Annual rainfall and Spring discharge (Lean period) during different years

Study the effect of irrigation schedule on onion and garlic

The mean onion yield (16,200 kg/ha) under drip irrigation was significantly higher in comparison with check basin irrigation (13,400 kg/ha). The highest onion yield (18,200 kg/ha) was obtained under drip irrigation scheduled at 1.2 IW: CPE ratio followed by drip irrigation scheduled at 1.0 IW: CPE ratio (Fig. 3.5.4). The lowest yield (10,400 kg/ha) was recorded under check basin irrigation scheduled at the rate of 0.8 IW: CPE ratio (Fig. 3.5.4). In case of garlic, the highest yield (9,250 kg/ha) was obtained under drip irrigation scheduled at 1.0 IW: CPE ratio. The lowest yield (2,150 kg/ha) was recorded under check basin irrigation scheduled at the rate of 0.8 IW: CPE ratio (Fig. 3.5.4).

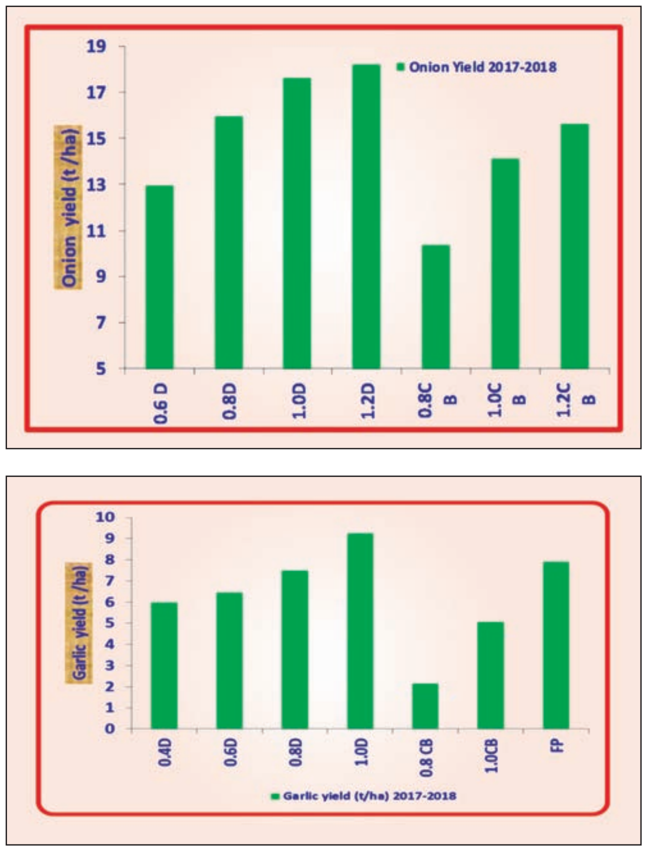


Fig. 3.5.4. Bulb yield of onion and garlic influenced by irrigation levels

4. Integrated Pest Management

Research Projects

- 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]*
- Race Pofiling, Variability and Management of Major Plant Pathogens of Hill Crops *[Drs. Rajashekara, H., Venkatesan, M. (upto June 26, 2018) & K.K. Mishra]*
- Biointensive Management of Major Polyphagous Pests of Uttarakhand Hills *[Drs. A.R.N.S. Subbanna, J. Stanley & Rajashekara H.]*

4. Integrated Management of Diseases and Pests of Hill Crops

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

4.1. Survey and Surveillance

Survey was conducted for monitoring of wheat crop at farmers' field during *rabi* 2017-18. At Pechuni (29°52'52" N, 79°22'22" E, 963m amsl), Almora, around 70% area was planted with VL *Gehun* 907. Few plants of VL *Gehun* 907 showed yellow rust up to 20S. In the village Quano (30°40'38" N, 77°45'52" E), in Dehradun district, a local barley variety was planted and yellow rust upto 40S was recorded. Some farmers also planted wheat variety VL *Gehun* 804 (about 10 ha area) and these fields were free of rust. At Domet, Vikas Nagar (30°30' 41" N, 77°51'16" E), Dehradun district, farmers planted VL *Gehun* 829 where no rust was observed.

Rust infected barley crop at Quano

Rust infected barley crop at Quano

During *kharif* season 2018, leaf and neck blast diseases of rice were moderate (20-25%) with 4-6 score on 0-9 scale. However, false smut incidence became severe (>50%). It occurred naturally in all the experimental trials conducted at Experimental farm, Hawalbagh as well as in farmers' field.

Field view of rice crop infected with false smut disease

In maize, turcicum leaf blight was moderate while maydis leaf blight severity was medium. The incidence of banded leaf and sheath blight was moderate in all the field trials. The severity of leaf blast of finger millet was high, but neck and finger blast severity was medium. In barnyard millet, incidence of grain smut disease was high. In garden pea, very low severity of wilt (2%), moderate severity of powdery mildew (30-45%) in polyhouses, low-medium severity of purple blotch in onion and garlic (5-20%) were noticed during March-April. Medium severity (25-30%) of french bean rust and very low severity of late blight (<2%) in tomato were observed.

The South American pinworm, *Tuta absoluta* was noticed for the first time in Uttarakhand during May 2018 and the damage in tomato was found to be up to 15%. High infestation of mustard aphids was found in *toria*, cabbage and radish during February and March. Medium infestation of thrips in onion was found during April. Severe infestation of fruit flies was noticed in summer squash during May-June. In organic fields, okra was found to be infested severely by flea beetles; medium infestation of blister beetles and aphids were also noticed during June. Medium infestation of chauliops in soybean during July to September was noticed. Grasshoppers were found to infest rice crop during September. In polyhouses, high infestation of mites and medium infestation of thrips were noticed in pea during April.

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

Virulence analysis of Magnaporthe oryzae isolates and race classification

Isolates collected from rice growing areas of Mukteshwar, Bhageshwar, Basulisera and Raulsera were characterized on monogenic blast differentials under artificial epiphytotic conditions. Isolates were established by adopting spore drop method and pure cultures were maintained on Potato Dextrose Agar (PDA) and Oat Meal Agar (OMA) media. Spore forming ability of *M. oryzae* isolates varied from high spore forming to low spore forming. The virulence per cent ranged from 23 to 92. The lowest virulence was seen in isolate Mo-nhz-09 collected from Raulsera rice growing area, while the maximum virulence was shown by isolate Mo-nhz-04 collected from Mukteshwar rice growing area (Table 4.2.1).

Pear shaped conidia of *M. oryzae* isolates (20x)

Resistance spectrum of R genes

Among twenty-four *R* genes, high degree of resistance was shown by *Pita2* followed by *Piz5, Pizt, Pita* and *Pi9* whereas, complete susceptibility was shown by *Pikm* and *Pikp* gene followed by *Pii, Pi19, Pi11, Piks* and *Pik* (Table 4.2.2).

Table 4.2.1. Per cent virulence of *M. oryzae* isolates from different rice growing areas

Isolate	No. of R gene knocked down	Percent virulence	Race No.
Mo-nhz-01	11	42.30	U00-i1-k072-z05-ta003
Mo-nhz-02	16	61.53	U50-i7-k153-z12-ta003
Mo-nhz-03	16	61.53	U12-i3-k173-z11-ta413
Mo-nhz-04	24	92.30	U42-i7-k177-z17-ta513
Mo-nhz-05	14	53.84	U72-i3-k117-z00-ta001
Mo-nhz-06	18	69.23	U70-i5-k177-z01-ta403
Mo-nhz-07	14	53.84	U42-i7-k177-z00-ta001
Mo-nhz-08	9	34.61	U40-i5-k013-z00-ta000
Mo-nhz-09	6	23.07	U30-i1-k012-z00-ta000
Mo-nhz-10	7	29.62	U50-i2-k014-z00-ta000

Table 4.2.2. Reaction of R-genes for different *M. oryzae* isolates

R-gene	Mo-nhz Isolates no.									
	01	02	03	04	05	06	07	08	09	10
Pi1	S	R	S	S	R	S	S	R	R	R
Pi11	S	S	R	S	S	S	S	S	R	R
Pi12	R	R	S	S	R	S	R	R	R	R
Pi19	S	S	S	S	S	S	S	R	R	R
Pi20	S	S	S	S	R	S	R	R	R	R
Pi3	R	S	R	S	S	R	S	R	R	S
Pi-5	R	S	S	S	R	S	S	S	R	R
Pi7	R	R	R	S	S	S	S	R	R	S
Pi-9	R	S	S	S	R	R	R	R	R	R
Pia	R	R	S	S	S	R	R	R	R	R
Pi-b	R	R	R	R	S	S	R	R	S	R
Pii	S	S	R	S	S	S	S	S	S	R
Pik	R	S	S	S	S	S	S	S	R	R
Pikh	S	S	S	S	R	S	S	R	R	R
Pikm	S	S	S	S	S	S	S	S	S	S
Pikp	S	S	S	S	S	S	S	S	S	S
Piks	R	S	S	S	S	S	S	S	R	R
Pish	R	S	S	R	S	S	R	R	S	S
Pit	R	S	R	S	S	S	S	S	R	S
Pita	R	R	S	S	R	R	R	R	R	R
Pita2	R	R	R	S	R	R	R	R	R	R
Piz	S	R	S	S	R	S	R	R	R	R
Piz5	R	S	R	S	R	R	R	R	R	R
Pizt	S	R	R	S	R	R	R	R	R	R
LTH	S	S	S	S	S	S	S	S	S	S
V 8657	R	R	R	S	R	R	R	R	R	R

Identification of resistance source to neck and finger blast disease from hill germplasm collection of finger millet

A total of 206 hill germplasm collections of finger millet were evaluated against leaf, neck and finger blast disease under natural field conditions during 2017 & 2018 *kharif* seasons. Based on two seasons scoring pattern, it was observed that none of the germplasm was highly resistant to leaf blast disease, but frequency distribution ranged from 37.5 to 82.5 (Fig.4.2.1).

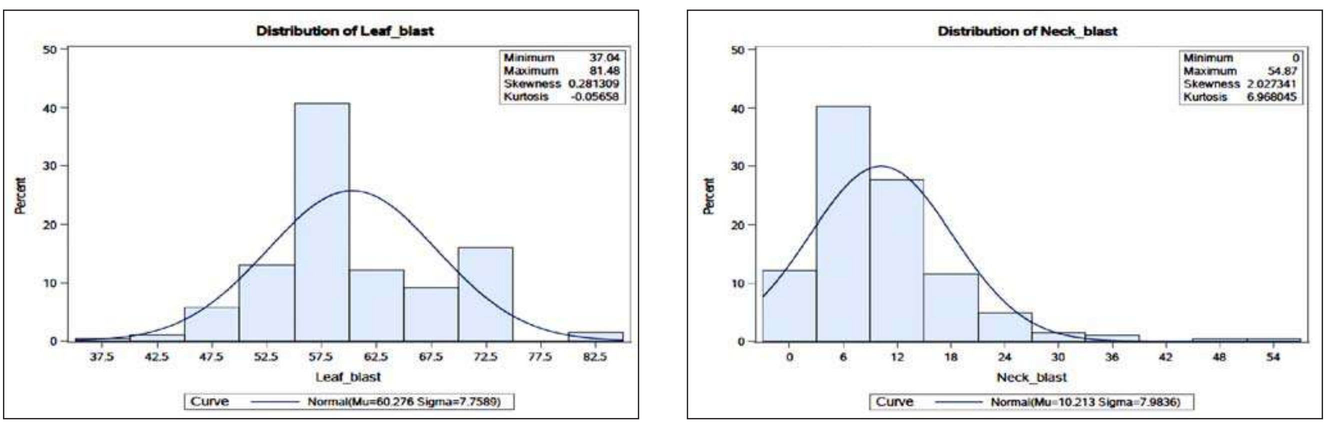


Fig. 4.2.1. Frequency distribution of leaf and neck blast disease in hill germplasm collections of finger millet

The frequency distribution of neck blast was 0 to 36. The identified resistance sources include VHC3637, VHC4085, VRB-MF-1817, VRB-MF-1819, VHC4180 and VHC4087. These entries were immune to neck blast with high degree of resistance to finger blast and moderate resistant to leaf blast. The frequency distribution for finger blast ranged from 0 to 28 (Fig. 4.2.2). None of the entry showed immune reaction to finger blast, however, some entries *viz*. VRB-MF-12, VRB-MF-1 and GPU-45 showed highly resistant reaction to finger blast (<1% incidence).

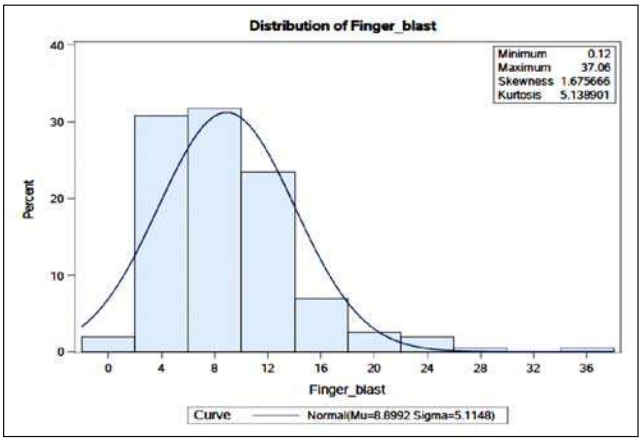


Fig. 4.2.2. Frequency distribution of finger blast in hill germplasm collections

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

Different biocontrol and chemical fungicides were tested for management of BLSB. Different parameters like germination per cent, plant disease index (PDI), number of sclerotia per plant and grain yield per plot basis were analyzed. Based on three replication data, germination per cent ranged from 80 to 91. The severity of infection can be seen on cobs and some plants were completely killed. Among all the treatments, it was observed that the lowest germination per cent (80%) was observed in T1 and maximum germination (91%) was found in T10 followed by T5 and T7. PDI ranged from 46.91 to 51.11%. There was not much difference in suppression of disease development among different treatments but reduction in sclerotial formation per plant and yield were significantly different. Treatments T2 and T4 showed maximum reduction in sclerotia formation (07 sclerotia per plant as compared to 12 sclerotia per plant of T1-control). Better yield was achieved due to reduction in infection of cobs. The highest yield of 55 q/ha was recorded in T2 and T6 treatments, which were significantly higher than T11 and T1 treatments (35 and 39 q/ha, respectively) (Fig. 4.2.3).

Cob infection with *Rhizoctonia solani* (A) Normal Cobs (B) Infected Cobs

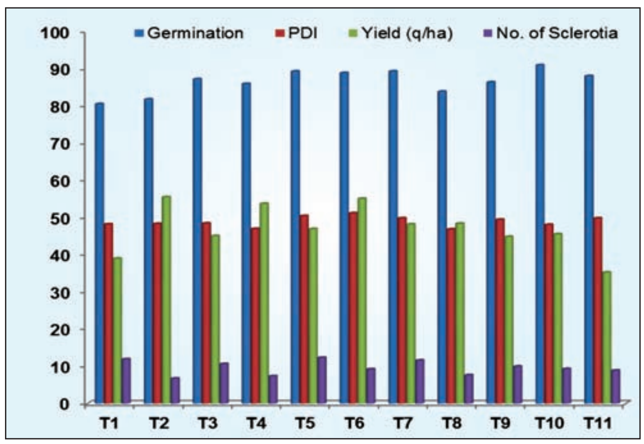


Fig. 4.2.3. Effect of different treatments on management of BLSB disease in maize

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

Artificial screening of maize inbred lines for BLSB resistance

Fifty-five maize inbred lines were screened under artificial epiphytotic conditions with an isolate from Hawalbagh for identifying resistant source to banded leaf and sheath blight disease. The pathogen (*Rhizoctonia solani*) was inoculated on 30 days seedlings with help of mycelium and sclerotia and proper humidity was maintained by spraying water at regular intervals. Disease was scored based on 0-5 disease rating scale on symptom development. Based on two replication data, identified tolerant sources include V334, V335, V372, V 406, V 407, VSL-4 and CM141.

Effective R genes for blast resistance under field conditions

Twenty-four monogenic blast differentials were evaluated for leaf and neck blast resistance under field conditions. It was observed that none of the gene is highly resistant to leaf blast disease, however, R genes showed varied reaction to neck blast disease. Some differentials like *Pi11, Pi20, Pi5, Pia, Pikh, Pikm, Piks, Piz, Piz5* and *Pizt* were highly resistant to neck blast disease.

Management of powdery mildew of garden pea using integrated approaches

Out of eleven treatments, comprising of both chemical and biological agents evaluated against root rot and powdery mildew diseases of garden pea, seed treatment with *Trichoderma harzianum* strain Tr-28 @ 10g/kg seeds+spraying at first symptom appearance @ 4g/L of water+chemical treatment (spray of karathane @ 0.1% at time of disease appearance) was found promising (3 score on 0-5 scale) in comparison to others.

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

Light trap catches of different species of whitegrubs

During May to October 2018, a total of 7,466 beetles were trapped in 10 light traps installed at the Experimental Farm, Hawalbagh, which was higher than the beetles trapped during 2017 (5200 beetles). As that of previous year, the maximum total catches of 87.6% were recorded during June-July months. Diversity of the beetles comprised of 33 species in comparison to 30 species of last year of which, 16.9% was the predominant species, *Aphodius* sp. *Anomala dimidiata* is no longer a predominant species which comprise only 6.64% of the total catches in comparison to 16.4% of previous year. Other species, *viz. Anomala* sp., *Apogonia* sp. and *Maladera iridescens* were 7.66, 4.19 and 2.85% of the total catch, respectively, whereas the scarabaeinae accounts for 28.86%. The species composition of light trap catches is given in the Fig. 4.3.1.

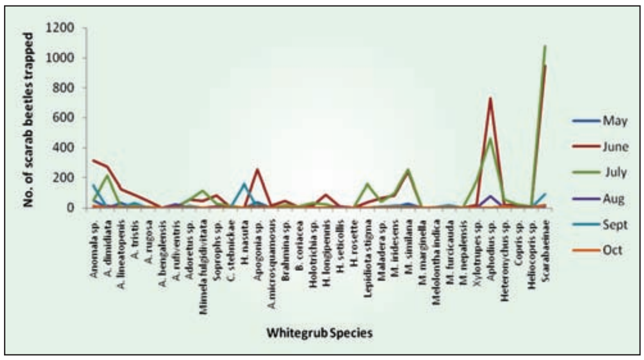


Fig. 4.3.1. Species composition of light trap catches during May-October 2018

Molecular identification of chitinolytic Bacillus species using 16S rRNA gene analysis

The phylogenetic position and molecular identification of selected strains of chitinolytic *Bacillus* species native to Uttarakhand Himalayas were analyzed through 16S rRNA sequences. Approximately, 850 bp region of targeted gene was sequenced and the similarity search using BLASTN of GenBank revealed high similarity of isolates with 16S rRNA sequences of various *Bacillus* and *Paenibacillus* species. A 16S rRNA sequence based phylogenetic tree clearly differentiated both the *Bacillus* and *Paenibacillus* species into two major clusters (Fig. 4.3.2). In addition, grouping amongst the observed clusters clearly inferred phylogenetic proximity and species identity. Out of the tested isolates, UKCH17 and UKCH77 were found to be *B. licheniformis* strain and the remaining was found to be the species of *Paenibacillus*. The highest boot strap values also support this species identity.

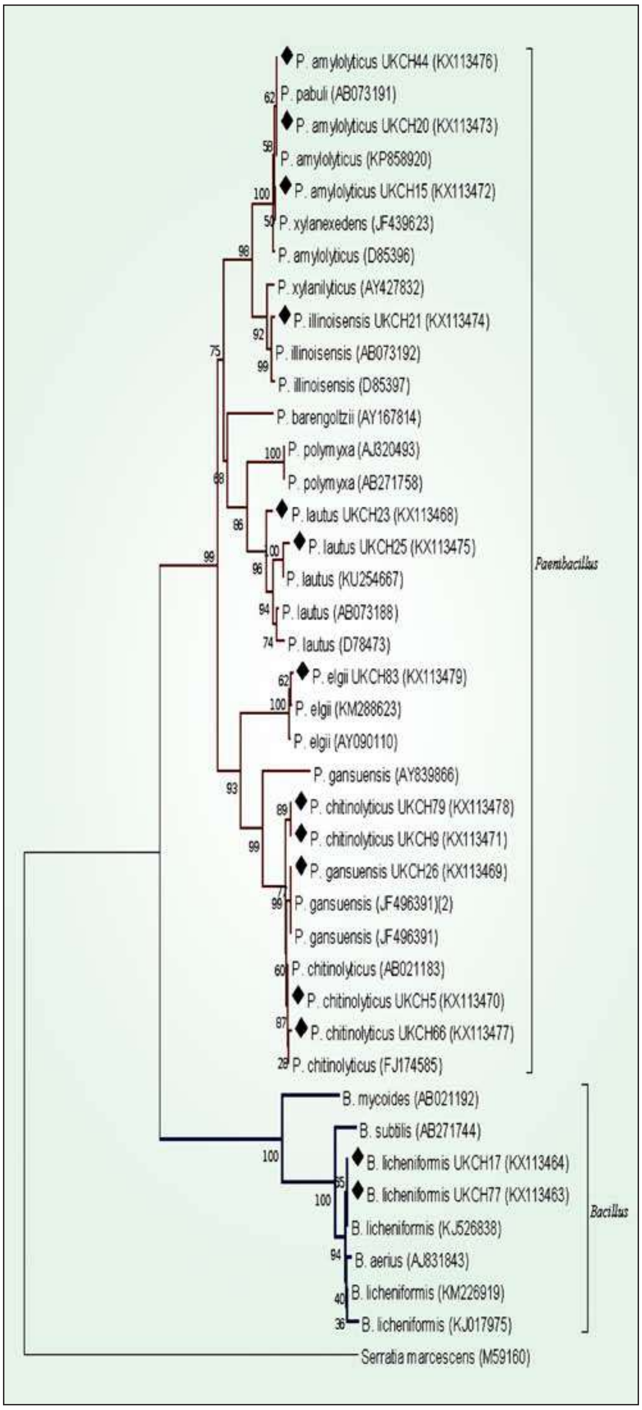


Fig. 4.3.2. Phylogenetic tree showing clustering of bacterial 16S rRNA gene sequences constructed by the neighbour-joining method (The scale represents 0.1 substitutions per site. The tree was constructed with known chitinase sequences retrieved from GenBank. The accession numbers are given in parenthesis. Numbers at each node indicate percentage of confidence levels generated from 1000 boot strap trees)

Bioefficacy and joint action of chitinolytic Bacillus thuringiensis with insecticides

Members of *B. thuringiensis* are well known producers of chitinase. A preliminary identification of *Bacillus thuringiensis* (Bt) collection in Uttarakhand showed detectable chitinolytic activity both qualitatively (haloes observed in CHDA medium) and quantitatively (chitinase activity measured) in all the isolates with great variability. The insect bioassays using chitinases from selected 11 Bt isolates showed poor direct toxicity on insect larva even at the highest concentration tested (5 ppm) in comparison with HD-1 strain (Table 4.3.1). Among the tested insect pests, *Thysanoplusia orichalcea* was found to be more susceptible to chitinases, compared to *Helicoverpa armigera* and *Mythimna separata*. With respect to the tested Bt isolates, highest mortality of 33.3, 7.1 and 7.1% was observed in *T. orichalcea, H. armigera* and *M. separata*, respectively. This highest mortality was recorded by VLBt135 against *T. orichalcea* and *M. separata.* In case of *H. armigera*, highest mortality was recorded by VLBt38 and VLBt109, which were the second best against *T. orichalcea.* The third best isolate, VLBt27 gave a mortality of 20.0, 3.6 and 7.1% in *T. orichelsia*, *H. armigera* and *M. separata,* respectively. No isolate recorded mortality more than 10% at the lowest concentration tested, *i.e.* 0.5 ppm but found to have substantial reduction in larval weights. A separate experiment on larval growth reduction of 1st, 2nd and 3rd instar larvae of *H. armigera* revealed an average weight reduction of 77.4, 71.0 and 56.4%, respectively within 4 days of treatment (Fig. 4.3.3). The results also showed a significant minimized susceptibility of 3rd instar larvae to all the tested Bt isolates. Among the tested isolates, VLBt135 was prominent inhibitor against all the three instars with larval weight reduction of 85.4, 74.8 and 65.3%, respectively.

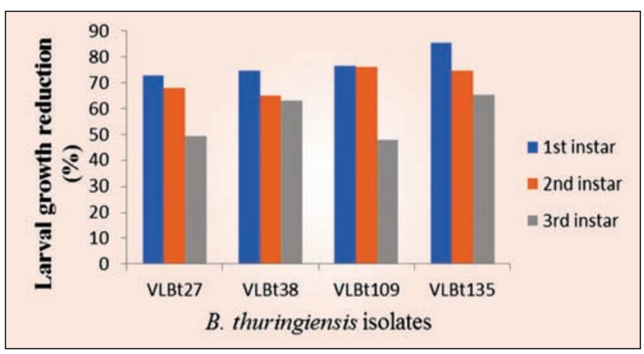


Fig. 4.3.3. Growth reduction in different instar larvae of *H. armigera* treated with 5 ppm supernatant proteins containing chitinases of respective isolate

Table 4.3.1. Toxicity of cell free culture supernatants from potent chitinolytic *B. thuringiensis* isolates

Isolates	Specific activity (U/mg of protein)	Mortality (%)				
		T. orichaelsia		*H. armigera*		*M. separata*
		5 ppm	0.5 ppm	5 ppm	0.5 ppm	5 ppm
HD-1	-	35.7	3.6	25	3.6	22.6
VLBt 15	44.9	17.9	3.6	3.6	0	0
VLBt 27	60.9	20	3.6	3.6	0	7.1
VLBt 35	63.1	15	0	3.6	0	4.1
VLBt 38	46.5	30	3.6	7.1	0	0
VLBt 109	91.8	23.3	3.6	7.1	0	0
VLBt 135	56.9	33.3	7.1	3.6	0	7.1
VLBt 238	99.8	11.4	0	3.6	0	0
VLBt247	78.4	17.9	0	3.6	0	0
VLBt 251	80.0	17.9	0	3.6	0	0
VLBt268	74.5	15	0	3.6	0	0
VLBt 275	38.2	14.3	0	3.6	0	0

The joint action of four potent chitinolytic bacteria with seven selected insecticides against *B. brassicae* was tested. Out of total 28 interactions, additive, antagonistic and synergistic effects were in the ratio of 15, 10 and 3, respectively (Table 4.3.2). Except for two interactions in acetamiprid (with VLBt27 and VLBt135), the co-toxicity factor value in remaining antagonistic interactions was very much near to -20 and so relatively can be considered as additive effect. All the four interaction of cartap hydrochloride were antagonistic. The only synergistic interactions were profenophos with VLBt38 and VLBt109 and imidacloprid with VLBt27. Interestingly, the remaining interactions in profenophos were additive with positive co-toxicity factor values and in imidacloprid, they were antagonistic.

Against *H. armigera,* a total of 16 interactions were tested of which 13 and 3 were synergistic and additive, respectively (Table 4.3.3) and no antagonistic interactions were found. In majority of synergistic interactions, the co-toxicity factor was more than 50 representing high levels of synergism.

Table 4.3.2. Joint action of *Bt*chitinases (3d old cultures of *Bt* in CHDA medium) with selected insecticides (at LC_{30}) against cabbage aphid, *Brevicoryne brassicae*

Insecticide/mixture	Mortality (%)		Co-toxicity factor	Interaction
	Realized	Expected		
Nimbecidine + VLBt27	71.11 ± 1.57 (57.51)	60.0	19	Additive
Profenophos + VLBt27	48.89 ± 1.57 (44.36)	44.5	10	Additive
Profenophos + VLBt38	71.11 ± 1.57 (57.51)	54.5	31	Synergistic
Profenophos + VLBt109	95.56 ± 1.57 (78.04)	47.8	100	Synergistic
Profenophos + VLBt135	64.44 ± 3.14 (53.46)	57.8	12	Additive
Imidacloprid + VLBt27	86.66 ± 4.71 (69.39)	57.8	50	Synergistic

(Nimbecidine – 5 ppm; Profenophos – 0.5 ppm & Imidacloprid – 0.8 ppm)

Figures in parenthesis are the transformed values. Treatments with positive co-toxicity factor were given.

Table 4.3.3. Joint action of *Bt* chitinases (3d old cultures of *Bt* in CHDA medium) with selected insecticides (at LC_{30}) against 1st instar larvae of *H. armigera*

Insecticide/mixture	Mortality (%)		Co-toxicity factor	Interaction
	Realized	Expected		
Profenophos + VLBt27	76 ± 6.78 (62.41)	45.6	67	Synergistic
Profenophos + VLBt38	64 ± 4.00 (53.23)	49.1	30	Synergistic
Profenophos + VLBt135	70 ± 4.47 (57.04)	45.6	54	Synergistic
Chlorpyriphos + VLBt27	80 ± 3.16 (63.73)	31.6	153	Synergistic
Chlorpyriphos + VLBt38	50 ± 4.47 (45.00)	35.1	42	Synergistic
Chlorpyriphos + VLBt109	56 ± 8.12 (48.64)	35.1	60	Synergistic
Chlorpyriphos + VLBt135	50 ± 3.16 (45.00)	31.6	58	Synergistic
Indoxacarb + VLBt38	60 ± 3.16 (50.819)	35.1	71	Synergistic
Indoxacarb + VLBt109	60 ± 4.47 (50.87)	35.1	71	Synergistic
Indoxacarb + VLBt135	58 ± 3.74 (49.67)	31.6	84	Synergistic
Spinosad + VLBt27	72 ± 4.9 (58.37)	29.6	143	Synergistic
Spinosad + VLBt38	56 ± 5.1 (48.51)	33.1	69	Synergistic
Spinosad + VLBt135	46 ± 2.45 (42.69)	29.6	55	Synergistic

(Profenophos – 0.5 ppm; Chlorpyriphos – 20.75 ppm; Indoxacarb – 3.25 ppm & Spinosad – 0.25 ppm)
Figures in parenthesis are the transformed values. Treatments with synergistic interaction were given.

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 A. bisporus

A total of 12 siderophore producing *Pseudomonas* strains were applied at the time of casing along with untreated check. Out of these, casing application of strain PCRs4 (14.13 kg/q), strain PGRs1 (13.34 kg/q), strain PBRs5 (13.22 kg/q) and strain NPRp15 (13.09 kg/q) provided significantly higher yield of *A. bisporus* than control (11.26 kg/q compost) (Fig. 4.4.1).

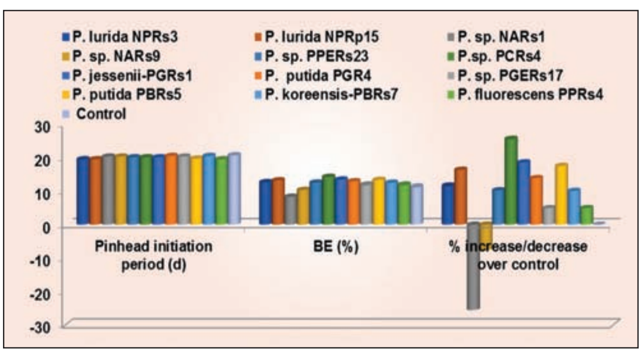


Fig. 4.4.1. Effect of siderophore producing *Pseudomonas* strains on yield of *A. bisporus*

Evaluation of 'P' solubilizing Pseudomonas strains on yield of A. bisporus

Fourteen 'P' solubilizing *Pseudomonas* strains were tested for enhanced *A. bisporus* production. Pin head initiation period varied from 16.3 to 19.3 days after casing in different strains. The average yield of *A. bisporus* was significantly higher in the casing soil inoculated bags with *Pseudomonas* sp. strain CS11RP1 (15.4 kg/q compost wt.) followed by *Pseudomonas fragi* CS11RH1 (14.4 kg/q compost wt.), which was 23.2% and 15.2% higher than the yield obtained in un-inoculated control (12.5 kg/q compost wt), respectively (Fig. 4.4.2).

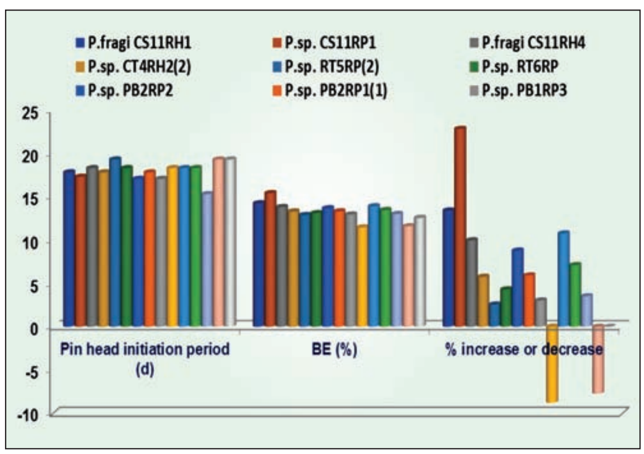


Fig. 4.4.2. Effect of 'P' solubilizing Pseudomonas strains on yield of *A. bisporus*

Evaluation of different casing soil on yield of Agaricus bisporus

Seven different casing soils *viz.*, farmyard manure (FYM), FYM+spent compost (SC), sandy soil (SS), FYM+SS (1:1), coir pith (CP)+sandy soil (1:1), FYM+SC+SS (1:1:1), and FYM+SC+CP (1:1:1) were evaluated for yield of *A. bisporus* for two consecutive years (Fig. 4.4.3). The casing soil FYM+SC (2:1) provided the maximum biological efficiency (19.5%) which was at par with FYM alone (18.9%).

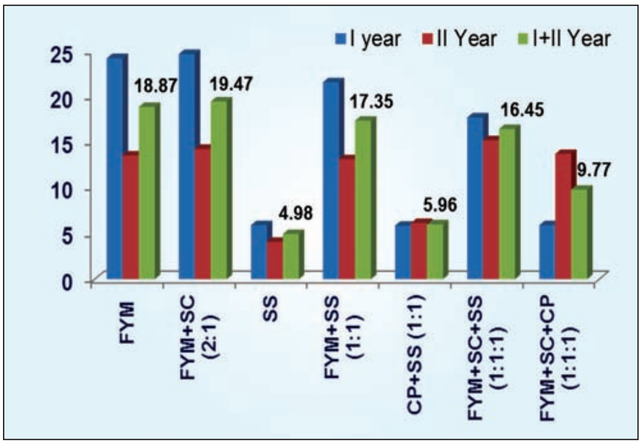


Fig. 4.4.3. Effect of different casing soil on yield of *A. bisporus*

Cultivation of Macrocybe gigantea and their antioxidant activity determination

Macrocybe gigantea, a tropical mushroom grows under the environment of high temperature and humidity. The mushroom was cultivated on wheat straw substrate using standard methodology. The temperature of the crop room was 25-35^{0}C and relative humidity was 70-80% during the cropping period. The biological efficiency of the mushroom was 62%. The mushroom can be kept for 10 days in refrigerated condition and 3-4 days at room temperature.

Polyphenols, total flavonoids, radical scavenging activity on DPPH and ABTS, total antioxidant activity and ferric reducing antioxidant power (FRAP) from cap, stipe and whole mushroom were evaluated. The cap contained higher polyphenols (9.72 mg GAE/100g dry wt.), total flavonoids (5.54 quercitine qui/g) (Fig. 4.4.4) and ferric reducing antioxidant power (234.94 mMtrolox eqv/g) (Fig. 4.4.5) than other parts tested. Our findings indicate that the mushroom is a good antioxidant food where its cap contributes the most.

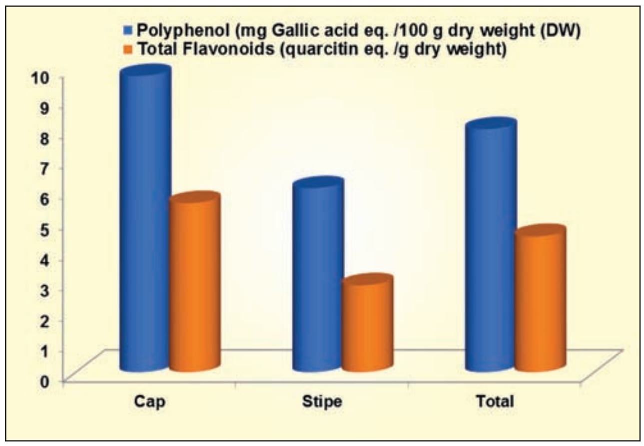


Fig 4.4.4. Polyphenol and total flavonoids content

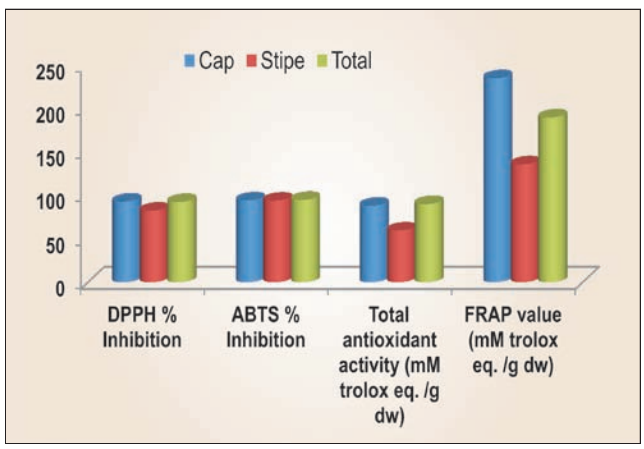


Fig. 4.4.5. Different antioxidant activities

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 & Sushil Kumar]*

- Impact of Constrained and Unconstrained Choices on Adoption of Improved Agricultural Practices by Farmers *[Drs. Renu Jethi, Kushagra Joshi & Ankita Kandpal]*

- Technological Interventions for Mitigating Drudgery and Improving Nutritional Status of Hill Farmwomen *[Drs. Kushagra Joshi, Renu Jethi, Nirmal Chandra & Sushil Kumar]*

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

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

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

Study of vegetable value chain in Nainital district of Uttarakhand

A baseline survey was conducted in four blocks of the district Nainital *viz.*, Bhimtal, Dhari, Okhalkanda and Ramgarh for primary and secondary data collection on vegetable value chain using structured interview schedule. Primary data were collected from key vegetable value chain actors and stakeholders.

Existing scenario of vegetable production in Nainital district

Horticulture production data (2017-18) from the Directorate of Horticulture and Food Processing, Chaubatia, Uttarakhand was used to draw the present scenario of vegetable production in the Nainital district. Among the various vegetable crops grown in the area, potato was the most important vegetable grown and marketed by the farmers in Nainital district occupying the maximum area (23.87%) of the total area under vegetable production. The other important crops were tomato, pea and cabbage occupying 20.42, 18.71 and 12.48% area, respectively. (Table 5.1.1).

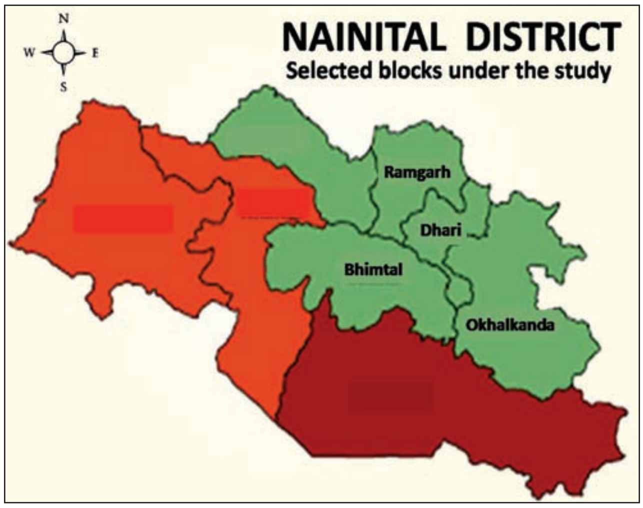


Table 5.1.1. Scenario of vegetable area, production and productivity in Nainital district

Vegetable Crop	Area (ha)	Per cent Area	Production (t)	Productivity (t/ha)
Pea	1445.25	18.71	9552.61	6.61
Radish	105.01	1.36	1383.8	13.18
French bean	503.52	6.52	3608.63	7.17
Cabbage	963.99	12.48	12331.01	12.79
Cauliflower	297.08	3.85	2020.01	6.80
Onion	388.51	5.03	5313.61	13.68
Capsicum	195.00	2.52	1190.99	6.11
Okra	73.01	0.95	554.36	7.59
Tomato	1577.07	20.42	21668.15	13.74
Brinjal	48.01	0.62	360.96	7.52
Potato	1843.90	23.87	26595.00	14.42
Other vegetables	284.50	3.68	2479.31	8.71
Total	7724.85		87058.44	118.32

Source: Horticulture production data (2017-18), Directorate of Hort. and Food Processing, Chaubatia, UK

Major crops grown in hills of Nainital district were pea, radish, french bean, cabbage, cauliflower, onion, capsicum, okra, tomato, brinjal, potato and other vegetables. Potato is the most important crop of the area with a total production of 26595 t followed by tomato (21668 t) and cabbage (12331 t). The major crops grown in Nainital district such as potato, tomato, pea and cabbage had the productivity of 14.42, 13.74, 6.61 and 12.79 t/ha, respectively (Table 5.1.1).

Existing vegetable marketing channels and estimated marketing cost in Nainital district

In the present study, 80 farmers (20 farmers from each block) were surveyed for documenting vegetable marketing channels operating in the area. It was found that marketing channel III (Producer-wholesaler/ commission agent-retailer-consumer) was the most prominent one which is being followed by more than 70% vegetable growers, who are disposing 64 to 90% of the total produce through this channel.

Marketing cost was estimated for various marketing channels operating in the selected blocks of the Nainital district (Table 5.1.2). The study revealed that 80% of the tomato was sold through the channel III (Producer-Commission agent cum Wholesaler-Retailer-Consumer) with the cost of marketing Rs 187.45 /q. Marketing cost was the lowest Rs 55.4 /q in channel-I (Producer-Consumer) but only 5% of tomato was sold through this channel. It is suggested that for achieving maximum profit and to reduce intermediary charges in trade, Channel I, Channel II should be preferred over the other marketing channels.

Assessment of post-harvest losses of vegetables

Post-harvest losses in tomato and pea were studied for small and large farms in the Nainital district (Table 5.1.3). It was found that the post-harvest losses in tomato occurred at different stages of the supply chain and was estimated to be 18.96% for small farms and 13.48% for large farms. In the case of pea, the physical loss in the supply chain was estimated to be 11.23% for small farms and 6.75% for large farms. In both the crops, maximum loss incurred was during transportation of farm produce.

Table 5.1.2. Marketing channels and estimated marketing cost of vegetables in Nainital district

Channels	Existing marketing channels	Cost of marketing (Rs./q)	Produce marketed (%)	Suggestions
I	Producer—Consumer	55.40	5	1. Channel I should be selected when farm produce is in less quantity whereas 2. Channel II should be preferred when produce is in large quantity for achieving maximum profit
II	Producer—Retailer—Consumer	85.00	10	
III	Producer—Wholesaler/Commission agent (local market) — Retailer— Consumer	187.45	80	
IV	Producer—Commission agent—Wholesaler (distant market) — Retailer— Consumer	205.00	5	

Table 5.1.3. Post-harvest losses for tomato and pea crops at different stages of the vegetable supply chain

Activity	Physical losses (kg/q)			
	Tomato		Pea	
	Small & marginal farmers (< 16 *Nali*)	Large farmers (>16 *Nali*)	Small & marginal farmers (< 16 *Nali*)	Large farmers (>16 *Nali*)
Harvesting	5.12	3.23	3.46	2.87
Sorting and grading	0.21	0.19	0.19	0.11
Packaging	0.84	0.78	0.35	0.24
Loading	0.59	0.56	0.45	0.43
Transportation	9.58	5.87	4.78	1.43
Unloading	1.28	1.87	1.09	0.89
Weighing	1.34	0.98	0.91	0.78
Total loss	18.96	13.48	11.23	6.75

Problems of vegetable growers in Nainital district

The identified problems were divided into three categories *viz.*, marketing problems, financial problems and institutional problems. Non-availability of remunerative price and the high cost of packing material were the major marketing problems. Untimely availability of fertilizers/chemicals and non-availability of reliable seeds were the major institutional problems (Table 5.1.4).

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

The extent of adoption of recommended agricultural practices in finger millet cropping system was measured by taking samples from selected two types of village areas. From area I, those farmers were selected who are exposed to technological interventions related to finger millet, whereas in area II those farmers, not received any intervention. The average distance between the two areas was 80 km. Random sampling technique was used to select 63 sample farmers with 29 and 34 farmers from area I and area II, respectively during the year 2018.

The adoption index of good agricultural practices developed by Sharma, 2002 was used. Adoption was measured 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, 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.

Table 5.1.4. Problems faced by vegetable growers in Nainital district of Uttarakhand.

Problems	Respondents (%) (N=80)	Suggestions for improvement
Marketing problems		Improving packaging facilities and organized marketing of off-season vegetables.
Non-availability of remunerative price	60	
The high cost of packing material	52	
Deduction by traders in the form of commission	45	
Means of transportation in the area	37	
High commission charges	28	
Distance from market	26	
Financial problems		
A large number of formalities	37	
Lack of funds to purchase inputs	28	
Institutional problems		
Untimely availability of fertilizers and chemicals	60	
Non-availability of improved seeds	58	
Lack of assured irrigation facilities	42	
Non-visiting of village level workers to fields	37	
Lack of extensions and training facilities.	28	

Table 5.2.1. Adoption level of recommended agricultural practices in finger millet crop

Area I				Area II			
Adoption level	**Categories**	**Percentage**	**Mean score**	**Adoption level**	**Categories**	**Percentage**	**Mean score**
Low	< 58.5	17.2	56	Low	< 45.8	12	42.5
Medium	58.5 – 69.3	62.1	63.5	Medium	45.8 – 54.6	76	50.1
High	>69.3	20.7	71.6	High	>54.6	12	57.4

"t" value: 10.94, "p" value: 0.000

It could be inferred (Table 5.2.1) that 62.1% farmers of area I, had medium adoption followed by high adoption (20.7%) of recommended agricultural practices in finger millet crop with mean adoption index score of 63.5 and 71.6, respectively. In the case of area II, 76% had medium adoption with mean adoption index score of 50.1.

Table 5.2.1. Practice wise adoption of recommended agricultural practices in finger millet crop using Mann-Whitney u test.

Recommended practices	Area I (Mean % score)	Area II (Mean % score)	z value	p value
Improved varieties used	100	35	7.740	0.000***
Seed rate	44	37	1.359	0.174 NS
Method of sowing	39	33	2.503	0.012*
Sowing time	98	95	0.975	0.329 NS
Thinning	62	42	4.23	0.000***
Intercultural operations	68	62	1.36	0.174 NS
Disease & pest management	38	33	2.22	0.026*
Nutrient management	45	40	1.23	0.219 NS
Stage of harvesting	92	88	0.95	0.34 NS
Improved method of threshing	54	35	3.86	0.000***

*** significant at 0.1% level, * significant at 5% level, NS= Non-significant

The p value shows that there was a significant difference in recommended practices followed by farmers of area I and area II area *viz.*, improved varieties used, thinning and improved method of threshing at 0.1 per cent level whereas method of sowing, disease and pest management at 5 per cent level.

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

The study compares the differences between choices made by farmers under unconstrained condition when asked about the recommended agricultural practices and farmers actual (constrained) practices and attempts to identify the sources of differences in both the types of areas selected.

In case of area I, 75.9% farmers indicated that they would follow the line sowing of finger millet in absence of constraints (lack of mechanization) compared to 17.2%, who have already tried it. In case of disease management 72.4% farmers indicated that they would use recommended methods of disease and pest management in the absence of constraints (non-availability of appropriate plant protection measures) compared to 13.8% farmers who are already using it. Only 58.6% farmers responded positively for using recommended practices of nutrient management (Fig. 5.2.1). Most of the farmers responded that they prefer to apply only manure in finger millet crop. Although, it occupied major cultivated area during *kharif* season, but it was rated as subsistence crop and less important crop than wheat and rice.

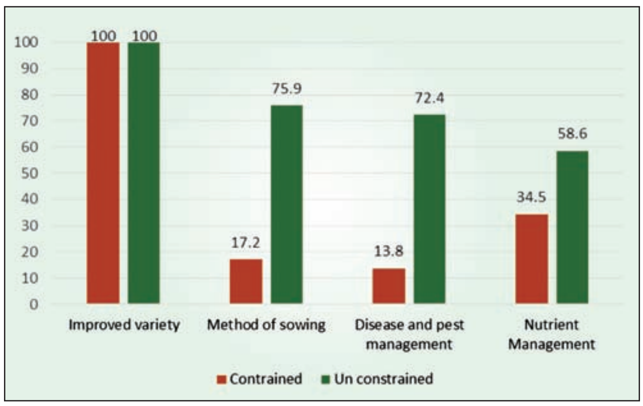


Fig. 5.2.1. Farmers' choices of recommended agricultural practices in finger millet in Area I

In case of Area II, 73.5% farmers indicated their interest in using improved variety of finger millet over their local variety. Fig. 5.2.2 shows that no farmers of these area are using line sowing (improved sowing method) and improved disease and pest management practices. In the absence of constraints (lack of knowledge about scientific cultivation practices, non-availability of appropriate plant protection chemicals etc), only 26.5% and 67.6% farmers showed their willingness to use improved method of sowing and disease management, respectively.

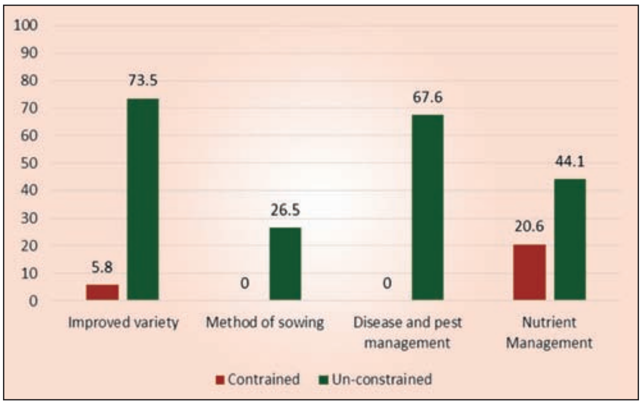
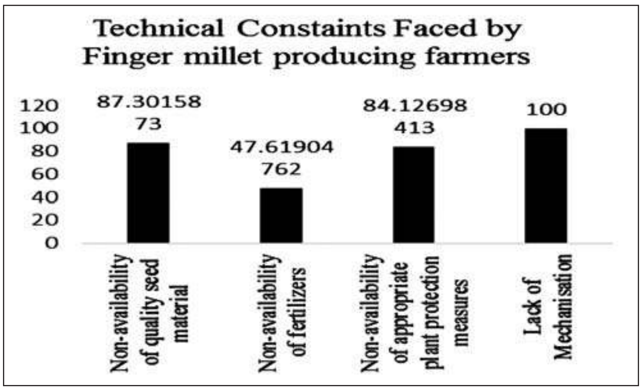


Fig. 5.2.2. Farmers' choices of recommended agricultural practices in finger millet in Area II

In area I, there was a significant difference among the constrained and un-constrained farmers choices for method of sowing and disease and pest management at 0.1 percent level. In area II, there was statistically significant difference in both the choices of farmers for adoption of improved variety, sowing method and disease & pest management at 0.1% level.



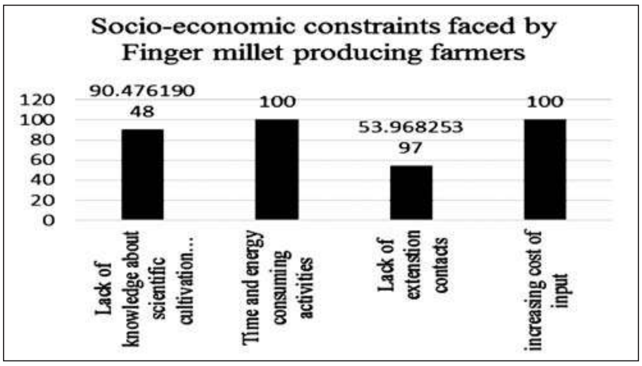


Fig. 5.2.3. Adoption constraints faced by farmers in cultivation of finger millet

Lack of mechanization was perceived by farmers as major constraints followed by non-availability of appropriate plant protection measures (Fig. 5.2.3). The crop is mostly grown in the slopes or bench terraces in hills with limited possibility of mechanization to reduce time and drudgery associated with production and post-harvest operations. Under socio-economic constraints, majority of the farmers perceived that, time and energy consuming activities associated with finger millet restricts adoption of recommended practices.

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

The project was taken up with an intention of studying the drudgery and other ergonomic risk factors of women in different cropping systems, to analyze their nutritional status and to design intervention package for reducing their drudgery and to improve nutritional outcomes. Finger millet-based cropping system (Finger millet–wheat) was selected as finger millet is a labor-intensive crop which requires a good deal of time and efforts by the farmers during production and post-harvest activities. For the study, data was collected from farm women of various villages practicing finger millet cultivation in Almora district namely Tunakot, Tipola in Tarikhet block, Raun and Kafun in Hawalbag block and Patiya and Kotyura in Takula block. A total of 120 women were interviewed and their work pattern was observed in the fields during the *kharif* season.

Participation in finger millet cultivation: Division of roles

The participation of women in finger millet cultivation was documented. Some activities like ploughing, *danela* application (intercultural activity) were solely performed by men whereas thinning and gap filling, weeding and harvesting are solely done by women. Broadcasting, cleaning field and threshing were also other activities dominated by women. Winnowing was an activity of equal participation. Drying and storage are carried by persons who remain at home and is also a woman dominant activity (Fig 5.3.1).

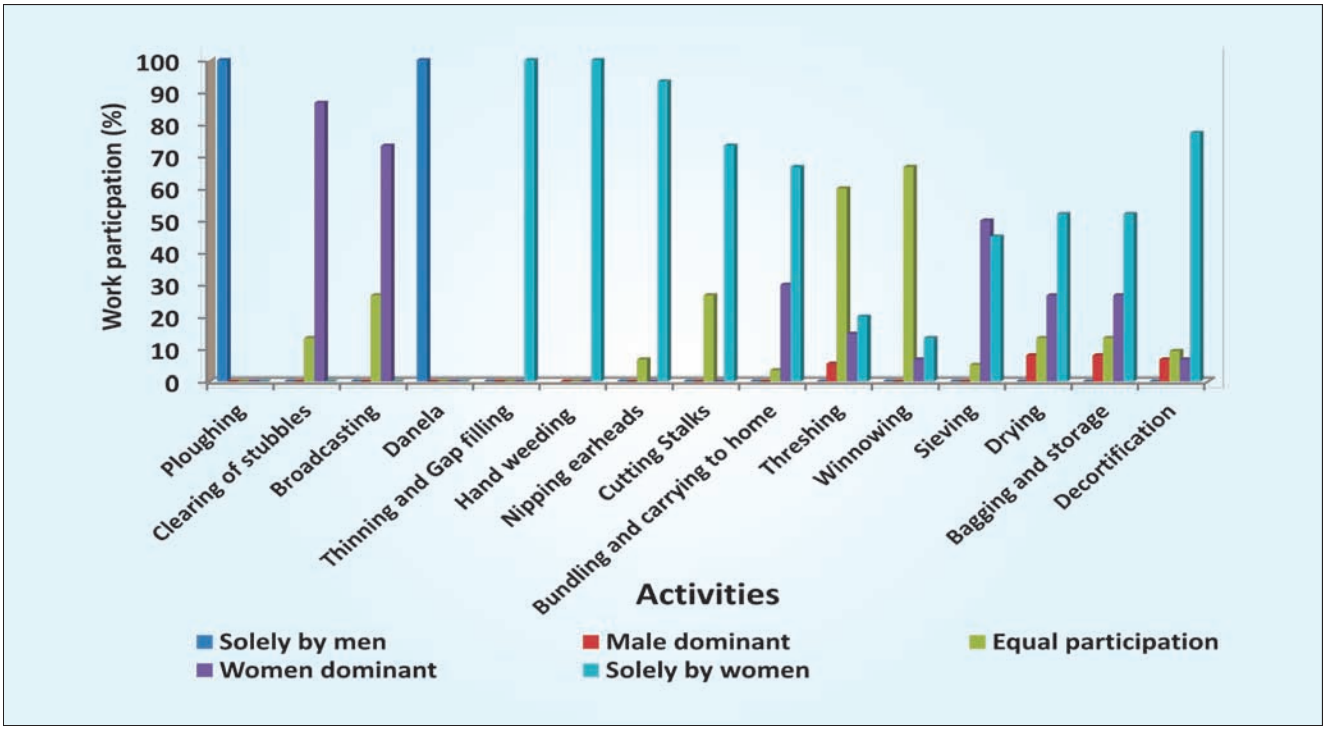


Fig 5.3.1. Gendered participation level in finger millet cultivation

Drudgery in finger millet cultivation

The drudgery of farm women in various activities in finger millet cultivation was ascertained on the basis of total score obtained for the physical load carried, time spent, discomfort experienced, posture adopted and exertion perceived.

Physical load carried by women (activity-wise)

The physical load in finger millet cultivation activities was assessed which was found highest in carrying the produce to home followed by nipping earheads. Manual loads being handled ranged from 1.50 to 22 kg and needed to be lifted up to 1.5m while performing various activities (Table 5.3.1).

Time factor (activity-wise)

For time load of various activities, nipping earheads took most of the time followed by stalk cutting and weeding (Table 5.3.2). Crop is harvested by hand, individual heads are cut off with a sickle, leaving a few centimeters of stalk attached or whole crop is harvested at base level leaving a few centimeters of stubble on the ground.

Table 5.3.1. Physical load carried and perceived load

Activity	Weight of load (kg)	Distance carried (km)	Height lifted (m)	Physical load rating
Removing stalks/ stubbles	1.50	1.0	0.9	2.0
Weeding	5.0	0.5	0.9	5.0
Nipping earheads	18.0	1	1.0	4.0
Cutting stalk	10.0	0.05	1.5	3.0
Carrying produce to home	22.0	1.20	1.5	5.0
Threshing	3.50	0.05	1.0	5.0
Winnowing	1.80	0.05	1.0	3.0
Decortification	3.50	0.05	1.0	5.0

Table 5.3.2. Time load of women in various activities

Activity	Mandays per nali	Workload perceived as time demand
Removing stalks/ stubbles and unwanted plants	3.09	2
Sowing	2.88	3
Weeding	15.60	5
Nipping earheads	24.80	5
Cutting stalk	15.63	5
Carrying to home	6.33	3
Threshing	4.85	3
Winnowing	2.27	3
Decortification	5.17	2

Discomfort rating (activity-wise)

Overall Discomfort Rating (ODR) was used to illicit responses on discomfort felt after carrying out various activities. Most discomfort was reported in weeding followed by threshing and decortification activity (Table 5.3.3).

Table 5.3.3. Discomfort perceived by women in various activities

Activity	Overall Discomfort Rating (ODR)	Type
Removing stalks/ stubbles and unwanted plants	2.78	Light
Sowing	3.20	Moderate
Weeding	8.48	High
Nipping earheads	6.80	More than moderate
Cutting stalk	7.33	High
Carrying to home	6.33	More than moderate
Threshing	8.00	High
Winnowing	5.00	Moderate
Decortification	7.87	High

Postural analysis (activity-wise)

The posture adopted by farmwomen during finger millet cultivation was analysed. Most of the activities were performed while standing and bending followed by squatting and sitting. Postural analysis was done using Rapid Entire Body Analysis technique (REBA). Carrying load, decortification and weeding were found at high risk for farmers and required to be intervened (Table 5.3.4). Women perceived exertion most in nipping earheads, threshing and weeding activities.

Table 5.3.4. Postural risk in various activities in finger millet cultivation

Activity	REBA Score	Risk Level
Removing stalks/ stubbles	4	Medium
Sowing	3	Low
Weeding	10	High
Nipping earheads	7	Medium
Cutting stalk	9	High
Carrying to home	10	High
Threshing	7	Medium
Winnowing	6	Medium
Decortification	8	High

Perceived exertion by women (activity-wise)

To understand the physical demand of the activities, exertion experienced by women while performing various activities was assessed on a psychophysical rating scale by Borg (1985) on a rating of 0 to 1 in terms of rated perceived exertion score (RPE). The activities with maximum exertion were threshing, carrying stalks to home, weeding and harvesting (Fig. 5.3.2).

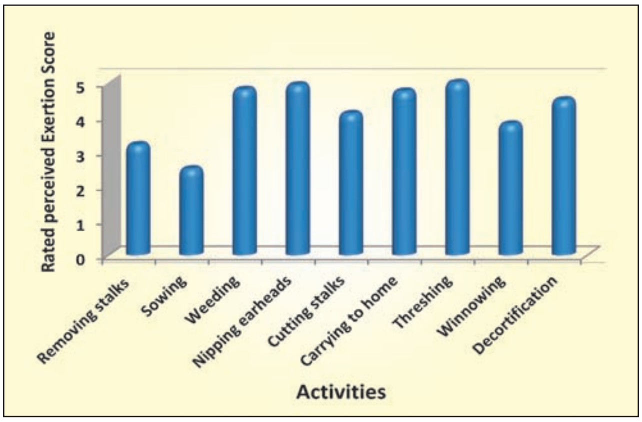


Fig. 5.3.2. Perceived exertion scores for different activities

Drudgery scores (activity-wise)

The cumulative scores for drudgery were calculated on the basis of scores obtained for physical load, postural strain, perceived exertion, discomfort rating and time load. Based on the scores attained, maximum drudgery was observed in harvesting (cutting stalks and nipping earheads) followed by weeding and threshing (Fig 5.5.3). It was found that these activities require some intervention for reducing drudgery and ensure health and safety of the worker.

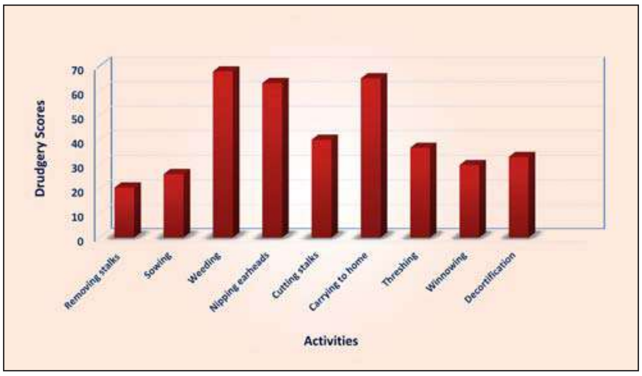


Fig. 5.3.3. Drudgery in various activities in finger millet cultivation

Ergonomic Evaluation of Selected Activities in Wheat Cultivation

Manual harvesting of wheat

The task of harvesting wheat involves cutting, tying and bundling as sub activities which are time consuming and possess postural stress. Postural analysis of the lumbo-sacral region was measured using inclinometer. For cervical region, angle of deviation was found to be 11.80° whereas for lumbar region it was found to be 12.70°.

Table 5.3.5. Physiological parameters of farm women performing wheat harvesting manually

Parameters	Manual harvesting	Manual tying and bundling
Heart rate while working (beats/min)	124.28	110
Total cardiac cost of work (beats)	833.4	569
Physiological cost of work (beats)	27.78	37.93
Energy expenditure rate (kJ/min)	11.04	8.61
Cardiac stress index	77.42	88.26

The energy expenditure rate of 11.04 kJ/ min indicates manual harvesting as heavy to perform (Table 5.3.5). On an average, a woman spends 21 days (three weeks) in wheat harvesting and bundling activity per season. Bundling and tying is an activity of short duration but still it requires frequent bending in arduous postures and exert stress. Angle of deviation was 2.5% and 8.5% in cervical and lumbar region, respectively was recorded while tying and bundling activity.

Women harvesting, tying and bundling wheat

Manual threshing of wheat

Threshing wheat by traditional method involves drudgery and takes more time to obtain required quality of *bhusa* (straw). A woman on an average beats the wheat stalks 75.65 times per minute during the activity with rapid movement of dominant hand. Average working heart rate during manual beating of wheat was recorded as 102.80 beats/min with an average energy expenditure of 7.62 kJ/min. which indicates that the activity is moderately heavy to perform (Table 5.3.6).

Table 5.3.6. Physiological parameters of farm women threshing wheat manually

Parameters	Manual threshing
Heart rate while working (beats/min.)	102.80
Change in heart rate over resting (beats/min.)	26.11
TCCW (beats/min.)	517.65
PCW (beats/min.)	17.26
EER (kJ/min.)	7.62
Cardiac strain index	77.89

Awareness about drudgery reducing tools and implements

Awareness about drudgery reducing implements was examined among 90 hill farmers (45 women, 45 men). Most of the respondents (93.3%) used traditional tools and implements at their farm to perform various intercultural activities. Most of the tedious and drudgery prone activities were done manually by local traditional tools such as hand hoe, sickles, etc. It was found that one-third of respondents have heard about improved tools and implements for crop cultivation. About 93.8 per cent respondents were willing to use improved tools if made available.

Woman threshing wheat manually

Dietary diversity and BMI scores of farm women

Inadequate diet intake among women remains a challenge due to their hectic work schedule. These women are often nutritionally vulnerable due to their increased nutrient requirements and disadvantages in intra-household distribution of nutrient-dense foods. The Minimum Dietary Diversity for Women (MDD-W) is a dichotomous variable that equals 1, if the women consumed at least 5 different food groups during the past 24 hours and 0 otherwise.

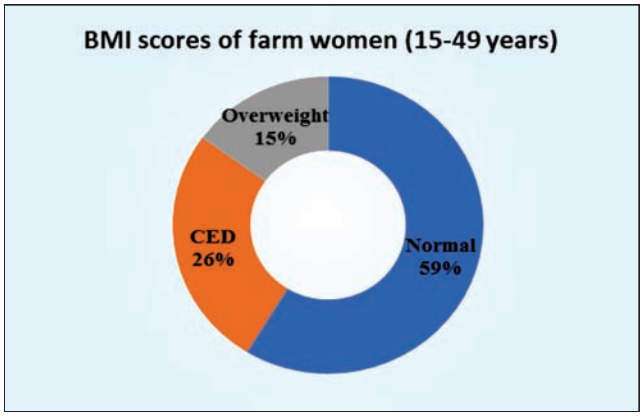


Fig. 5.3.4. BMI scores of farm women (15-49 years age)

Out of total women studied in Raun and Patiya villages, 59.0% were normal, whilst 26.0% were found to be chronic energy deficient (CED) and 15.0% were overweight (Fig 5.3.4). The mean MDD-W for the sample was 4±1.0. The percentage of women who achieved minimum dietary diversity (5 or more) was 31.1%, and they are more likely to have higher (more adequate) micronutrient intakes than the 68.9% of women who did not meet the minimum dietary diversity (Fig. 5.3.5).

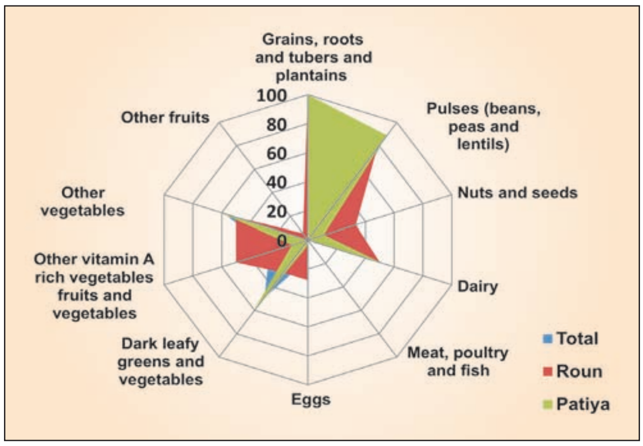


Fig. 5.3.5. Percentage of women (15-49 years) reported intakes of each food group in last 24 hour

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 (on study leave)]*
- ICAR-CRP on Molecular Breeding in Maize *[Drs. R.K. Khulbe, R.S. Pal, Rajashekara H. & Rakesh Bhowmick (on study leave)]*
- 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)]*

6.3. 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. DUS Project

- 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, 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 Project on Organic Farming (NPOF) *[Drs. Dibakar Mahanta, P.K. Mishra, K.K. Mishra, J. Stanley, V.S. Meena & Venkatesan M. (upto June 26, 2018)]*

6.6. 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]*

6.7. ICAR-FCI Sponsored Project

- Study on Determining Storage Losses of Food Grains in FCI and CWC Warehouses and to Recommend Norms for Storage Losses in Efficient Warehouse Management *[Dr. Sher Singh]*

6.8. NMHS Project

- Identification, Assessment and Enhancement of Soil Carbon and Nitrogen Sequestration Potential of Different Ecosystems in the Central Himalayan Through a Community Participatory Approach *[Drs. V.S. Meena, B.M. Pandey, A. Mukherjee (upto July 13, 2018), T. Mondal (on study leave), R.P. Yadav, N.K. Singh, H.C. Joshi, P. Nautiyal & G. Papnai]*
- Strategies to Improve Health and Nutriotional Status of Hill Farm women through Technological Interventions *[Drs. Renu Jethi, Nirmal Chandra, Pankaj Nautiyal & Manisha Arya]*

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. DST Funded SERB Young Scientist Project

- Habitat Management of Non-Apis Bee Pollinator Conservation *[Dr. J. Stanley]*

6.11. NABARD Funded Project

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

6.12. DAC Funded Project through ICAR-NCIPM

- Efficacy of Phosphine Fumigant Against Storage Pests of Pulses, Wheat, Rice and Coffee Beans; and Residue Analysis for Quarantine and Long-term Storage Purpose *[Dr. J. Stanley]*

6.13. National Food Security Mission (NFSM)

- Enhancing Breeder Seed Production for Increasing Indigenous Production of Millets in India *[Dr. D.C. Joshi]*

6.14. 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

The amenability of VL maize hybrids to haploid induction using R1-nj-based haploid inducers was scored in each cross. Kernel pigmentation was present in all the hybrids (except CMVL 55), indicating their amenability for DH derivation using the *in vivo* system. Among the 19 parental inbreds, all except V 405 expressed kernel pigmentation. Of the two hybrids (CMVL 55 and VMH 51) having V 405 as female parent, kernel pigmentation was absent to weak in CMVL 55, whereas complete pigmentation was present in VMH 51. The observations suggested that all VL hybrids used in the study (except CMVL 55 and FH 3703) were suitable for use as potential sources for generation of early maturing DH lines using *R1-nj*-based haploid inducer lines.

Ears of inbreds (left panel) and hybrids (right panel) pollinated with haploid inducer TAILP1

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

An understanding of communication networks and knowledge sharing about agricultural practices bears significant importance for undertaking interventions regarding local information needs. The public extension systems catering need of farmers having a basic understanding of their search strategies are often well-received. A study was carried out to generate the data related to media utilization pattern and to analyse the communication characteristics of farming communities in the three districts of Uttarakhand namely Almora, Bageshwar and Uttarkashi. The survey and a self-structured interview schedule were used for data collection tool to meet out the objectives.

Media ownership among farmers

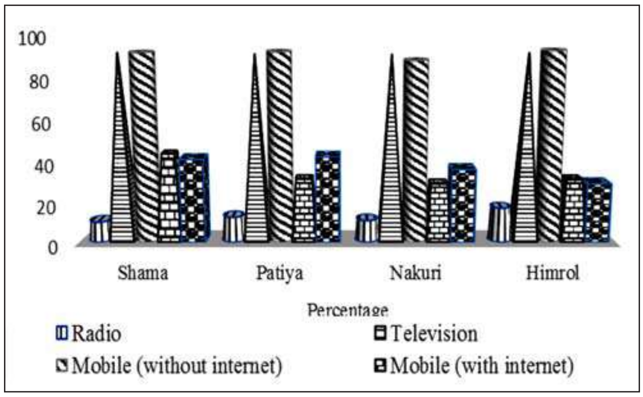


Fig. 6.1.1. Accessibility/Owners to different media by farmers in selected clusters

It can be clearly concluded that Television and Mobile (without internet) were the major accessible mass media sources in all village clusters (Fig. 6.1.1) Television among the mass media showed strong contact among the farmers. Similarly, majority of respondents (>90.0%) in all four village clusters reported that they had accessibility to mobile phones (without internet), whereas radio was the least accessed media amongst the respondents of each village cluster. This may be due to very limited use of radio among the farmers as farmers were not aware of agriculture related programme broadcast by AIR (All India Radio).

Extent of usage of different communication sources for accessing agricultural information

Credibility of different communication sources used for agricultural information

Weighted mean scores were drawn on the basis of farmer's responses for credibility of various

Table 6.1.1. Use of different communication sources for accessing agricultural related information

Source	Himrol	Patiya	Nakuri	Shama	Weighted Mean
Friends/neighbours	2.77	2.65	2.79	2.85	2.76
Rural leader	2.17	1.94	2.05	1.95	2.02
Village Development Officer	1.29	1.36	1.80	1.40	1.46
Block Development Officer	1.15	1.16	1.13	1.30	1.10
Other farmers	2.90	2.83	2.59	2.86	2.79
Shopkeeper	2.36	1.79	2.38	1.93	2.11
Scientist	1.63	1.38	1.21	1.61	1..45
Radio	1.58	1.06	1.34	1.10	1.27
Television	2.11	2.60	2.29	2.41	2.35
Telephone/mobile	2.61	2.37	2.42	2.36	2.44
Tape recorder	1.19	1.04	1.09	1.03	1.08
Video	1.68	1.69	1.66	1.67	1.47
Newspaper	2.09	1.54	1.64	1.65	1.73
Magazine	1.09	1.18	1.15	1.39	1.20
Pamphlet	1.28	1.40	1.99	1.55	1.55
Hoarding/boards	2.10	1.39	1.80	1.67	1.74
Plays	1.46	1.11	1.62	1.18	1.34
Announcements	2.15	1.35	1.72	1.35	1.64
Demonstration	2.03	1.59	2.10	1.87	1.89
Fair/exhibition	1.97	1.66	2.12	1.74	1.87
Panchayat meeting	2.56	2.73	2.64	2.32	2.56

Average weighted mean (AWM) score revealed that among the communication sources, fellow farmers (2.79), friends/neighbours (2.76), panchayat meetings (2.56) showed a strong degree of usefulness for the farmers in order to get agricultural information. It could be due to the easy availability, timeliness, need based and understandable content of message delivered by these sources. Some farmers often contacted shopkeepers (2.11) and rural leaders (2.02) as agricultural information sources. Whereas the mass media sources like telephone/ mobile (2.44) and television (2.35) were found to be the moderately used information sources. The findings conclude that most of the farmers were relying on informal sources than the formal sources for agricultural information (Table 6.1.1).

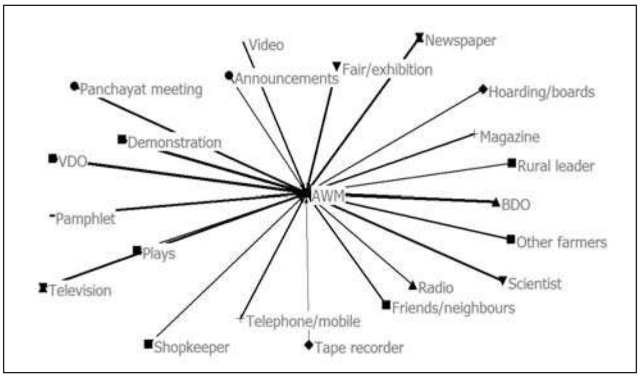


Fig. 6.1.2. Credibility of different communication sources used for agricultural information

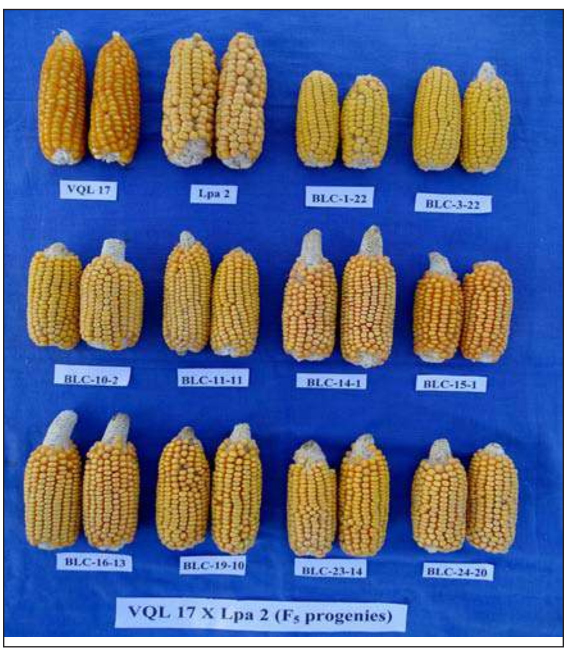
information sources. Social network analysis technique was applied to analyse the strength of credibility (Fig. 6.1.2). It was found that state department officials like Block Development Officers (BDO) and Village Development Officers (VDOs), Scientists and panchayat meetings and demonstrations laid by the line departments were the most credible sources of information. Television, pamphlet, fair/exhibition and newspapers were other credible sources of information amongst the respondent farmers. For this, formal sources can make use of effective motivational activities like farm visits, mass campaign, demonstration activities etc. so that farmers can realise that they can have easy and quick access to these sources when they require information. As farmers fetch information from input dealers and shopkeepers, there is a need to consider them also as agents for transferring information to farmers of their area. Hence, trainings should also be arranged for them for ensuring credibility and accuracy of information.

6.2. Consortium Research Platform (CRP) Projects

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

F_6 populations of five crosses between elite QPM lines (VQL 1, VQL 2, VQL 17, VQL 373 and SA-12-1) and low phytate donor LPA 2 were raised at Almora during *kharif* 2018. 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 (<3 mg/g)] were selected for further advancement. The number of plants selected for advancement is as given below:

Cross	No. of selected plants
VQL 1/LPA 2	54
VQL 2/LPA 2	35
VQL 17/LPA 2	45
VQL 373/LPA 2	75
SA 12-1/LPA 2	31



Variation in low phytate lines derived from VQL 17 x Lpa 2 cross

6.2.2. ICAR-CRP on Molecular Breeding in Maize

BC_2F_3s between trait specific donors and their respective recipient lines [QPM (V407/VQL 373), Beta-carotene (V 400/CIMMYT 4 and V 412/CIMMYT 13) and low phytate (V409/LPA 2 and V 407/LPA 2)] generated during *rabi* 2017-18 at Winter Nursery Centre, ICAR-IIMR, Hyderabad were raised during *kharif* 2018 at Almora. Individual plants were screened with suitable foreground markers (umc1066 and phi057 for high tryptophan, crtRB1 for high beta carotene and umc2230 for low phytate) and BC_2F_4 for each cross was generated.

BC_2F_4 progenies of VQL 373 x V 407 (left panel) and V 390 x (CML 173)

The number of plants selected for advancement (homozygous/heterozygous for the target trait with recurrent parent phenotype) is as given below:

In case of V 407/LPA 2, individual plants with recurrent parent phenotype were biochemically screened for phytate content and 36 plants with phytic acid content of <3 mg/g were selected for further advancement.

Cross	Target trait	No. of plants selected
V 407/VQL 373	High tryptophan	36
V 390/CML 173	High tryptophan	20
V 412/CIMMYT 13	High provitamin A	40
V 400/CIMMYT 4	High provitamin A	41
V 409/LPA 2	Low phytate	47

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

Six hundred and ninety-eight wheat accessions were inoculated for loose smut during 2016-17 and sown in expression nursery. Among these, 130 were found free (0.0% infection) and 48 were found resistant (0.1 to 5.0% infection) to loose smut.

Field view of CRP Agrobiodiversity materials

Field view of CRP Agrobiodiversity materials

Powdery mildew was also recorded in these accessions and 684 were found resistant to powdery mildew (Avg. score 0-3).

Another set of 865 new accessions were inoculated during *rabi* 2017-18.

6.2.4. CRP on Molecular Breeding Wheat

Popular wheat varieties *viz.,* VL *Gehun* 907 (Timely sown condition) and VL *Gehun* 892 (Late sown condition) were selected for pyramiding durable rust resistance genes *viz., Yr10* and *Lr 24* as these varieties have started showing susceptibility to the new races of yellow rust pathogen. During *rabi* 2017-18, BC_3F_{1s} [(VL *Gehun* 892/ Yr10/5*Datatine //VL *Gehun* 892) (205 plants), (VL *Gehun* 892/ FLW1// VL *Gehun* 892) (264 plants), (VL *Gehun* 907/ Yr10/5*Datatine //VL *Gehun* 907) (288 plants) and (VL *Gehun* 907/ FLW 1 //VL *Gehun* 907) (288 plants)] were planted at Hawalbagh farm. After foreground as well as agronomic selection positive genotypes in BC_3F_1 generation were intercrossed (around 1000 seeds).

Field view of CRP molecular breeding materials

During off-season of 2018, the F_{1S} of intercrosses (VL *Gehun* 892/ Yr10/5*Datatine // VL *Gehun* 892) / (VL *Gehun* 892 / FLW1 // VL *Gehun* 892), (VL *Gehun* 907 / Yr10/5*Datatine // VL *Gehun* 907)/ (VL *Gehun* 907/ FLW1 // VL *Gehun* 907) were planted at Dalang Maidan, Lahaul Spiti, Himachal Pradesh. The Desirable F_1s were advanced to produce F_2s. These F_2 populations were planted during *rabi* 2018-19 for evaluation of plants carrying pyramided *Yr*10 and *Lr*24 genes with agronomic suitability.

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

Demonstrations comprising landraces and improved varieties were conducted in black soybean (*Kala Bhat*, VL Soya 65 and VL Bhat 201), horsegram

Glimpses of activities at farmers' field at Gallibaseura & Chinauna villages of Almora district

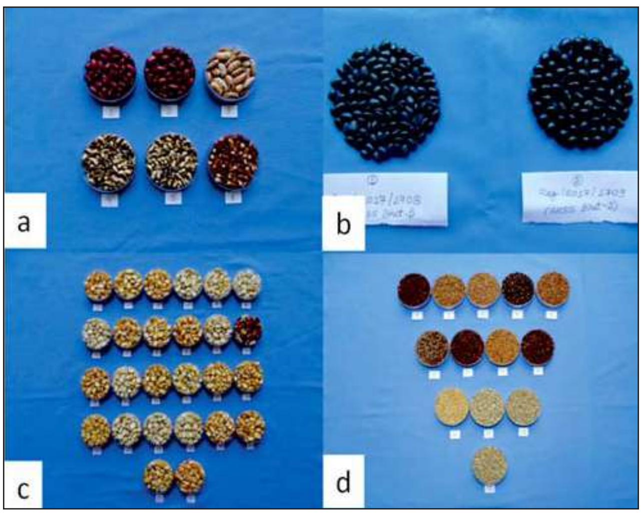
(*Kala Gahat*, *Bhura Gahat*, VL *Gahat* 8, VL *Gahat* 10, VL *Gahat* 15 and VL *Gahat* 19), finger millet (*Gadhwali*, *Golpahari*, *Nagchuni*, VL *Mandua* 315, VL *Mandua* 324, VL *Mandua* 352 and VL *Mandua* 376), amaranth (*Kala Chua*, *Safed Chua* and VL *Chua* 44), buck wheat (*Namadua* and VL *Ugal* 7) and rice (*Dudh*, *Borani*, *Gajayee*, *Dudh Jhonki*, *Vivek Dhan* 158 and *Vivek Dhan* 156) at farmers' field at *Gallibaseura* & *Chinona* villages and Experimental farm of the Institute during *kharif* 2018. Land races and improved varieties of target crops were also characterized for DUS grouping traits to facilitate their registration with PPV & FR Authority, New Delhi.

A field day was organized on March 27, 2018 at Experimental farm, ICAR-VPKAS, Almora with active participation of 18 farmers from *Chinauna* and *Gallibaseura* villages of target site in Almora district. During the exposure visit to trials of local Bhat, VL *Bhat* 201 and VL Soya 65 in black soybean; *Local Bhura Gahat*, VL *Gahat* 15 and *Local Black Gahat* in horsegram; Vivek *Dhan* 158, Vivek *Dhan* 156 and *Baurani local* in rice; *Golpahari local*, VL *Mandua* 315 and VL *Mandua* 324 in finger millet; *Safed Chua Local*, *Kala Chua Local* and VL *Chua* 44 in amaranth were most preferred by farmers based on grain colour, grain size, plant type, bearing and disease and insect pest reaction.

Field day conducted at Experimental Farm ICAR-VPKAS, Almora

6.4. DUS/GOT Trials

Farmer's varieties (FVs) in kidney bean (Reg/2018/1859, Reg/2018/2137, Reg/2018/2138 & Reg/2018/2182), soybean (Reg/2018/1708 & Reg/2018/1709), maize (Reg/2018/190, Reg/2018/202, Reg/2018/204, Reg/2018/222, Reg/2018/197, Reg/2018/195, Reg/2018/198, Reg/2018/199, Reg/2018/200, Reg/2018/209, Reg/2018/207, Reg/2018/211, Reg/2018/203, Reg/2018/212, Reg/2018/216, Reg/2018/217, Reg/2018/213, Reg/2018/221, Reg/2018/214, Reg/2018/185, Reg/2018/188, Reg/2018/189, Reg/2018/192 & Reg/2018/193) finger millet (Reg/2017/1690, Reg/2017/1691, Reg/2017/1692, Reg/2017/1693, Reg/2017/1694, Reg/2017/1695 & Reg/2017/1696), barnyard millet (Reg/2017/1697 & Reg/2017/1698) and foxtail millet (Reg/2017/1699) were raised for grow out test & characterized for DUS traits as per national guidelines for the conduct of test for DUS in respective crops.



Farmers' Varieties of (a) kidney bean (b) soybean (c) maize (d) millets under GOT during *Kharif* 2018

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)

Design, development and evaluation of light weight wheat thresher suitable for hilly areas

In Uttarakhand hills, after harvesting of wheat (full plant or plucking only earheads), farmers thresh the crop manually by beating with sticks or by bullock trampling, which is time consuming, labourious and uneconomical. Besides, good quality chopped wheat straw is not obtained from manual threshing. Transportation of large capacity tractor operated heavy threshers/machines in hilly areas is very difficult and to carry them to the undulating fields/ terraces in hills seems unfeasible. Also, more sophisticated machines are difficult to be adopted by the farmers because of high cost, weight, and 3-phase electric power requirement problems. Most of the wheat growing farmers are small /marginal and their socio-economic condition cannot afford big tractor operated threshers and they require low-cost and light weight wheat thresher. Keeping these points in view, ICAR-VPKAS has developed light weight Vivek Wheat Thresher suitable for hilly areas. The Vivek wheat thresher is 140 kg in weight (including 1.5 hp single phase electric motor) and has a capacity of 45 to 55 kg grains/hour. This can thresh the small volume of their produce and can also make good quality straw for their animals and will reduce the drudgery to the farmers.

Vivek Wheat Thresher

Adaptive trial on Soya processing unit

Farmers of the hilly region are ignorant about the improved post-harvest equipments and technologies.

The process of milk extraction, *Tofu (Soya Paneer)* making and *Badi* preparation from soybean were demonstrated to farmers/entrepreneurs using a commercially available soya processing machine. The machine fits well to the small-scale production system of hills and about 12 kg of *Tofu* can be prepared in 6 hours with 12 kg soybean per day and it requires about 2-man days. Comparative economics of *Soya* milk with that of *Tofu* (*Soya Paneer*) showed that *Soya* milk preparation from soybean resulted into relatively higher net returns (₹ 23,936) and B:C ratio (3.52) than *Tofu* preparation where net returns of ₹ 12,986 and B:C ratio of 2.37 was obtained (Table 6.5.1). Overall, Soya milk+Soya *Badi* preparation resulted into 1.5 times higher BC ratio than *Tofu*+*Soya Badi*. Farmers were very much convinced with soya processing machine for economic viability and feasibility among the hill farmers.

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

Development of portable plastic solar cabinet dryer for hilly region

The Institute has developed "Vivek Solar Dryer" to overcome the problem of damage to agricultural commodity/produce/food from birds, insects, monkeys and unexpected rainfall being faced during the conventional method of drying. The polycarbonate sheet used in the dryer is flexible and do not break easily like conventionally used glass. It has wheels and can be easily transported from one place to other. The dryer is fitted with solar operated exhaust fan and has three trays of different capacities. The agricultural commodity/produce/food can be dried using solar thermal energy in a cleaner and healthier way under hygienic conditions with zero operational cost. It can be used for drying

Demonstration of soya processing machine to the trainees

Table 6.5.1. Economics of *Soya* milk + *Soya Badi* and *Tofu* + *Soya Badi* using *Soya* Cow machine

Particulars	*Soya* milk + *Soya Badi*	*Tofu* + *Soya Badi*
Soybean used (kg)	150	150
Total fixed cost (Rs) @ Rs. 41.09 per day	514	514
Total variable cost (Rs) @ Rs. 60.00 per kg material used	9000	9000
Total cost (Rs)	9514	9514
Total milk/ *Tofu* prepared (liter or kg)	1200 lt milk	150 kg *Tofu*
Total *Badi* prepared (kg)	30	30
Selling price of *Badi* (Rs/kg)	75	75
Selling price of Milk or *Tofu*	Milk @ Rs 26 per lt	*Tofu* @ Rs 135 per kg
Returns from *Badi* (Rs)	2250	2250
Returns from milk or *Tofu* (Rs)	31200	20250
Gross reruns (Rs)	33450	22500
Net returns (Rs)	23936	12986
B:C ratio	3.52	2.37
Cost of milk & *Tofu*	Milk @ Rs 7.93 per lt	*Tofu* @ Rs 63.42 per kg

of perishable, semi-perishable and non-perishable agricultural commodities/produce/food and wet processed food material. The drying capacity of the drier is 5 to 20 kg per batch depending on the type of produce and its cost is ₹ 9,000/-.

The dryer will help marginal and poor farmers, who cannot afford hi-tech facilities and equipments to preserve their agricultural products and to eliminate the unwanted and unpredictable food spoilage due to lack of facilities in the region. The dried products can be stored for longer time in less volume. A successful enterprise can be run based on this principle, which can easily utilize the surplus produce facing the seasonal glut. In off seasons, the farmer can sell the dried products at higher price.

Portable plastic solar cabinet dryer for hilly region

Design and development of low-cost multiple use portable polyhouse for higher hills

In higher hills, it is difficult to find a single field or terrace of at least 100 m^2 or larger size. Even if the field or terrace of 100 m^2 size is available, then either it is narrow in width (2 to 5 m) or it is not straight in length (being curved in shape). Merging the two or more fields or terraces not only involves huge earth work but also increases the cost. It also raises the vertical height between two terraces. Rainfall in higher hills is very high and the temperature in the winter goes down, which reduces the plant growth. Being small fields or terraces, small size polyhouse structures can be very useful in these areas.

To overcome these problems, the Institute has developed a low cost portable polyhouse (62.4 m^2 surface area with 12.0 x 5.2 x 2.6 m) using GI pipes and MS angles and rods. The polyhouse is made up by joining 3 parts with the help of nut-bolts and can be easily shifted from one field/terrace to the other as per requirement. 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 having multiple use. The cost of this polyhouse is approx. ₹ 75,000/-

Low-cost multiple use portable polyhouse for higher hills

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

Change in species spectrum of scarab beetle catches in light traps in different years

The total beetle catches during 2017 & 2018 are very low compared to the last ten year catches. A significant reduction in number of *Anomala dimidiata* (the predominant species) and an increase in other species of Anomala was noticed. An increase in *Mimela fulgidivitata* and *Heteronychus lioderus* was observed (Table 6.5.2).

Table 6.5.2. Change in species spectrum of white grubs

White grubs	Per cent species composition (% of species with total catches)								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
Anomala dimidiata	58.4	67.2	63.1	79.9	78.8	85.6	44.3	16.4	6.64
Heteronychus lioderus	0.3	0.6	1.8	1.7	0.4	0.4	1.0	1.5	1.3
Mimela fulgidividata	0.8	1.1	1.2	1.0	0.9	1.2	1.6	2.3	2.1
Total number of beetles caught	17,965	18,021	18,261	26,700	26,171	54,329	18,578	5,200	7,466

Corelation between weather and light trap catches of Scarab beetles

A correlation of weather with the light trap catches of scarab beetles for the last 10 years was made. It was found that the maximum tempeature during May & June had a positive correlation with the incidence of white grubs. Temperature variation during winter months (December- February) was found to have a negative correlation with whitegrub occurrence. Rainfall during April and August was found to have detrimental effect on the incidence of white grubs.

Cytochrome oxidase I phylogeny of subtribe Anomalini from Uttarakhand Himalayas

The scarab tribe Anomalini contains one of the largest genera in the animal kingdom, the genus *Anomala,* some species of which are the major agricultural pests. To resolve the molecular phylogeny of seven major species, *i.e. A. dimidiata*, *A. rufiventris*, *A. lineatopennis*, *A. rugosa*, *Mimela fulgidivittata*, *Anomala* sp1 and sp2 in Uttarakhand Himalayas, mitochondrial cytochrome oxidase I (COI) gene was amplified and sequenced. BLASTn search of the obtained 679 bp region of COI gene revealed the identity of *A. dimidiata* and *A. lineatopennis* with percent similarity with the available sequences. However, the sequences for the remaing species were not available in NCBI. In all the species COI gene was A+T biased and showed differential codon usage between species. Phylogenetic analysis of COI sequences showed two major clusters one with *A. dimidiata*, *A. rufiventris*, *A. lineatopennis*, and *Anomala* sp1 and another with *A. rugosa*, *Anomala* sp2 and another anomalini species, *Mimela fulgidivittata* (Fig. 6.5.1). The realiability of the phylogenetic branching is also confirmed by separate branching of two out group species, *i.e.*, *Adoretus versutus* (an adoretini white grub species) and *Heliocverpa* (a lepidopteran species). The estimate of nucleotide substitutions between species was presented in Table 6.5.3. The nucleotide frequencies between species was estimated as 0.307 (A), 0.393 (T), 0.154 (C) and 0.145 (G). The transition/transversion rate ratios are 1.247 and 2.905 for purines and pyramidies, respectively with an overall transition/transversion bias of 0.69. Within the *Anomala* species, maximum genetic distance was found between *A. rufiventris* and *A. rugosa*; *Anomala* sps2 and *A. dimidiata* with pair wise genetic distance of 0.176 and 0.171, respectively. The study illustrates a complex genetic variation coupled with highly structured evolutionary divergences within species of *Anomala* and in tribe anomalini in large.

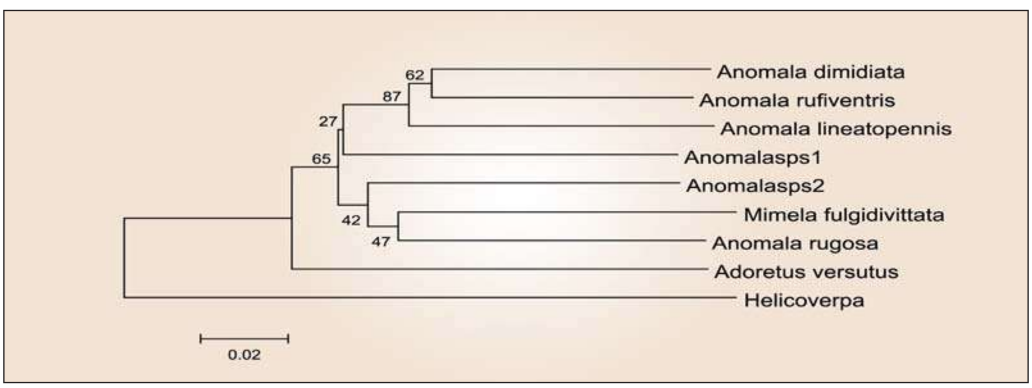


Fig. 6.5.1. Evolutionary relationships between subtribe, Anomalini resolved using Neighbor-Joining method (The evolutionary distances were computed using the Maximum Composite Likelihood method)

Table 6.5.3. Maximum composite likelihood estimates of the patterns of nucleotide substitutions

Nucleotides	A	T	C	G
A	-	*9.47*	*3.72*	**4.36**
T	*7.38*	-	**10.8**	*3.5*
C	*7.38*	**27.5**	-	*3.5*
G	**9.20**	*9.47*	*3.72*	-

Only entries within a row should be compared. Rate of different transitional substitutions are shown in bold and that of transversions are shown in italics.

6.5.4. Network Project on Organic Farming (NPOF)

Evaluation of organic, inorganic and integrated production systems

Organic and chemical amendments were evaluated for finger millet+black soybean–wheat+*toria* and grain amaranth–wheat+lentil under rainfed system. Among crop management systems, application of 100% N requirement of crop through farmyard manure produced highest wheat equivalent grain yield of 3535 and 8306 kg/ha for finger millet+black soybean–wheat+*toria* and grain amaranth–wheat+lentil, respectively (Fig. 6.5.2). The highest yielding treatment recorded 68 and 107% higher wheat equivalent grain yield of finger millet+black soybean–wheat+*toria* and grain amaranth–wheat+lentil, respectively compared to 100% inorganic management, respectively.

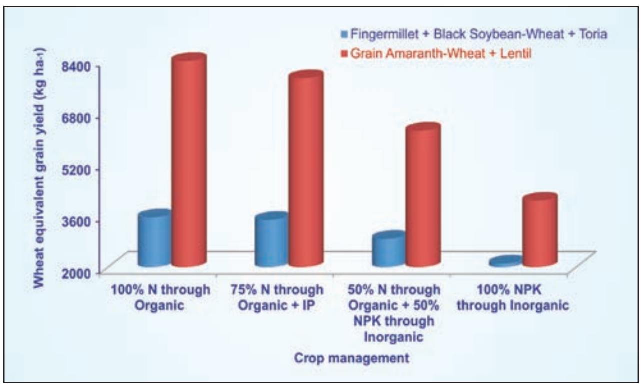


Fig. 6.5.2. Wheat equivalent grain yield of finger millet+black soybean–wheat+*toria* and grain amaranth–wheat+lentil in different crop mnagement system (IP = Innovative practices – 3% *Panchagavya* and vermiwash)

Before the start of the experiment, there was neither application of manure nor fertilizer to the soil. The land was used for grass multiplication. After three years' cropping, the soil organic carbon (SOC) increased from the initial (0.54% SOC). The increase (30%) was highest for 100% organic and lowest for inorganic management, which is almost equal to initial level (Fig. 6.5.3). The activity of 6 enzymes was estimated. Except urease, the activity of other enzymes was highest under 100% organic management system. But, for urease, the highest value was recorded under inorganic system.

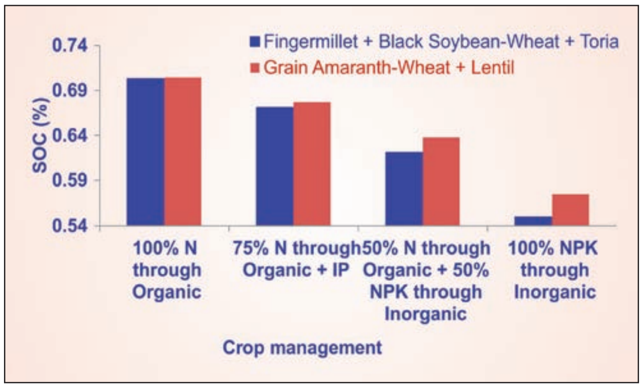


Fig. 6.5.3. Soil organic carbon of finger millet+black soybean–wheat+*toria* and grain amaranth–wheat+lentil in different crop mnagement system (IP = Innovative practices – 3% *Panchagavya* and vermiwash)

It is clearly proved that estimation of individual activity of different soil enzymes will not provide any clear information about overall productivity or sustainability of crops, as enzymes respond differently to different nutrient sources. Hence, soil enzyme activity index (SEAI) was developed to provide a single comprehensive unitless value.

The non-linear scoring was done based on highest activity recorded of individual enzyme from the best management practices in this region. The highest soil enzyme activity index was recorded under 100% organic management system, although the highest value of urease was recorded under inorganic system (Fig. 6.5.4).

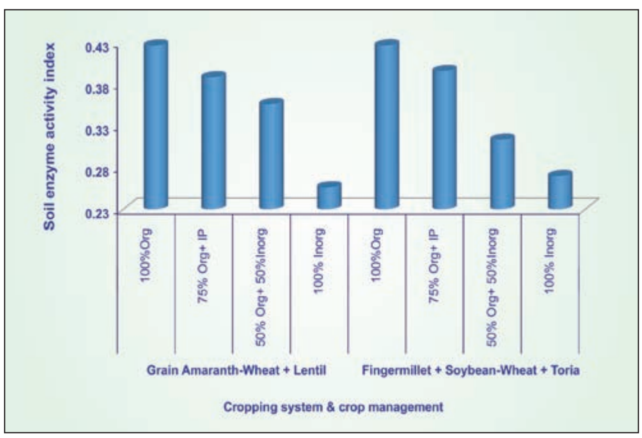


Fig. 6.5.4. Influence of cropping system and nutrient management on soil enzyme activity index

The soil temperature was recorded under different nutrient management system. The peak winter at Almora is during the first week of January. Hence, the soil temperature was recorded for seven days during first week of January. Wherever FYM is added, the minimum soil temperature is higher than inorganic system (Table 6.5.4). There is difference of about 1ºC, which is huge for the crop root. Contrary to this, the maximum soil temperature during peak winter was highest under inorganic and lowest under organic. The root of crop suffers badly due to lowest minimum soil temperature and highest diuranal difference of temperature during peak winter under inorganic management.

Evaluation of farm waste recycling techniques for organic farming

Farm wastes were composted with different proportion of raw materials and inoculation of different microbes and earthworm. The total fungal population was highest with inoculation of *Pleurotos sajorcaju+Trichoderma harzianum+ Biomineralizer+Aspergillus niger+Azotobacter spp.* to the 3:1:1 ratio of Cereal residue (CR): Cattle dung slurry (CDS): Legume residue (LR) (Table 6.5.5). The microbial count of *Trichoderma* spp. and *Aspergillus* spp. were highest with inoculation of *P. sajorcaju+T. harzianum* to the 3:1:1 ratio of CR:CDS:LR and *P. sajorcaju+T. harzianum*+Bio mineralizer+*Aspergillus niger+Azotobacter* spp. to the 4:1 ratio of CR:CDS, respectively. The highest microbial count treatment recorded 52, 59 and 49% higher population of total fungus, *Trichoderma* spp. and *Aspergillus* spp. compared to control treatment, respectively. Vermicomposting with the 3:1:1 ratio of CR:CDS:LR provided 30 and 5% higher microbial count of total fungus and *Trichoderma* spp. compared to control treatment, respectively. Addition of legume residue for preparation of composts from farm waste enhanced the total fungal and *Trichoderma* count.

Table 6.5.4. Influence of cropping system and nutrient management on soil temperature

Treatment		Morning (ºC)	Afternoon (ºC)	Temperature difference (ºC)
Grain amaranth–wheat+lentil	100% Org	11.2	14.0	2.8
	75% Org+IP	11.0	14.3	3.3
	50% Org+50% Inorg	10.9	14.6	3.7
	100% Inorg	10.4	15.1	4.7
Finger millet+black soybean–wheat+*toria*	100% Org	11.1	14.0	2.9
	75% Org+IP	11.0	14.4	3.4
	50% Org+50% Inorg	10.8	14.7	3.9
	100% Inorg	10.4	15.1	4.7

Org–Organic; Inorg–Inorganic; IP–Innovative practices (3% Panchagavya and Vermiwash)

Table 6.5.5. Microbial count of composts from farm waste

Treatment	Total fungal population (cfu/g)	Total *Trichoderma* spp. (cfu/g)	Total *Aspergillus* spp. (cfu/g)
Control (CR:CDS[µ] = 4:1)	3.24	2.05	1.11
Vermicompost (CR:CDS = 4:1)	3.99	2.10	1.02
Vermicompost (CR:CDS:LR = 3:1:1)	4.21	2.15	1.05
CR:CDS = 4:1+*Pleurotos sajorcaju+Trichoderma harzianum*	4.37	3.21	1.03
CR:CDS:LR = 3:1:1 + *P. sajorcaju+T. harzianum*	4.43	3.25	1.10
CR:CDS = 4:1 + *P. sajorcaju+T. harzianum*+[*]Biomineralizer+*Asper gillus niger+Azotobacter* spp.	4.85	3.05	1.65
CR:CDS:LR = 3:1:1+*P. sajorcaju+T. harzianum+ Biomineralizer+Aspergillus niger+Azotobacter* spp.	4.92	3.10	1.59

[µ]CR - Cereal residue; CDS - Cattle dung slurry; LR - Legume residue; [*]Biomineralizer = Microbial consortia of P & Zn solubilizer and PGPR

Field evaluation of botanicals and bioagents against toria aphids

An experiment was conducted in the field to evaluate the organic pest management options for the management of aphids in *toria*. Spray of botanicals and bio-agents were made at the time of peak incidence of aphids, which coincided with late flowering of the crop. 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 *toria* considerably. Nimbicidine spray 3 mL/L was found to reduce the aphid infestation by 17% (Table 6.5.6).

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 6.5.7. shows the sucking bug, *Chauliops choprai* infestation in the treatments. The pre-treatment counts showed severe infestation of sucking bug (3.00 to 4.00 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.

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

Treatment	PTC*	Pest reduction (%)					
		1 DAT	3 DAT	5 DAT	7 DAT	10 DAT	Average
Melia extract 5%	96	6.25	13.54	10.41	6.25	6.25	8.54
Artemisia 5%	93	3.22	13.97	13.97	10.75	7.52	9.88
Pine extract 5%	100	3.22	7.52	7.52	7.52	3.37	5.83
Nimbicidine 3mL/L	90	14.0	24.00	17.05	17.10	14.27	17.28
Metarhizium anisopliae 3g/L	86	7.50	10.75	10.75	7.52	7.50	8.80
Beauveria bassiana 3g/L	93	6.25	10.41	3.12	3.12	3.12	5.20
Acetamiprid 0.25g/L	97	65.6	79.16	83.33	86.45	89.58	80.82
Control	90	-3.25	-11.33	0.27	-9.27	-20.18	-8.75

*PTC- Pre-treatment count (% infestation in the tagged plants); DAT – Days After Treament

Table 6.5.7. Effect of organics on the management of sucking bug of soybean

Treatment	Number of sucking bugs					Per cent Reduction w.r.t. control
	PTC	2 DAT	5 DAT	7 DAT	Average	
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 Treament

The effect of organic pest management options on aphids of soybean is given in table 6.5.8. 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 from 9.67 to 15.45 aphids per plant. So, the treatment effects are not very clear in this experiment.

Table 6.5.8. Effect of organics on the management of aphids of soybean

Treatment	PTC	2 DAT	5 DAT	7 DAT	Average	Per cent 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	

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

Out of 62 zinc solubilizing bacterial isolates/ strains, 9 potential bacteria were screened on minimal medium amended with ZnO (0.1%) for solubilization index (SI) and solubilization efficiency (SE) for 5 days at 28°C. The highest zinc solubilization efficiency (SE) values were observed by *Pseudomonas* sp. CT4RH2(2) (380%) followed by isolate BFMRpN2 (328%) & *Pseudomonas poae* PB2RP1(2) (238%) after 6 days of incubation at 28°C. Maximum zinc solubilization index (SI) values were observed in *Pseudomonas* sp. CT4RH2(2) (4.80) followed by isolate BFMRpN2 (4.28) and *Pseudomonas poae* PB2RP1(2) (3.4) after 6 days of incubation at 28°C (Fig. 6.6.1). These potential zinc solubilizing isolates were grown in minimal liquid broth supplemented separately with zinc oxide, zinc phosphate and zinc carbonate in order to assess the magnitude of soluble Zn released in the medium in response to inoculation. Analysis of supernatants of *Pseudomonas* sp. CT4RH2(2), *Pseudomonas poae* PB2RP1(2) & isolate BFMRpN2 inoculated liquid medium amended with ZnO (0.1%) by AAS showed an increase in the concentration of soluble zinc up to values of about 29.2, 25.7 & 5.18 ppm, respectively after 8 days at 28°C under shaking conditions (150 rpm). During the time course of the experiment, bacterial proliferation occurred concurrently with a drop in the pH of zinc oxide supplemented cultures. The greatest range of pH fall occurred in zinc oxide-supplemented medium by three isolates were 3.81 to 5.12.

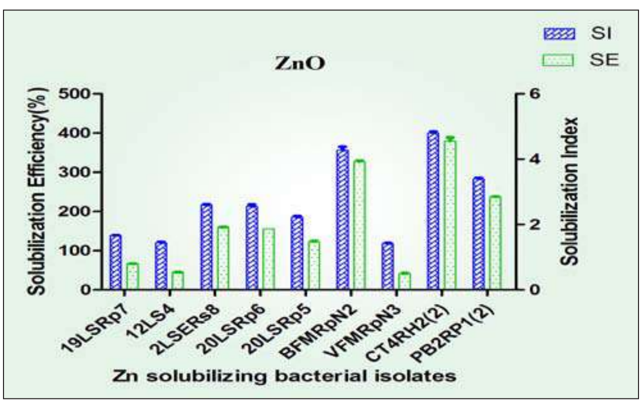


Fig. 6.6.1. qualitative screening of zine solubilizing bacterial isolates on zine oxide amended medium at 28°C

Out of 63 siderophore producing bacterial strains, 12 potential strains were further screened for SE and SI on CAS agar plates at 28°C. The SE and SI values ranged from 120 to 920% and 2.2 to 10.2, respectively after 5 days of incubation at 28°C. These 12 siderophore producing strains were grown in SSM medium to assess the production of siderophore. Spectrophotometric analysis of liquid medium supernatants of eight strains revealed the production of siderophore in the range of 140.6 to 392.1 μg/ml of siderophore. Radar diagram (Fig. 6.6.2) showed that *Pseudomonas* sp. RT5RP(2) produced maximum (392.1μg/ml) siderophore followed by *Pseudomonas* sp.CT4RH2(2)

(345.5µg/ml) and *Pseudomonas fragi* CS11RP4 (324.5µg/ml) after 72 hrs at 28ºC under shaking conditions (120 rpm) (Fig. 6.6.2). Dual plate culture technique was employed to access the compatibility among the selected zinc solubilizing and siderophore producing bacterial isolates/strains at 28ºC for the development of PGPR bacterial consortium.

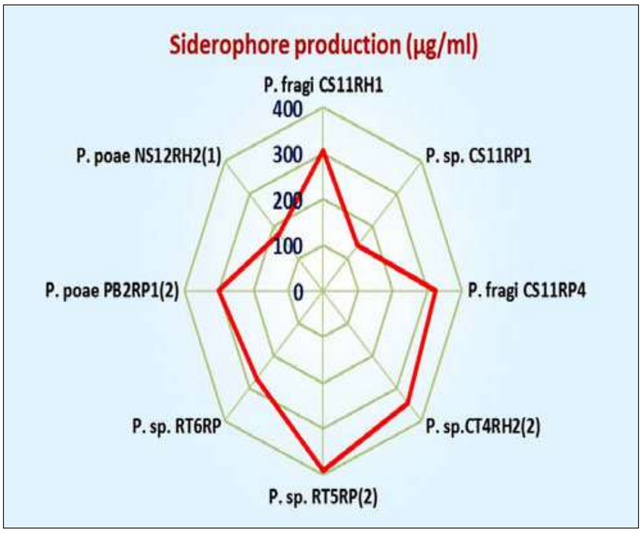


Fig. 6.6.2. Siderophore production in Sodium Succinate Medium by bacterial strains at 28ºC

6.7. ICAR-FCI Sponsored Project

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

The liquidation of all the 24 stacks of wheat and 24 stacks of rice was completed and fortnightly data on quality parameters, moisture content and 1000-grain weight and all other data including temperature and relative humidity recorded/ taken during the study was entered into the prescribed software and submitted to the Project Coordinator, AICRP on PHET. After three years of storage, there was loss of 0.02% in wheat, while the loss in rice was to the tune of 1.72%. Once the report of all the centres is compiled and analysed, the study will help in identification of the factors responsible for losses in storage and help in formulation of storage loss norms in different Agro-climatic regions/State with respect to various factors. The study will also suggest ways and means to reduce the extent of storage losses in different unit operations.

6.8. National Mission on Himalayan Studies (NMHS)

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

Three awareness and one farmers' training programme were conducted benefitting 120 farmers. Four land uses pattern [forest land (FL), grass land (GL), cultivated land (CL) & barren land (BL)] confirmed distinct effects on walkley black carbon (WBC), labile organic carbon (LOC), total carbon (TC), total nitrogen (TN) and carbon management index (CMI). Across the soil depth average, WBC, TC and TN concentrations were highest under forest land, followed by grass & cultivated land, and least in barren land. Non-labile carbon (NLC), labile carbon (LC), lability index (LI) and carbon pool index (CPI) also followed similar trends as WBC, TC and TN. Overall, TC and TN concentrations decreased markedly with increase in soil depth under FL, GL, CL and BL, while in case of LOC in the barren land, similar values were obtained in the 0–30 cm depth.

Different land uses had different impact on carbon and nitrogen stability and decomposition. Forest land had significantly higher C:N ratio at the depth of 0–45 cm than soil of grass land, barren land. The lowest CN ratio was recorded under cultivated land. The highest and lowest CMI were recorded under forest and barren land, respectively. While forest and grass land effectively enhance WBC, TC, TN, CMI, carbon and nitrogen sequestration, and reduce soil C:N ratio. The carbon and nitrogen sequestrations significantly greater for forest land followed by grass, cultivated and barren land use system. Conversely, cultivated and barren land had relatively weak effect on TC and TN sequestration by forming WBC.

Among all four-land use systems, forest land sequestered higher carbon and nitrogen in the top layer of the soil than 15–30 and 30–45 cm soil depths. The depth distribution of WBC, TC and TN were impacted by different land use systems, which may influence the potential nutrients supply to crop/plant. Forest and grass land system, which promoted litter fall/root residues in the soil may

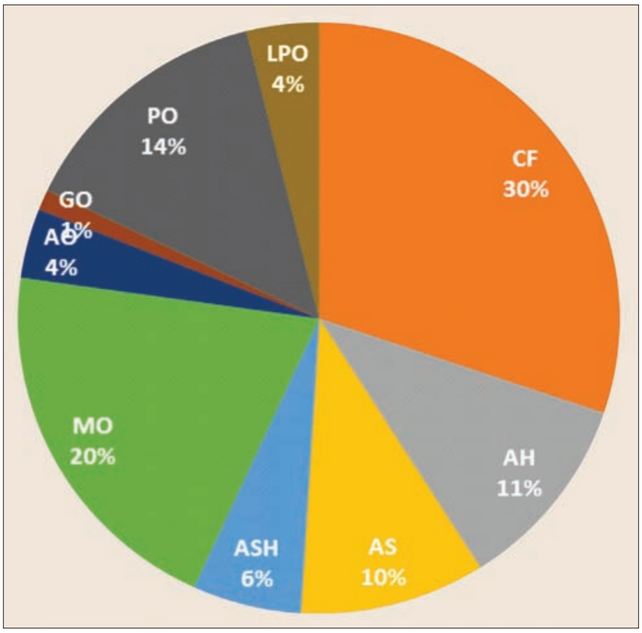


Fig. 6.8.1. Biomass carbon sequestration contribution of different land use system

PO- Peach orchard; LPO- Lemon-pomegranate orchard; CF-Chirpine forest; AH- Agri-horticulture; AS- Agri-silviculture; ASH- Agri-silvi-horticulture; MO- Mango orchard; AO- Apple orchard; GO- Guava orchard

have beneficial impacts on soil fertility through maintenance of carbon and nitrogen storage in the Indian mid-Himalayan ecosystem. The LUS management is necessary for increasing soil carbon and nitrogen stocks, and the research on the carbon and nitrogen storage of different LUS is required for making future policies and strategies on land use planning and management. The high carbon and nitrogen losses upon deforestation of natural forest and potential for carbon and nitrogen storage upon cultivated and grass land abandonment stress the importance of carefully assessing ongoing and future land use system changes. Hence, conservation and restoration of natural ecosystems in addition to incorporation of tree components on cultivated, barren and grass land system will enhance soil quality and sustainability.

The study was conducted in Uttarkashi district of Uttarakhand to assess above ground biomass and carbon stock in different land uses. The chirpine forest (CF) recorded significantly higher vegetation biomass carbon (106.4 Mg/ha) compared to agri-silviculture (35.1 Mg/ha), agri-silvi-horticulture (28.6 Mg/ha), lemon-pomegranate orchard (13.6 Mg/ha), apple orchard (13.5 Mg/ha) and guava orchard (3.9 Mg/ha). However it was at par with mango orchard (71.8 Mg/ha), peach orchard (49.3 Mg/ha) and agri-horticulture (38.1 Mg/ha). Thus, these land uses are not only remunerative to the farmers, but also contributing towards tapping of atmospheric CO_2 vis-à-vis mitigation of greenhouse gases (Fig. 6.8.1).

6.8.2. Strategies to Improve Health and Nutriotional Status of Hill Farmwomen through Technological Interventions

Two project sites (Pithoragarh and Uttarkashi) were selected for studying dietary pattern and nutritional status of women. Anthropometric measurements of women were recorded that includes weight, height, skin fold measurements, blood pressure and pulse rate. The extent of malnutrition in women was assessed by computing the Body Mass Index (BMI). Average BMI of respondents was 21.3 kg/m² with standard deviation of 3.3. On the basis of BMI, Chronic Energy Deficiency (CED) was calculated and the overall age combined prevalence of CED was 21.5%. Out of these, 2.6%, 3.5% and 15.5% belonged to CED grade III, CED grade II and CED grade I categories, respectively. Majority of women received medium dietary diversity score with 4-5 food groups only. Average vegetable consumption by women farmers was found to be 163.6 g/day which is 45 per cent less than Recommended by Indian Council of Medical Research (ICMR). ICMR recommends 300 g/day vegetable consumption by women, which includes 50 g roots & tubers, 50 g green leafy vegetables (GLV) and 200 g other vegetables. Consumption of roots and tubers was 119% higher than RDA, whereas consumption of GLV and other vegetables were 42.4% and 87.3% less than RDA, respectively.

Anthropometric measurements of women in hills

Medium to low dietary diversity score and low BMI of hill farm women emphasized the need of location specific nutrition related intervention. The concept of "nutri-garden" was introduced in two project locations in high hills of Uttarakhand to promote consumption of nutritious foods by cultivating them locally. There are different vegetables that can be grown in a plot of 100 to 200 m² in hilly areas which are rich source of nutritional bio-active compounds. They are the important sources of vitamins, minerals, antioxidants, folic acid and dietary fibers. More than 50 nutri-gardens are being demonstrated with plot size of 100 to 200 m² for different seasons with active participation of farm women. During *kharif* 2018, eight type of vegetables were introduced in nutri-garden along with package of practices. Average production of vegetable in a 100 m² size nutri-garden was found to be 82 kg during first *kharif* season which can meet vegetable demand of a family of 5 member for 55 days. It was found that crop damage by wild animal, unavailability of quality seeds and white grub infestation as the major problems in the project locations. Fencing of nutri-gardens were done along with installation of light traps to manage the damage by animals and white grubs, respectively. During *rabi* 2018-19, ten different types of vegetables were introduced in nutri-garden along with mushroom production to meet protein requirement of farm women. A three days training programme on "*Poshan Vatika mein adhik utapadan hetu unnat taknikiyan*", two exposure visits were conducted for farm women at ICAR-VPKAS, Almora and two trainings were conducted at KVK, Chinyalisaur.

Baseline data collection and site selection

Awareness campaign on balanced diet

Training cum demonstration on mushroom cultivation

Distribution of drudgery reducing gender friendly small agricultural tools

Field visit alongwith farmers

Demonstration of nursery preparation at farmers' field

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

Relation between rainfall and yield

The relationship between yield and rainfall was computed in view of fluctuations in yield and rainfall observed in last decades. The rainfall data of 13 years (2004-2016) was collected from IMD website for three districts i.e. Dehradun, Nainital and Tehri Garhwal of Uttarakhand. The relationship between yield and rainfall was carried out by grouping yield in two groups, *i.e.*, the yield of wheat was grouped into- A (yield below average) and B (yield more than average of 13 years) and the rainfall received was also averaged separately for the respective groups (Fig. 6.9.1 & 6.9.2).

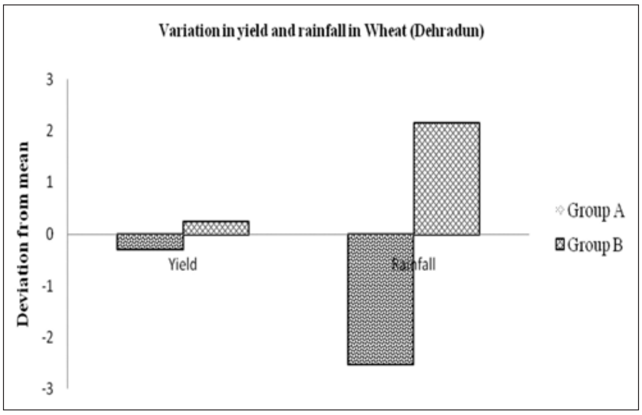


Fig 6.9.1. Variation in wheat yield and rainfall in Dehradun

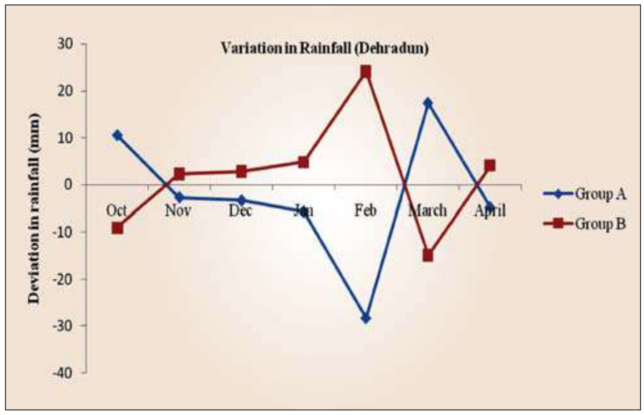


Fig 6.9.2. Monthly rainfall variation in low and high yield years in Dehradun

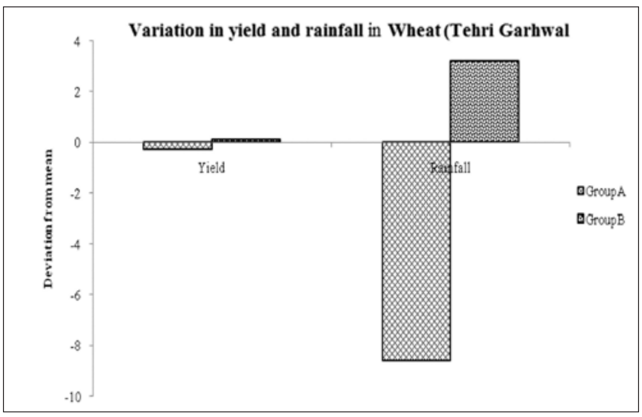


Fig. 6.9.3. Variation in wheat yield and rainfall in Tehri Garhwal

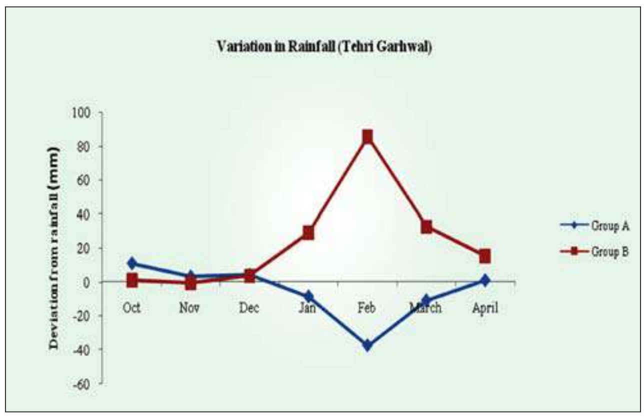


Fig. 6.9.4. Monthly rainfall variation in low and high yield years in Tehri Garhwal

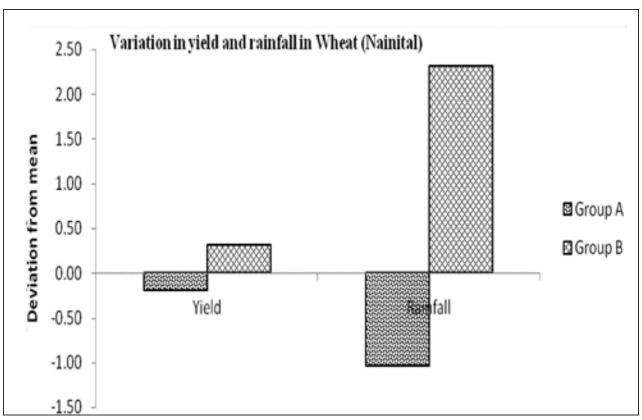


Fig. 6.9.5. Variation in wheat yield and rainfall in Nainital

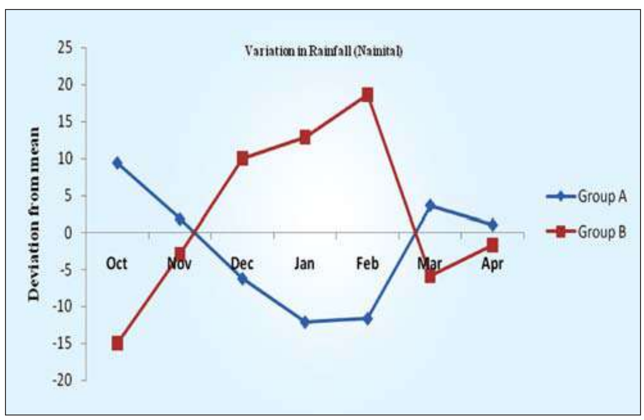


Fig. 6.9.6. Monthly rainfall variation in low and high yield years in Nainital

The month wise rainfall analysis revealed that the higher yield years (Group B) received higher rainfall than the average rainfall in their respective months over 13 years (2004-2016), whereas lower yielder years (Group A) received lower rainfall in different months. The variation of rainfall was examined across season of wheat (vegetative and reproductive stage) in three districts depicted in Fig. 6.9.2, 6.9.4 and 6.9.6. The wheat yield was mostly affected due to the variation in rainfall during January and February in comparison with other months. The rainfall and yield analysis of Dehradun district revealed that the lower rainfall years resulted in lower yields and vice versa. Similar results were observed for Tehri Garhwal and Nainital districts also (Fig. 6.9.3 & 6.9.5).

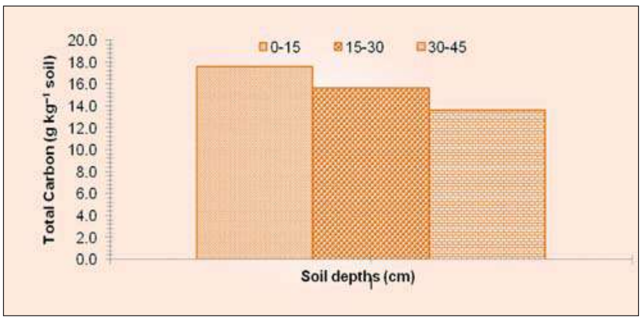


Fig. 6.9.7. Total carbon of 109 composite soil samples for each soil depth under selected

A total of 327 composite soil samples were collected from 109 sampling sites with three soil depths. After soil processing, these soil samples were analysed for different soil parameters. The selected village area was further divided on the basis of eleven dominant cropping systems. These were finger millet–wheat, maize–wheat, rice–wheat, rice–vegetable, vegetable–vegetable, horse gram–lentil, horse gram–wheat, barnyard millet–lentil, finger millet–lentil, soybean–wheat and soybean–lentil.

TC is the organic fraction of soil exclusive of non-decomposed plant and animal residues. It was reported that the TC concentration in different soil depths of the ecosystem ranged from 15.90 to 17.98, 13.63 to 16.10 and 11.71 to 14.22 with 0-15, 15-30 and 30-45 cm soil depth, respectively. The representative mean of the soil depth was 16.98, 15.03 and 13.28 g/kg with 0-15, 15-30 and 30-45 cm soil layers, respectively (Fig. 6.9.7).

In the adopted village, Jur-Kafun, a total of 195 kg seeds of *rabi* crops, *i.e.*, wheat, barley, lentil was distributed in the year 2017-18 which covered an area of 2.30 ha. The data revealed that wheat yield of different varieties was 19% to 21% lower than rain-fed yield and 48% to 54% lower than irrigated yield of experimental farm but 37-42% more than the state average yield. The barley yield was 28.57% lower than experimental farm yield but 27.33% more than the state average yield. However, in case of lentil, the yield is 18.79% and 144.56% more than the experimental farm and state average yield, respectively.

Demonstration of polytank and nethouse

During *kharif* season 2018, a total of 105 kg seed of rice, maize, finger millet, barnyard millet, *gahat*, soybean, bean and amaranth were distributed to the farmers and cover an area of 4.72 ha. Ten polythene lined tanks of total capacity 304.35 m^3 were constructed during 2018 which can irrigate about 0.61 ha of area through flood irrigation in one filling. In order to improve the yield of the crops and protect them from the wild animal damage, a poly cum shed net house of an area 75.6 m^2 with a very low cost was constructed leaning to one side of the terrace riser. The yield for tomato, okra and capsicum was 175.0, 127.3 and 90.9 q/ha by the application of FYM, respectively.

In addition to the prior eight low tunnels, three more low tunnels were established at the farmers' field. They were advised to grow nursery and leafy vegetables like coriander, spinach, lahi, fenugreek, etc. to fully utilize the low tunnels in order to increase productivity. The data related to the yield of crops (fenugreek, coriander) grown in the low tunnels was recorded. The data analysis revealed that the yield of fenugreek and coriander were 32.5% and 51.5% more than open field yield, respectively.

A survey on the incidence of pests in the adopted village was done. Medium to high infestation (11-38%) of fruit flies in cucurbits and low to medium infestation of bean pod borer (6%) were noticed. Scarab beetles like, *Anomala lineatopennis, Holotrichia seticollis* and *H. longipennis* were found to get attracted and caught in the light trap during the month of June. *Anomala lineatopennis* was found to occupy 31% of total scarab beetle catches through VL whitegrub beetle traps in the village during June. Fruit flies are controlled by installing cue lure traps in cucurbits. Honeybee, *Apis cereana* boxes (5 colonies) are being maintained.

Crops grown in the low tunnel

One day skill training on apiary management was organized for the interested farmers of Jur kafun on 24th August 2018 at experimental farm, Hawalbagh. Two lectures as well as practical training sessions were organized. The 14 beneficiaries (8 women and 6 men) attended bee management training.

With the aim of increasing nutritional status of farm women and men and to enhance the income of farmers from allied sources, demonstrations about the processing of soybean, which is widely grown in the village was given to the villagers of Jur Kafun. The villagers, especially the farm women were informed about the nutritional qualities of soybean, soymilk, *paneer* and a variety of products that can be made from it. The process of making soymilk and paneer from soybean was demonstrated to villagers with easily available equipments and materials, *i.e.* mixer grinder and citric acid/lemon.

Skill training on apiary management

Demonstrations of soymilk production

Demonstrations of Vivek Millet Thresher cum pearler

A demonstration of Vivek millet thresher-cum-pearler was given to a group of farm women at Jur-Kafun for reducing the drudgery related to manual threshing of barnyard millet *(madira)*. They were also informed about the nutritional qualities of millets and its potential health benefits. To improve the livelihood status of farm women, information about the millet-based value-added products and their market demand such as bakery and pasta products, millet vermicelli and instant food mix, flaked and popped products were provided to encourage the villagers to adopt millet-based livelihood.

Adaptation Policy Research

Information on existing policies, programmes and schemes related to climate change adaptation in agriculture in the states of Uttarakhand, Jammu & Kashmir and Himachal Pradesh were collected through primary and secondary sources. The reviewed information is summarised and presented in the table related some of the key issues, their adaptation strategies and related schemes/programmes initiated by central and state government to facilitate climate change adaptation in agriculture (Table 6.9.1).

Table 6.9.1. Issues and adaptation strategies

Issues/ constraints	Strategies	Ongoing schemes
Lack of sufficient water for irrigation	• Adoption of water conservation methods • Rainwater harvesting • Construction of poly tanks • Use of efficient method of irrigation like drip and sprinklers.	❖ Integrated watershed management programme, ❖ Pradhan Mantri Krishi Sinchayee Yojana, ❖ National Water Mission, ❖ National Mission on Sustainable Agriculture, ❖ On Farm Water Management, ❖ National Innovations on Climate Resilient Agriculture, ❖ Accelerated Irrigation and Flood Management Programme, ❖ Groundwater Management and Regulation Scheme, ❖ Rajiv Gandhi Micro-Irrigation Scheme
Increased pest and disease infestation	• Integrated pest and nutrient management programme	❖ National Mission on Agricultural Extension and Technology ❖ National Mission on Oilseeds and Oil Palm ❖ National Food Security Mission
Extreme weather conditions	• Timely weather forecast and early warning system • Weather-based agro-advisories at the farm level • Disaster relief mechanisms and funding	❖ Agro-Meteorological Services Programme ❖ Flood Forecasting ❖ Numerical Modelling of Weather and Climate
Lack of accessibility of farm inputs and advanced technologies	• Building proper extension infrastructure and dissemination of suitable technologies to farmers	❖ National Mission on Agricultural Extension and Technology ❖ National Innovations on Cimate Resilient Agriculture ❖ Rashtriya Krishi Vikas Yojana ❖ National Food Security Mission ❖ National Mission on Oilseeds and Oil Palm

Low farm income	• Diversification to high value crops • Integrated farming/enterprise diversification • Value addition • Improved market access and building rural infrastructure	❖ e-National Agriculture Market Scheme ❖ Price Stabilization Scheme ❖ Integrated Scheme for Agricultural Marketing ❖ Agri-Tech Infrastructure Fund ❖ Paramparagat Krishi Vikas Yojana ❖ National Project on Promotion of Organic Farming ❖ Mission for Integrated Development of Horticulture ❖ Mega Food Parks ❖ Cold Chain Value Addition and Preservation Infrastructure ❖ Pradhan Mantri Gram Sadak Yojana ❖ Deen Dayal Upadhyaya Gram Jyoti Yojana
Crop loss due to adverse impact of climate change (erratic rainfall and variations in temperature)	• Promotion of micro-irrigation methods like drip and sprinklers, • Improving irrigation and drainage infrastructure, • Water harvesting infrastructure at farm level and community level • Use of short-duration varieties • Shift to less water intensive crops like millets and pulses • Crop diversification to reduce the risk of crop failure • Crop insurance • Access to credit	❖ National Mission on Sustainable Agriculture ❖ National Innovations on Climate Resilient Agriculture ❖ Pradhan Mantri Fasal Bima Yojana ❖ Weather Based Crop Insurance Scheme ❖ Interest Subvention Scheme for Short-Term Crop Loans ❖ Kisan Credit Card Scheme
Lack of employment opportunities and labour migration	• Creation of opportunities for off-farm and non-farm employment	❖ National Rural Livelihood Mission ❖ Pradhan Mantri Kaushal Vikas Yojana ❖ Mahatma Gandhi National Rural Employment Guarantee Scheme ❖ Prime Minister's Employment Generation Programme ❖ National Dairy Plan ❖ Dairy Entrepreneurship Development Scheme ❖ Development of Inland Fisheries and Aquaculture.

6.10. DST Funded Projects

6.10.1. Habitat Management for Non-Apis Bee Pollinator Conservation (SERB YSS 00861/2015)

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

Impact of honeybee introduction on native non-Apis bees

Honeybees (*Apis cerana* and *A. mellifera*) were introduced in *toria* and radish fields and impact, if any, on the non-Apis bee foraging was studied.

The average presence of non-Apis bee in the honeybee introduced fields of *toria* (0.96 bees/m^2/min) is almost same as that of the non- introduced fields (0.94 bees/m^2/min). In case of radish, a few sand bees were found foraging in the honeybee introduced field than the non-introduced fields. Honey bee introduced and non-introduced radish harboured an average of 0.14 and 0.47 sand bees/m^2/minute, respectively. This reveals a competition between the native sand bees (*Andrena* sp.) and the introduced honeybees in radish fields.

Managing flora and providing nesting sites

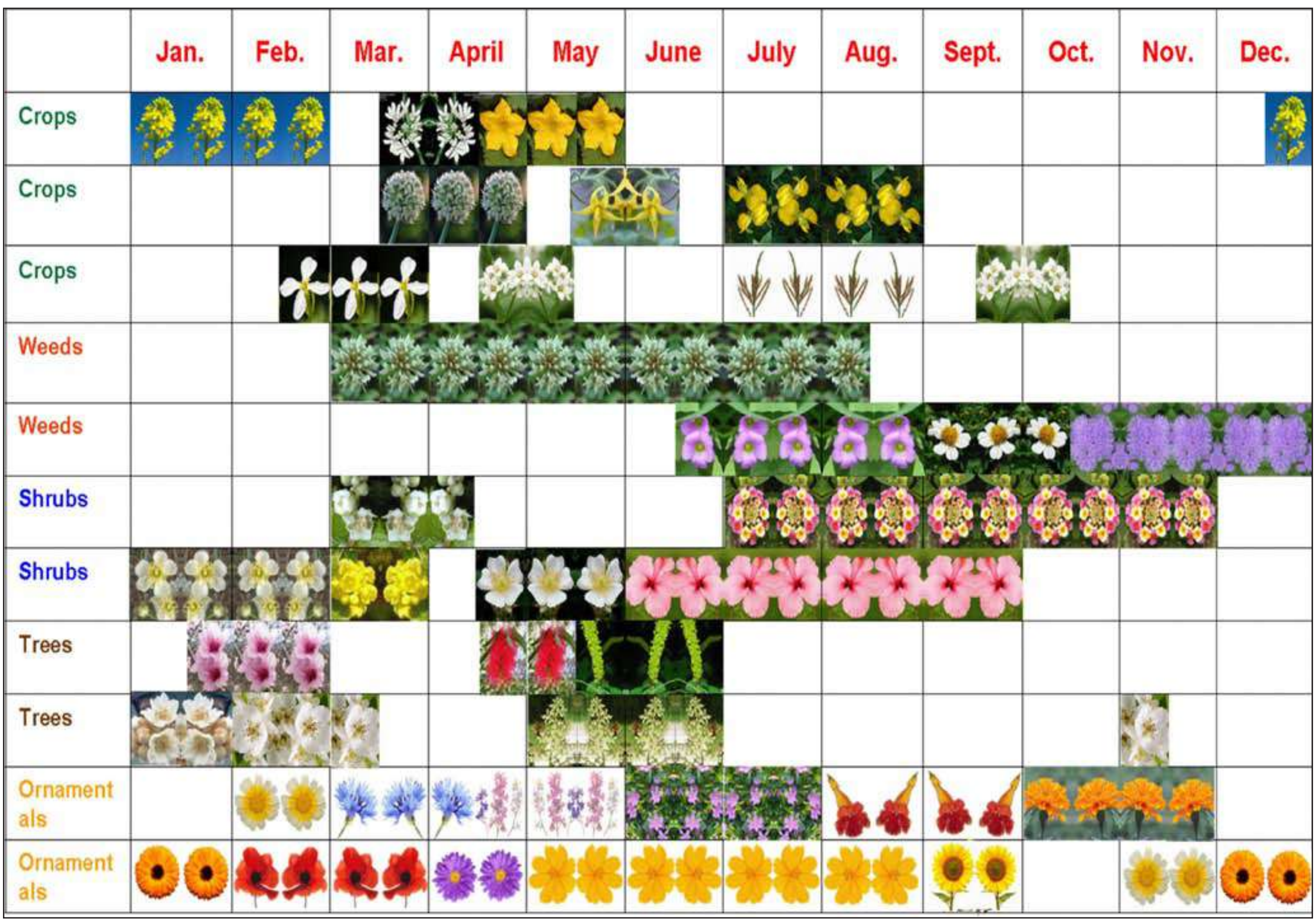
Floral calendar of cultivated crops, natural vegetation and trees and ornamental plants was made for throughout the year foraging of different non-Apis bees. Nesting sites with sticks of *Morus alba*, *Grewia optiva*, *Jacaranda mimosifolia*, *Lantana camara* etc. of pith size of 2.8 to 3.8 mm were provided for nesting of three different Ceratina bees. Nesting sites were provided in forest areas and urbanized areas to find any difference in the number of native bees occupying the stick nests.

6.11. NABARD Funded Project

6.11.1. Formation and Promotion of Farmers' Producer Organisation

Under the project, an exposure visit showcasing and sale of agri products by Farmer Producer Organisation (FPO) at *Kisan Mela* was organised. One market exposure visit of farmers was organized

Collective marketing of vegetables through FPO



Floral calendar for bee pollinator conservation to Haldwani *mandi* and Rudrapur for collective purchase of seeds, fertilizers and pesticides through FPO. *Krishak gosthis* were organized for mobilizing farmers towards importance of FPO and collective marketing. During the year 2018-19, FPO carried out collective purchase and selling of vegetables of more than four lakh rupees. *Tuta absoluta* infestation was found in the crops, especially in tomato crop in the area for the first time. Farmers in consultation with scientists of ICAR-VPKAS followed control measures collectively and were able to save their crops in time with no major loss. FPO purchased 7 quintal seeds of improved Potato variety *Kufri Himalini* from the institute and distributed among FPO members. Biocontrol agents (*Bacillus cereus* WGPSB 2, *Trichoderma* 202 and *Trichoderma* 28) were distributed among FPO members as a measure of pest management.

6.12. Department of Agriculture & Cooperation (DAC)

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

Laboratory bioassays were conducted to estimate toxicity of phosphine on the adults of important storage pests like *Sitophilus oryzae*, *Rhyzopertha dominica* and *Tribolium castaneum.* Phosphine was generated using standard procedure and assayed in specially designed desiccators with phosphine concentration monitoring mechanism. The test insects were exposed to different concentrations of phosphine and for three different exposure periods of 24, 48 and 72 hours. Mortality data was taken after the exposure period and the insects were kept in insect growth chamber for 7 days to confirm the mortality. The mortality data was subjected to Abbott's correction and then Probit Analysis using EPA Probit Analysis Program Ver. 1.5 (Table 6.12.1).

The median lethal concentration of phosphine to lesser grain borer, *R. dominica* was 1.100 mg/L

Bioassay on phosphine with modified desiccator

Table 6.12.1. Acute toxicity of phosphine to different storage pests at different exposure periods

Insect	Exposure period (h)	LC_{50} (mg/L)	Fiducial limits of LC_{50}		Equation Y=a+bx	Chi square
			Lower limit	Upper limit		
Rhyzopertha dominica	24	1.100	0.907	1.311	Y=4.90+ 2.28±0.32x	5.76
	48	0.733	0.586	0.884	Y=5.33+2.49±0.37x	6.56
	72	0.316	0.226	0.439	Y=5.73+1.46±0.21x	5.67
Sitophilus oryzae	24	0.391	0.286	0.501	Y=5.74+1.82±0.24x	3.35
	48	0.183	0.128	0.254	Y=6.16+1.58±0.25x	1.80
	72	0.077	0.054	0.105	Y=6.83+1.64±0.26x	1.03
Tribolium castaneum	24	0.227	0.157	0.314	Y=5.93+1.44±0.21x	0.83
	48	0.113	0.076	0.160	Y=6.26+1.34±0.19x	1.52
	72	0.062	0.045	0.083	Y=7.41+1.99±0.37x	0.38
Trogodema granarium	24	2.594	2.225	3.037	Y=3.38+3.89±0.71x	0.85
	48	0.938	0.730	1.145	Y=5.09+ 3.57±0.83x	2.34
	72	0.682	0.532	0.839	Y=5.52+ 3.16±0.56x	5.61

at an exposure of 24 hours. When the exposure increases the toxicity also increases and the LC_{50} value reached 0.733 and 0.316 mg/L for 48 and 72 hr exposures, respectively. The khapra beetle (*T. granarium)* was found to be most resistant of all the four important storage insect pests tested with LC_{50} value of 2.594 mg/L for 24 hr exposure. The most susceptible insect pest was red flour beetle *(T. castaneum)* in which 50% of the insects were found dead when exposed to a concentration of 0.062 mg/L phosphine for 72 hours. Same kind of bioassays were conducted with test insects, which are provided with wheat grains (food) while treatment. The test insects (*R. dominica* and *S. oryzae)* were found to have some resistance when fed with wheat grains, while exposed to phosphine than those of the starved ones.

High Altitude Testing Site (HATS), Mukteshwar

Yield evaluation trials

French bean: Twenty new genotypes (advance lines) were evaluated with three checks (VL Bean 2, Arka Suvidha and Pant Anupama) for their suitability to high altitude in randomized block design during *kharif* 2018. VLFB 1612 (107.3 q/ha) & VLFB 1630 (105.7 q/ha) were found promising during off season cultivation in high altitude.

Garden pea: Fourteen new genotypes of garden pea (advance lines) were evaluated for their suitability to high altitude during off season in randomized block design during *kharif* 2018. VP 1516 and VP 1517 produced 99 q/ha and 95 q/ha green pod yield, respectively.

Breeder seed production

Onion & Garlic: Breeder seed crop of VL *Piaz* 3 and VL *Lahsun* 2 (long day garlic) have been grown in 1000 and 500 m^2 area as planting materials and produced 4.5 and 5 q bulb, respectively and supplied to the institute.

Truthful labelled seed

Total 20 q truthfully labelled planting materials of potato (*Kufri Girdhari & Kufri Himalini*) were produced at HATS, Mukteshwar during 2018-19.

Seed crop of *Kufri Himalini*

Seed treatment of potato

Onion bulb production of VL *Piaz* 3

Breeder seed production of VL *Lahsun* 2

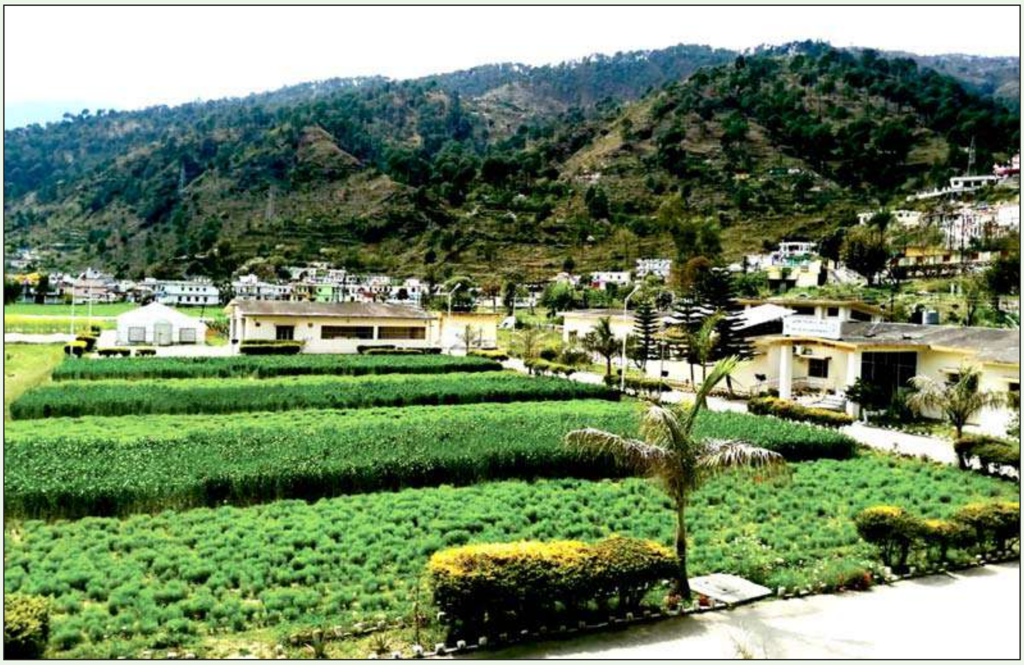
Field view of farm

On-going Infrastructure Development Work

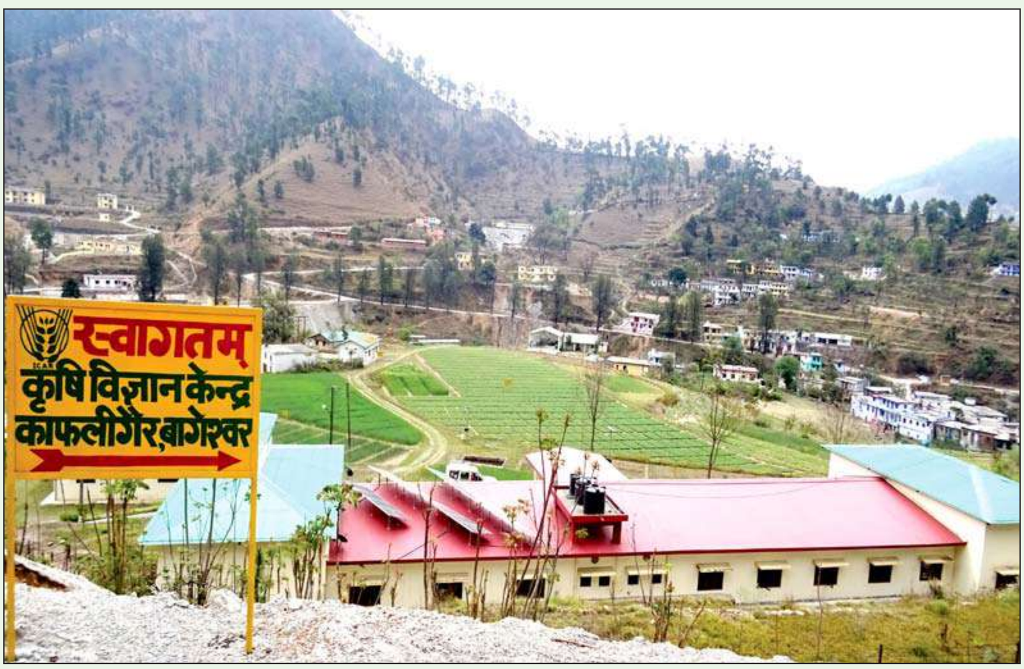
An 80 cubic meter capacity polytank was constructed during 2018-19 at the HATS Mukteshwar to cater the needs of the water requirement of the experiments/trials.

Eighty cubic meter polytank at HATS Mukteshwar

7. Technology Assessment and Transfer



Krishi Vigyan Kendra, Chinyalisaur, Uttarkashi



Krishi Vigyan Kendra, Kafligair, 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 & 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, Uattarkashi

7.1.1. Trainings

Krishi Vigyan Kendra, (ICAR-VPKAS), Chinyalisaur, Uttarkashi conducted 63 training programmes for the practicing farmers, farm women, and rural youths on various topics in the disciplines of horticulture, home science, agricultural extension with an objective to uplift the socio-economic status of underprivileged farmers through improvement in agriculture production and allied enterprises. These trainings were attended by total 1763 participants (730 male and 1033 female) (Table 7.1.1).

7.1.2. On Farm Trials

Six on farm trials (OFTs) on (i) management of Marssonina blotch in apple orchards, (ii) effect of zinc sulphate on yield and quality of potato, (iii) management of Stemphylium blight in onion, (iv) assessment of effectiveness of mobile messaging and (v) social media (Whatsapp) in bridging the information needs of the vegetables growers and (vi) assessment of effectiveness of nutritional practices for correcting malnutrition and nutritional kitchen gardening were conducted (Table 7.1.2).

Table 7.1.1 Discipline wise training programme conducted by KVK, Chinyalisaur

Discipline	No. of courses	No. of participants		
		Male	Female	Total
Horticulture	24	359	321	680
Home Science	20	82	421	503
Agricultural Extension	13	180	248	428
Sponsored Training Programme	6	109	43	152
Total	**63**	**730**	**1033**	**1763**

Table 7.1.2. On farm trials conducted

Year 2018-19	Crop/ Variety	Farmers
Management of Marssonina blotch (*Marssonina coronaria*) in apple orchards.	Apple / Red Delicious	10
Effect of zinc sulphate on yield and quality of potato.	Potato/ Kufri Jyoti	5
Management of Stemphylium blight in onion during seed production.	Onion/ VL Piaz-3	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

7.1.3. Front Line Demonstrations

Front line demonstration on oilseed, pulses, other crops were conducted at the farmers' field in an area of 48.0 ha during *Kharif* 2018 and *Rabi* 2018-19. A total of 801 farmers were benefitted (Table 7.1.3).

Table 7.1.3. Front line demonstration conducted during *kharif* 2018 & *rabi* 2018-19

Crop/ livestock	Variety	Area/ Nos.	No. of farmers
Kharif 2018			
Pigeon pea	VL *Arhar*-1	10.0	159
Horse gram	VLG-19	2.0	26
Soybean	VL-47/63	1.0	15
Maize	VL CM-31	3.5	96
Finger millet	VL-324	5.0	55
Okra	VL *Bhindi*-2	2.0	77
Napier	CO3	2.0	35
Total		25.5	463
Rabi 2018-19			
Pea	Vivek *Matar*-11	1.0	20
Lentil	VL-514, 126	10.0	120
Wheat	VL-829,892,907	10.0	166
Oat	Kent	1.0	17
Onion	VL *Piaz*-3	0.5	15
Total		22.5	338

7.1.4. Seed Production

A total of 35.02 quintal seeds and 1,70,800 seedlings were produced at KVK farm.

7.1.5. Other Extension Activities

- ***World Health Day*:** The KVK organized World Health Day on April 7, 2018. During the programme, essay competition was conducted, in which 29 college students participated.
- ***World Environment Day*:** The KVK organized World Environment Day on June 5, 2018 in which 29 students and farm women participated.
- ***Webcast of Prime Minister's Interaction*:** The KVK organized the web casting of Hon'ble Prime Minister's interaction with farmers of the country at KVK campus on June 20, 2018 in which 103 farmers participated.
- ***International Yoga Day*:** The KVK organized the International Yoga Day on June 21, 2018.
- ***Webcast of Prime Minister's Interaction with SHGs*:** KVK organized the web casting of Hon'ble Prime Minister's interaction with women SHGs of the country at KVK campus on July 12, 2018 in which 56 farmers and farm women participated.
- ***Breastfeeding Awareness Week*:** KVK celebrated the Breastfeeding awareness week from August 1 to 7, 2018 in which 95 participants participated.
- ***Plantation Drive*:** Plantation drive was organized on the occasion of Independence Day on 15th August 15, 2018 in which more than 300 plants were planted in KVK campus and surrounding areas.
- ***Parthenium Awareness Week*:** The KVK celebrated Parthenium awareness week from August 16 to 22, 2018.
- ***National Nutrition Week*:** The KVK celebrated National Nutrition week from September 1 to 7, 2018 in which total 72 participants participated.
- ***Hindi Pakhwada*:** The KVK celebrated Hindi *Pakhwada* from September 14 to October 13, 2018 in which 21 participants participated.
- ***Swchatta Hi Sewa Hai*:** The KVK organised *Swchatta* hi sewa hai programme from September 15 to October 02, 2018. Total 47 participants participated in the programme.
- ***Gandhi & Shashtri Jayanti*:** Gandhi & Shashtri Jayanti was celebrated at KVK along with *Swchatta hi sewa hai* programme on October 02, 2018. Total 25 participants participated in the programme.
- ***Scientific Advisory Committee*:** The KVK organized 14th Scientific Advisory Committee meeting on October 6, 2018.
- ***Mahila Krishak Diwas*:** The KVK celebrated *Mahila Krishak Diwas* on October 15, 2018 in which total 35 participants participated.
- ***Vigilance Awareness Week*:** The KVK organised Vigilance Awareness Week from October 29 to November 03, 2018. During the week, different programmes were organized by KVK, Chinyalisaur.

- ***Quinquennial Review Meeting*: **Quinquennial Review meeting held on December 03, 2018.
- ***Pre-Rabi Sammelan cum World Soil Day*: **The KVK organized Pre-*Rabi Sammelan* cum World Soil Day at KVK campus on December 05, 2018. A total of 113 soil health cards were distributed to farmers and more than 170 farmers participated in the programme.
- ***Swachhta Pakhwada*: **The KVK celebrated *Swachhta Pakhwada* from December 16 to 31, 2018. During the campaign, different programmes like discussions, sanitation drives, rallies, lectures, competitions, etc. were organized by KVK, Chinyalisaur.
- ***Kisan Diwas*: **The KVK celebrated *Kisan Diwas* on December 23, 2018 at Mahrgaon village with the farmers of the surrounding villages.
- ***Skill Development Training*: **The KVK organized 34 days (200 hrs) training for Assistant Gardener at KVK campus from Jan., 21 to Feb., 28, 2019 in which 20 candidates participated.
- ***Skill Development Training*: **The KVK organized 34 days (200 hrs) training for Agriculture Extension Service Provider at KVK campus from Jan., 21 to Feb., 28, 2019 in which 20 candidates participated.
- ***Pradhan Mantri Kisan Samman Nidhi Yojna*: **The KVK organized Live telecast of *Pradhan Mantri Kisan Samman Nidhi Yojna* on February 24, 2019.
- ***Rural Agriculture Work Experience (RAWE)*: **Eleven B.Sc. Agriculture students joined KVK, Uttarkashi for Rural Agriculture Work Experience (RAWE).
- ***Kisan Mela*: **KVK participated and awarded 1st Prize in the kisan mela organized by ILSP-*Aajivika* Project at Uttarkashi on February 15-16, 2019.
- ***Gram Swaraj Abhiyan*: **The KVK participated in *Gram Swaraj Abhiyan–Kisan Kalyan Diwas* organized in different blocks of Uttarkashi *viz.* Bhatwari, Chinyali, Dunda and Purola by the Department of Agriculture. Total 536 farmers were benefitted by the programme.
- ***Republic Day*: **KVK celebrated 70th Republic Day on January 26, 2019.
- ***News Paper Coverage*: **25 KVK activities were covered in various daily local and national newspapers.

Training for Assistant Gardener

Awareness on soil health among children

Training for Agriculture Extension Service Provider

***Pre-Rabi Sammelan cum* World Soil Day**

Exposure visit of students at KVK, Chinyalisaur

KVK participated in Kisan Mela organized by ILSP-Aajivika

Webcast of Prime Minister's interaction at KVK

Demonstration on low chilling varieties of apple at KVK

***Swchatta hi sewa hai* programme conducted by KVK**

KVK Participated in Spring festival at Dehradun

7.2. Krishi Vigyan Kendra, Bageshwar

7.2.1.Trainings

The KVK, Kafligair, Bageshwar organised 71 training programmes including 19 sponsored training programmes with the participation of 1429 farmers (785 males, 644 females) on various topics (Table 7.2.1).

Table 7.2.1. Training Programmes conducted during 2018-19

Discipline	No. of trainings	No. of Trainees		
		Male	Female	Total
Animal Science	14	187	97	284
Plant Protection	15	177	125	302
Horticulture	12	151	49	200
Home Science	11	60	199	259
Sponsored training	19	210	174	384
Total	71	785	644	1429

Dr Rajveer Singh Director ATARI interacting with farmers

Rice field day

7.2.2. Front Line Demonstrations

Front Line Demonstrations (FLD's) on various crops in *kharif* 2018 and *rabi* 2018-19 were conducted on 67.58 ha (33.23 ha in *kharif* and 34.35 ha in *rabi*) benefitting 2241 farmers (Table 7.2.2). Under FLD on backyard poultry farming, five hundred chicks were distributed to 25 farmers. The FLDs resulted in increasing average yield of various crops from 10.7 to 48.6 per cent in various hill crops.

7.2.3. On Farm Trials

Six on farm trials (OFTs) on (i) effect of plant growth regulators (ii) pinching on yield and quality of Kiwifruit, (iii) effect of integrated management techniques on citrus decline, (iv) integrated pest management for wilt and nematodes in pigeon pea, (v) efficacy of chemical and biological agents for management of Anthracnose disease of chilly, (vi) assessment of effect of non-clinical treatments on control of Mastitis in cows and assessment of effect of non-clinical treatment in control of anoestrous condition in post calving buffaloes were conducted (Table 7.2.3).

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

Crop	Variety	Area (ha.)	No. of beneficiaries
Kharif 2018			
Cereals & Millets	VL *Dhan* 62, 65, 85 & Vivek *Dhan* 154, Pusa Basmati 1509, VL *Mandua* 347, 324 & PRJ1,	16.99	478
Oil seeds	VL Soya 47, VL Soya 65	5.38	206
Pulses	VL *Arhar1* & VL *Gahat*10	8.8	271
Vegetables	Okra (VL *Bhindi* 2), Cauliflower (Snowcrown F1) & Cabbage (Varun F1)	1.0	113
Fodder	Maize (African Tall) & Sorghum (MP Chari)	1.06	62
Sub-total		33.23	1130
Rabi 2018-19			
Cereals & Millets	VL Gehun-829, 832, 892, 907 & 953,VL Barley 118 & 130	10.50	280
Oil seeds	Ts 67, Pant *Pili Sarson* 1	10.0	225
Pulses	VL *Masoor* 126 & PL8	9.63	270
Vegetables	Arkil & GS 10, VL *Piaz* 3 & ALR	2.2	240
Fruits	Peach (Red June)	0.25	11
Kitchen garden	Japanese white, Pant Haritima, Pant Ragini, All green, Hathikan	0.6	28
Animal Science	Poultry Chebro	500 Chicks	25
Fodder	Oat JHO822, Berseem Meskavi	1.17	32
Sub-total		34.35 ha & 500 Chicks	1111
Grand Total		67.58 ha & 500 Chicks	2241

Table 7.2.3. On farm trials conducted

Year 2018-19	Farmers
Effect of plant growth regulators and pinching on yield and quality of kiwifruit	5
Effect of integrated management techniques on citrus decline	5
Integrated pest management for wilt and nematodes in pigeon pea	10
Efficacy of chemical and biological agents for management of anthracnose disease of chilli	5
Assessment of effect of non-clinical treatments on control of Mastitis in cows	15
Assessment of effect of non-clinical treatment in control of anoestrous condition in post calving buffaloes	15

7.2.4. Production of Seed and Bio-products

During 2018-19, a total of 32.61 q quality seed, 1,24,800 vegetable seedlings, 160 q vermicompost and 7192 L milk were produced by KVK, Kafligair and a total revenue of Rs 9.37 lakhs was generated.

7.2.5. Other Extension Activities

- ***Farmers Field Days:*** KVK, Kafligair organized 4 field days on wheat (VL *Gehun* 953), soybean (VL *Soya* 65), paddy (PB 1509) and Pigeon pea (VL *Arhar* 1) crops and 132 farmers were benefitted.
- ***Krishak Gosthi and* Farmer's Feedback Programme*:*** A *Krishak Gosthi* and Farmers feedback programme was organized on the visit of Shri. Ajay Tamta, Hon'ble Minister of State for Textiles, Government of India and Shri Chandan Ram Das, Member of Legislative Assembly, Uttarakhand on August 25, 2018. A *Krishak Gosthi* and farmer's feedback programme was also organized during the visit of Dr. Rajveer Singh, Director, ICAR-ATARI, Zone I, Ludhiana at KVK, Kafligair on May 16, 2018.
- ***Webcast of Prime Minister's Interaction with SHGs:*** A live webcast of Hon'ble Prime minister's interaction with SHGs was organized at KVK, Kafligair on July 12, 2018 in which 40 progressive farmers and farm women participated.
- **Pre-*rabi Kisan Sammelan, Krishak Gosthi* and World Soil Day:** KVK Kafligair, Bageshwar organized *Pre-Rabi Kisan Sammelan and Krishak Gosthi, 2018* and World Soil Day on December 5, 2018 in which 150 soil health cards were distributed to farmers. On the occasion of *krishak gosthi*, farmers' produce exhibition, soil health card distribution and quiz competition were conducted.
- ***Institute QRT visit at KVK, Kafligair*:** Institute QRT visited KVK, Kafligair on December 06, 2018.
- **National Nutrition Week:** KVK, Kafligair celebrated National Nutrition Week during September 1-7, 2018. During the programme, awareness compaign and distribution of Mini Seed Kit of vegetables was done.
- **Breast Feeding Week*:*** KVK Kafligair celebrated Brest feeding week programme during August 1-7, 2018. Awareness programmes were organised through trainings, *gosthis* and poster competition to educate the village women.
- **Parthenium Awareness Week** (16-22 August 2018), **Vigilance Awareness Week** (29 October-03 November 2018) ***Swachata Pakhwada*** (15 September- 02 October 2018 and December 16-31, 2018) and ***Kisan Diwas*** (December 23, 2018) were also organized at KVK, Kafligair.
- **Agriculture Education Awareness Programme:** KVK, Kafligair organized 10 agriculture education awareness programmes during 2018-19 for creating awareness about career opportunities in agricultural science among school students.
- **Stall Exhibition at *Uttarayani Mela*, Bageshwar:** KVK, Kafligair participated in *Vikas Pradarsani* at *Uttarayani Mela* during Januray 14-21, 2019 and awarded second prize.
- **Stall Exhibition at *Hilance Kisan Mela*, Bageshwar:** KVK Kafligair participated in *Hilance Kisan Mela* during February 12-13, 2019 and awarded first prize.

7.3. Institute Headquater

7.3.1. Trainings Organized

Institute organised 23 trainings and 21 exposure visits for farmers, agricultural officers benefitting 1413 (598+815) persons during 2018-19 (Table 7.3.1).

Table 7.3.1. Trainings organized for farmers at the Institute

Topic	Block/ district	Duration	Coordinators	No. of Trainees
Trainings				
Farmers Participatory Variety Selection Programme	Block – Dhauladevi & Hawalbagh District - Almora	April 26, 2018 (1day)	Drs. Lakshmikant and D.C Joshi	8
Training programme on *Kharif Fasalon ki Unnat Utpadan Takniken* under ATMA Project, Pauri Garhwal	Block - Jaharikhal, Rikharikhal, Dugadda. District- Pauri Garhwal	May 7-9, 2018 (3 days)	Drs. D.C Joshi and R.S Pal	30
Summer Training Programme for B.Sc (Ag.) Students	Banaras Hindu University, Varanasi	May 15-18, 2018 (4 days)	Drs. J. Stanley, D. Mahanta and V.S. Meena	30
Training Programme on Jaivik Kheti Sponsored by Directorate of Agriculture, Govt of U.P.	Block – Hasanpur, Dhanota, Syohara District – Amroha, Bijnor, UP	May 21-25, 2018 (5 days)	Drs. D. Mahanta, R.S. Pal, Kushagra Joshi and V.S. Meena	34
Training Programme on *Sanrakshit Kheti* under HMNEH Project	Block – Hawalbagh, Takula, Dhauladevi, Sult, Tarikhet and Syalde District - Almora	June 1-2, 2018 (2 days)	Drs. Chaudhari, G. Vasudev, Hanuman Ram and R.S. Pal	24
Training Programme on *Mushroom Utpadan* sponsored by Department of Agriculture, Tehri Garhwal, Uttarakhand	Chamba, Kirtinagar, Dev Prayag, Jonpur, Tholdhar, Narendra Nagar Distt. – Tehri Garhwal	July 16-18, 2018 (3 days)	Dr. K.K. Mishra	29
Training Programme on *Gair krishigat udhyamo se janjatiy mahilaon ki aay mein vraddhi* under TSP	Block – Kalsi, Dasoli, Sitarganj and Munshyari Distt.- Dehradun, Chamoli, Udham Singh Nagar and Pithoragarh	August 1-15, 2018 (15 days)	Dr. Kushagra Joshi	16
Training Programme on *Sabjiyon ki unnat utpadan takniki* under TSP	Block - Chakrata Distt. - Dehradun	August 23-25, 2018 (3 day)	Drs. N.K. Hedau and Kushagra Joshi	25
Training Programme on *Maun Palan*	Block – Hawalbagh Distt. – Almora	August 24, 2018 (1 day)	Dr. Kushagra Joshi	14
Training Programme on *Parvatiya kshetron mein krishi avam gair krishigat udhyamon se krishak aay mein vraddhi* under TSP	Rajori (Jammu)	September 06-09, 2018 (4 days)	Drs. R.K. Khulbe and Kushagra Joshi	30
Training Programme on *Kadanna fasalon ka katai uprant prabandhan*	Distt.- Tehri Garwal, Dehradun, Nainital, Almora	September 18, 2018 (1 day)	Drs. Sher Singh and Jitendra Kumar	30
Training Programme on *Kadanna fasalon ka Katai uprant prabandhan*	Distt.- Pauri Garhwal, Champawat, Pithoragarh, Bageshwar,	September 19, 2018 (1 day)	Drs. Sher Singh and Jitendra Kumar	25

Topic	Block/ district	Duration	Coordinators	No. of Trainees
Training Programme on *Unnat uttpadan takniki me kisano ki aay mein vraddhi* under TSP	Block – Kalsi Distt. - Dehradun	September 25-27, 2018 (3 days)	Drs. B.M. Pandey and Kushagra Joshi	38
Training Programme on *Unnat utpadan takniki mein kisano ki aay mein vraddhi* under TSP	Block – Chakrata Distt. - Dehradun	September 27-29, 2018 (3 days)	Drs. B.M. Pandey and Nirmal Hedau	32
Training Programme on *Bemausami sabji utpadan avam polyhouse prabandhan*	Block – Bhatwari, Gorshali, Natin and Barsu Distt. - Uttarkashi	October 2-4, 2018 (3 days)	Dr. Chaudhari, Ganesh Vasudev	20
Training Programme on IPM Major Hill Crops Sponsored by Directorate of Extension, Ministry of Agriculture and Farmers Welfare, GoI	Uttarakhand, Himachal Pradesh, Arunachal Pradesh, Kerala and Sikkim	October 3-10, 2018 (8 days)	Dr. J. Stanley, A.R.N.S. Subbanna and Rajashekara H.	20
Training Programme on *Bemausami sabji utpadan avam polyhouse prabandhan*	Block - Bhatwari District - Uttarkashi	December 21-23, 2018 (3 days)	Dr. Chaudhari Ganesh Vasudev	29
Training Programme on *Kaushal vikas sukshm sinchai taknikiyan*	Block – Hawalbagh, Dwarahat, District - Almora	December 27, 2018 to January 25, 2019 (30 days)	Dr. Jitendra Kumar	20
Training Programme on *Kaushal vikas mushroom utpadank*	Block – Hawalbagh, Dwarahat, Takula, Bageshwar, District – Almora, Bageshwar	February 01, 2019 to March 02, 2019 (30 days)	Dr. K.K. Mishra	17
Training Programme on *Parvatiy fasalon ka beejotpadan avam kirshigat udyam* under ICAR Seed Project	Block- Bhaisiyachana District – Almora	February 14-16, 2019 (3 days)	Drs. Renu Jethi and Hanuman Ram	24
Training Programme on *Janjatiy krishakon ka beejotpadan mein kaushal vikas* under TSP	Block- Sitarganj District – Udham Singh Nagar	February 19-21, 2019 (3 days)	Drs. Chaudhri, G.V, Hanuman Ram and Devender Sharma	34
Training Programme on *Parvatiy fasalon ka beejotpadan avam krishigat udyam* under TSP	District- Lahaul Spiti	February 25 to March 01, 2019 (5 days)	Drs. Renu Jethi and Chaudhari Ganesh V	48
Training Programme on *Poshan vatika mein adhik utpadan hetu unnat takneekiyan* under NMHS Project	Block- Berinag District – Pithoragarh	March 11-13, 2019 (3 days)	Drs. Renu Jethi, Ankita Kandpal and Sushil Kumar	21
Exposure Visits				
Students, Govt Junior High School, Salyudi, Gineli and Gainar	Block - Garur District - Bageshwar	April 02, 2018	Drs. Nirmal Chandra, R.P. Yadav and V.S. Meena	104
Students, Govt Junior High School, Payya and Chaurson	Block – Bhaisiyachhana District - Almora	April 06, 2018	Dr. Nirmal Chandra	30

Topic	Block/ district	Duration	Coordinators	No. of Trainees
Students, Govt Junior High School, Balta	Block – Hawalbagh District - Almora	April 09, 2018	Dr. Nirmal Chandra	32
Students, Govt Junior High School, Saural, Chhitar and Dorakhal	Block – Tarikhet District - Almora	May 05, 2018	Dr. Ramesh Singh Pal	18
Students, Govt Junior High School, Melgaun	UNISED Unit of Science and Education Devlopment	May 05, 2018	Dr. Nirmal Chandra	66
IFS Officers, ATI Nainital	A T I Nainital	May 09, 2018	Dr. Nirmal Chandra	35
Student, Govt Junior High School, Mateena	Block – Garur District - Bageshwar	May 18, 2018	Mr. L.D. Milkani	50
Student, Govt Junior High School, Jethai	Block – Bageshwar District - Bageshwar	May 22, 2018	Mr. L.D. Milkani	38
Student, Govt Junior High School, Chauwatta	Block – Bageshwar District - Bageshwar	May 25, 2018	Dr. Subbanna A.R.N.S	27
Farm women under NMHS project	Block-Berinaag, Distt.-Pithoragarh	May 30, 2018	Dr. Renu Jethi	22
Himalayan Action Research Center (HARC)	Block – Pokhari District - Chamoli	June 20, 2018	Dr. J.P. Aditya	19
Hans Foundation, Pindari Valley, Bageshwar	The Hans Faundation, Pindari Valley, Bageshwar	August 22, 2018	Dr. J.P.Aditya	15
Kumaon University Students	S.S.J Campus, Almora	September 30, 2018	Dr. J. Stanley	29
Students from Vivekananda Inter College Ranidhara, Almora	Block - Hawalbagh District - Almora	November 20, 2018	Dr. Nirmal Chandra	24
Students from Govt Inter College, Devlikhet, Almora	District – Almora	February 05, 2019	Dr. Ramesh Singh Pal	62
Students from Govt Inter College, Devlikhet, Almora	District – Almora	February 06, 2019	Dr. Manoj Parihar	63
Students from Govt Inter College, Lodhiya, Almora	Block- Hawalbagh District – Almora	February 11, 2019	Dr. Dibakar Mahanta and Er. D.C. Mishra	125
Students from Govt Inter College, Kathapuriya, Almora	Block- Hawalbagh District – Almora	February 13, 2019	Dr. Dibakar Mahanta and Er. D.C. Mishra	37
Students from Govt Uchatar Madhyamik Vidyalaya Raun-Dal, Almora	Block- Hawalbagh District – Almora	February 23, 2019	Dr. Ramesh Singh Pal	30

Topic	Block/ district	Duration	Coordinators	No. of Trainees
Students from Govt Inter College Jainoli, Almora	Block- Tarikhet District – Almora	February 25, 2019	Dr. Ramesh Singh Pal	72
Students from Govt Uchatar Madhyamik Vidyalay Talar, Almora	Block- Hawalbagh District – Almora	February 23, 2019	Drs. Nirmal Chandra and Kushagra Joshi	19

7.3.2. Front Line Demonstarations

To assess the performance of newly released varieties of small millets, soybean, rice, wheat and maize hybrid at farmer's field, front line demonstrations (FLDs) were conducted in a total of 42.1 ha area across the state benefitting more than 400 farmers.

Soybean/ black soybean

Under AICRP on soybean, frontline demonstrations of improved soybean and black soybean varieties with recommended package of practices for the cultivation were conducted in 4.86 ha area involving 111 farmers at village Raun-Dal of Almora district during *kharif* 2018. In FLDs, VL Soya 59 (1875 kg/ha), VL Soya 47 (1907 kg/ha) and VL Soya 77 (1956 kg/ha) and black soybean variety VL Bhat 201 (1275 kg/ha) yielded higher than local traditional cultivars by 29.19, 28.03, 26.03 and 50.19%, respectively. As per Benefit-Cost ratio, cultivation of improved black soybean (0.80) variety was found more profitable than soybean (0.74) varieties and comparatively more economic returns are realised from black soybean (₹ 40,122) than soybean (₹ 33,251) cultivation in hills.

Results exhibited more technology gap (Yield gap I) for soybean (687 kg/ha) as compared to black soybean (225 kg/ha), whereas, extension gap (Yield gap II) had not much difference for soybean (413 kg/ha) and black soybean (421 kg/ha). As per technology index, cultivation of improved varieties of black soybean (15.0) was found more feasible as compare to improved yellow soybean (26.44) cultivars in hills. A field day on soybean was organised at Raun-Dal village on September 20, 2018 benefitting 102 farmers.

Glimpses of soybean FLDs and field day at Raun-Dal village of Almora district

Millets

Frontline demonstrations of four improved varieties of finger millet (VL *Mandua* 324, VL *Mandua* 352, VL *Mandua* 376 and VL *Mandua* 379) and two varieties of barnyard millet (VL *Madira* 172 and VL *Madira* 207) were conducted in 11 ha and 2.02 ha area, respectively, in two districts (Almora and Nainital) of Uttarakhand. Results of high yielding cultivars under FLDs during *kharif* 2018 are given in table 7.3.2.

Finger millet field day was organized at Tipola village of Almora on September 17, 2018. Around 100 farmers participated in this field day.

Wheat

Frontline demonstration of improved wheat variety VL *Gehun* 953 was conducted in 8.0 ha area of 3 villages (Supai, Bajuoli, Amshyari) of Almora district benefitting 130 farmers. In these areas,

Seed distribution to farmers

Weedicide spray in FLD fields with farmer's participation

Finger millet field day at Tipola

Field view of improved and local wheat variety

Table 7.3.2. Economics of millet FLDs

Cultivar	Grain yield (kg/ha)	Fodder yield (kg/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C ratio
VL *Mandua* 352	1983	4233	34705	63282	28577	0.82
VL *Mandua* 324	1725	4450	34705	62106	27401	0.78
VL *Mandua* 376	2654	3987	34705	64534	29768	0.85
VL *Mandua* 379	2743	4323	34705	65467	28654	0.82
Mean	**2278**	**4248**	**32956**	**63847**	**28600**	**0.81**
Farmers' practice	**1424**	**3876**	**35486**	**52346**	**20345**	**0.57**
VL *Madira* 172	1423	2718	28645	48517	23456	0.82
VL *Madira* 207	1654	2654	28645	46786	22456	0.78
Mean	**1538**	**2686**	**28645**	**47651**	**22956**	**0.80**
Farmers' practice	**1134**	**2254**	**30934**	**47377**	**13475**	**0.28**

Field view of improved varieties of wheat crop in farmers field

improved variety (VL *Gehun* 907 and VL *Gehun* 953) has shown significant yield advantage of 40.5 per cent over local check variety. Cost Benefit ratio was 1:1.9 and 1:1.6 for demonstrated improved wheat variety and local check variety, respectively. It was found that wheat FLD programme had a positive impact over the existing local varieties.

Rice

Frontline demonstrations of rice variety, VL *Dhan* 68 was conducted during *kharif* 2018 among 24 farmers in 3.7 ha area of 3 villages of Almora District. The average yield of 4,355 kg/ha was recorded and overall yield advantage of improved cultivar was 31.71% over local checks *viz.*, Taichung, China 4 and Thapachini. A rice field day was also organized at Baari village on October 04, 2018 to sensitize the farmers of the locality for improved varieties of rice.

Field view of improved varieties of wheat crop in farmers field

Maize

Frontline demonstrations of VMH 45 were conducted in Dhanpau-Lakhwad tribal cluster (block Kalsi, district Dehradun) in 12.5 ha during *kharif* 2018. In the demonstrations, VMH 45 recorded average yield of 52.4 q/ha, which was 66.3 per cent higher than the local cultivar Dhanpau Local (31.6 q/ha). Maize Field Days were organized at Dhanpau (Dehradun) on July 15, 2018 and September 15, 2018.

Field days organised on Maize


Maize production at Dhanpau village

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 villages and take latest technologies to the doorstep of the farming community. Under this programme, 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 for the wholistic development of village clusters.

Demonstration of VL solar Dryer in Khunt village

Installation of drip irrigation system in Salla Rautela village


Field monitoring for plant diseases and insects in Jageshwar cluster in Almora district

Scientist-Farmers interaction meeting at Bhikiyasain block of Almora district

Vegetable seedlings distribution in villages of Hawalbagh block

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 record radio talks on various aspects of hill agriculture beneficial to farmers at AIR, Almora. The programme is broadcasted every Sunday at 6 PM, from All India Radio, Almora, Uttarakhand. In the year 2018-19, fifty-two talks were recorded and broadcasted covering information pertaining to cereal crop production technologies (19%), crop protection (15%), natural resource management (13%), income generation related aspects (11%) and horticulture crop production techniques. 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.

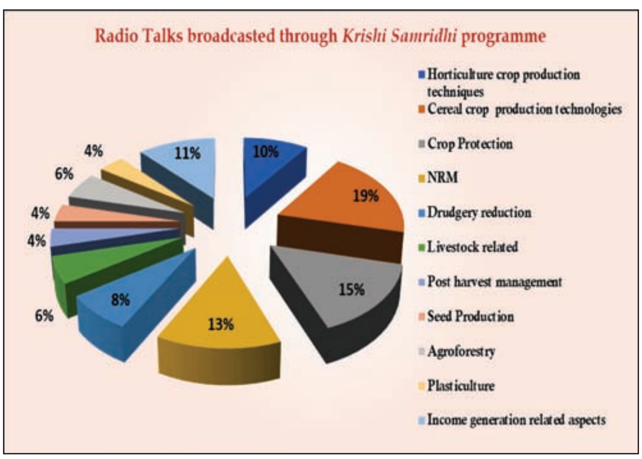


Fig. 7.3.1. Content analysis of radio talks broadcasted through *Krishi Samridhi* programme

7.3.5. Krishak Helpline

The institute offers a toll-free telephone (1800 180 2311) service to the farmers by providing answers to the querries raised by them on working days during 10 AM to 5 PM. Content analysis of advisories provided to farmers shows that majority of the advisories were related to seed availability (18.5%), plant protection (15.3%), other related information (14.5%) and water conservation (11.3%) (Fig. 7.3.2).

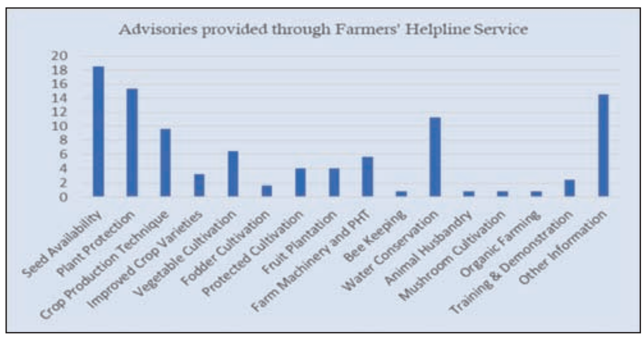


Fig. 7.3.2. Advisories provided through farmers' helpline service

7.4. Swachhta Pakhwara

Institute and its KVKs celebrated swachhta fortnight during September 15 to October 2, 2018 and December 16 to 31, 2018. The institute organized *Swachhta Pakhwara* twice in the year 2018-19. *Swachhta Hi Seva* fortnight programmes were organized during September 15, 2018 to October 2, 2018 and *Swachhta Pakhwada* was organised during December 16-31, 2018. Under *Swachhta hi Seva* programmes, the Institute along with its KVKs at Chinyalisaur and Kafligair organised various programmes. All the staff of the institute and KVKs took *Swachhta* pledge on September 15, 2018 and various activities were taken up during the fortnight.

Swachhta oath taken by staff of the institute

Goshthis on importance of cleanliness

Awareness on importance of sanitation during institute Kisan Mela

Cleaning campaign at Hawalbagh

Cleaning of water source (Badreswar Naula) at Almora

Cleaning the backside of institute office building

Cleaning of water tanks at Hawalbagh campus

Rallies and awareness programme for the students

During *Swachhta Pakhwara*, various activities, *viz.*, cleaning of water storage tank, awareness about cleanliness in kitchen gardens, cleaning of sewage, drainage lines and chocked water pipes were taken up in residential colonies of Hawalbagh campus and Mahet village of Almora district.

A competition among the various laboratories was organized on cleanliness in laboratories. A team of scientists examined various laboratories based on their adherence to cleanliness, safety measures, working environment, categorization of chemicals, working guidelines. A total nine laboratories of the institute viz. agronomy, soil science, biochemistry (quality), plant physiology, entomology, molecular entomology, soil microbiology, biotechnology and plant pathology were examined. The biochemistry (quality) got the first place followed by soil microbiology and entomology laboratory.

Team of scientists examining laboratories for cleanliness

Team of scientists observing office for cleanliness

Quiz competition was organized for students of *Vivekananda Ucchatar Madhyamik Vidya Mandir*, Kafligair by KVK, Bageshwar. An Essay competition on "*Swacch Bharat Abhiyan*, *Jeevan me swacchtta ka mahatav* and *Swacch evam viksit rashtra*" was organized by KVK, Chiniyalisaur for students of Government Inter college, Chinyalisaur.

Quiz competitions organized for students

Essay Competition organized for students

7.5. Tribal Sub Plan (TSP)

7.5.1. TSP

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

7.5.1.1. Farmer Trainings

Training on tailoring and beauty culture

Young tribal women often travel to nearby cities and towns to work in well being shops. Pre-skilling young women in the job requirements of well beings' shops can help them fetch jobs more easily and with better remuneration, and at the same time capacitate them to start up their own small venture. With this objective, a residential 15-day vocational training programme on skill upgradation (beauty culture and tailoring) of tribal women was organised during August 1-15, 2018 by ICAR-VPKAS, Almora in which 16 tribal women participated.

Vocational training programme on skill upgradation

After successfully completing the training programme, 06 women have started tailoring in their respective villages: Jaunsar (02 women), Chamoli (01 woman), Jhankat (02 women) and Munsyari (01 woman). These women are getting work from the villagers for stitching of suits, blouses and frocks. One woman in Jhankat is providing beauty culture services in addition to tailoring. These newly acquired skills are giving them a decent additional income (Rs. 150-170 per clothing and about Rs. 500 per beauty culture session) in the range of 1000-2500 per month (Table 7.5.1). They are spending this additional income on their childrens' education and/or expanding their services, and part of it is also going towards savings. Remaining trainees are stitching their clothes themselves and are thus able to save money, which otherwise was earlier spent on getting clothes stitched by the tailors.

Table 7.5.1. Cluster wise income of farmer trainees after vocational training on tailoring and beauty culture

Cluster	Total trainees	Trainees started their venture	Income per trainee per month (Rs.)
Munsyari	03	01	1000-1500/-
Chamoli	04	01	1500-2000/-
Jhankat	03	03	1500-2500/-
Jaunsar	06	02	1500-2000/-

Training on improved vegetable cultivation techniques

A 3-day training on *Sabjiyon Ki Unnat Utpadan Takniki* was organized at Experimental Farm of ICAR-VPKAS, Almora during August 23-25, 2018. In this training, information on improved production technique of tomato, capsicum, onion and garlic were imparted to 26 farmers of Kwanu tribal cluster of district Dehradun. An exposure visit to model village Bhagartola in district Almora (a village adopted and developed by the institute and now engaged in high-tech vegetable production under protected conditions.) was also organized.

Trainings on income enhancement

A 4-day training programme on *Parvatiya Kshetron mein Krishi evam Gair-Krishigat Udyamon se Krishak Aaya Virddhi* was organized at ICAR-VPKAS, Experimental Farm, Hawalbagh during 6-9 September 2018 for tribal farmers of district Rajouri (Jammu) under Tribal Sub-Plan. A total of 30 farmers from 17 villages of blocks Rajouri, Dungi, Koteranka, Planger, Panjgrawain of district Rajouri participated in the programme. In the training programme, the farmers were imparted information on improved varieties, improved crop production and crop protection technologies, seed production, small tools and farm machinery, mushroom

production and bee-keeping. An exposure visit of farmers to model village Bhagartola in district Almora was also organized.

Two 3-day training programmes on **"Increasing farmer's income through improved agricultural production technologies"** were organized at ICAR-VPKAS, Experimental Farm, Hawalbagh during September 25-27 and September 27-29, respectively for farmers of tribal region of Jaunsar area of district Dehradun. A total of 72 farmers from Kalsi and Chakrata blocks participated in the

programme. The farmers were imparted information on improved varieties of hill crops, improved crop production technologies including disease and insect-pest management, seed production, farm mechanization and mushroom production. They were also sensitized on '*Swachha Bharat Abhiyaan*'. A live demonstration of preparation of soymilk and *tofu* was also given, which was much appreciated by the farmers.

On Farm Training Programmes

A one-day training on *Improved Production Techniques and Intigrated Pest Management of Crops of High Hills* was organized at Malari (3300m amsl) in Niti Valley in May, 2018. In the training, information regarding improved production technique of French bean, garden pea and potato was imparted and quality seed of French bean and garden pea along with agro-chemicals were also distributed among the tribal farmers. A total of 25 farmers participated in the programme.

A one-day training programme was organized on at Chakrata in Dehradun district in August, 2018. In the programme, the technical details of off-season production technology of garden pea were explained to the farmers by means of a power-point presentation and 2.0 q quality seed of garden pea variety *Arkel* along with suitable agro-chemicals was distributed among 81 tribal farmers of Chakrata cluster.

Farmers training programme at Chakrata

Farmers training programme at Malari

7.5.1.2. Exposure Visits

During the *Kisan Mela* an exposure visit of 92 tribal farmers was organized at Experimental Farm Hawalbagh, ICAR-VPKAS, Almora on September 27, 2018. The farmers were exposed to progressive agricultural technology including crops/seed production, water conservation technology, post harvest processing technology, and other technologies developed at the institute.

7.5.1.3 Krishak Goshthis and Farmer-Scientist Interactions

Shelling of maize in Jaunsar area is an activity that is done manually and mainly involves female members of the family. The activity requires women to sit for long hours in static postures that had potential long-term health effects. Besides, the activity consumes considerable amount of energy and time of female members of the family, which otherwise can be utilized for other productive activities including spending more time for off-farm income or caregiving. A small maize sheller, therefore, was got specially designed and manufactured, and as an easy means of shelling maize to mitigate this drudgery. Programme on *Makka Sheller ke Samavesh se Kathin Manav Shram Nyunikaran'* was conducted in Sahiya cluster of Kalsi block and Kwanu cluster of Chakrata of district Dehradun during August 7-8, 2018, respectively. In the programme, functioning of the sheller was demonstrated to the farmers. Hands-on training to selected village youth was imparted. The farmers were also sensitized on the long-term health hazards associated with manual maize shelling.

Krishakgosthi at Sahiya cluster of Dehradun

Demonstration of Maize Sheller to farmers

Visits were undertaken to explore the possibility of Saffron cultivation in Uttarakhand hills during September 20-23, 2018 and farmers-scientist interactions were held in Parsari, Merag, Malari, Niti, Gamshali and Mana. The tribal farmers were given a demonstration of saffron planting and provided saffron corms for trials.

Demonstration of saffron cultivation to farmers

Demonstration of saffron cultivation in Mana village

7.5.1.4 Technology Dissemination and Adoption

Frontline demonstrations of Vivek Maize Hybrid 45 were conducted in Dhanpau-Lakhwad village cluster of Jaunsar tribal area of district Dehradun in about 16.5 ha during *kharif* 2018. Like previous year, performance of the VMH 45 (5.24 t/ha) was superior to the local cultivar (3.16 t/ha). Apart from a yield advantage of 66.3% over the local cultivar, the hybrids offered advantage in terms of green fodder (owing to their stay green trait), lower bird damage and higher tolerance to lodging. Demonstrations on garden pea (8 ha) were also undertaken in Niti and Mana valley. Demonstrations on wheat (32 ha) and onion (0.5ha) have also been undertaken in various adopted villages of Dehradun, Almora and Chamoli districts during *rabi* 2018-19. Demonstrations of maize hybrids, VMH 45 and VMH 53, were conducted in Jammu and Kashmir (Rajouri and Jammu districts) and the north eastern states (Nagaland and Manipur) also. In Peren District of Nagaland, a tribal district in NEH region, Vivek Maize Hybrid 45 outyielded both local check Lingta' and check variety 'Allrounder'.

VMH – 45, VMH – 53, Allrounder and Local variety in farmer's field at Peren, Nagaland

The performance of VMH 45 in demonstrations conducted in Rajouri and Jammu districts of Jammu & Kashmir was also significantly higher than the popular local cultivars. The hybrid on an average yielded 50-60% higher grain besides yielding on an average 25 t/ ha green fodder at maturity. Demonstrations of maize hybrid VMH 53 (which is similar to VMH 45) were conducted in 2.0 ha in tribal clusters of district Rajouri in Jammu during *kharif* 2018. The hybrid gave an average yield of 5.2 t/ha, which was 15.5% higher than RASI's hybrid 9447 (4.5 t/ha), which the farmer normally grows. Besides higher yield, the farmers liked earliness and stay green character of the hybrid.

VMH 45 in farmer's field in Rajouri district

Demonstration of VMH 53 in village Deharian (dist Rajouri)

7.5.1.5. Experimentation in Institute

Potato is the main crop of the tribal belt of Dehradun and Chamoli. Keeping in view the need for refinement of the existing package of practices, an experiment was conducted to study the response of plant geometry [3 row-to-row spacing (45, 60 and 72 cm) and 4 plant-to-plant spacing (15, 20, 24 and 30 cm)] on tuber yield of potato (*Kufri Himalini*). The highest tuber yield was recorded with 45 cm row-to-row spacing (58.76 t/ha) followed by 60 cm row spacing (55.30 t/ha) and 72 cm row spacing (52.25 t/ha). The difference among plant-to-plant spacing was not found significant. However, maximum tuber yield was recorded at 45 cm x 15 cm spacing (61.94 t/ha) followed by 45 cm x 30 cm (59.12 t/ha). Highest tuber number per plant were recorded at 60 cm row-to-row spacing (10.25) and 20 cm plant-to-plant spacing (10.60), however row spacing of 72 cm (94.7 g) and plant spacing of 30 cm (90.86 g) gave maximum average tuber weight.

7.5.1.6. Establishment of Farmer Participatory Seed Production System

French bean is very important and cash crop of remote village in Niti Valley (Malari, Gamshali, Niti *etc.*). The climatic conditions for taking seed crop of French bean is very congenial and hence as part of the institute's work plan to establish a farmer-participatory seed production system at local level, seed production programme was undertaken at Malari (3300m amsl) in Niti Valley during *kharif* 2018. A total of 30 kg seed of French bean variety VL Bean 2 along with suitable agro-chemicals were provided to a selected group of tribal farmers.

7.5.1.7. Development of Linkages with Seed Agencies

A visit of NSC officials to the institute was organized in October 2018 to demonstrate institute's popular and potential technologies. The visit was followed by formulation of a work plan for building a robust seed production chain to cater to the requirement of farmers of adopted tribal regions and elsewhere. Demand for parental seed of maize hybrids has been coming in from state seed agencies also. For example, West Bengal State Seed Corporation Ltd. has shown interest in carrying out a pilot scale production of Vivek Maize Hybrid 45 and Vivek Maize Hybrid 53 with a view to upscaling it in the subsequent seasons.

NSC team visiting finger millet seed production plot

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

Under the Scheme, an initiative was undertaken in tribal village Jhankat in Sitarganj block of district US Nagar (Uttarakhand) in 2014 with the objective of developing Jhankat from "grain village to seed village" by skilling the farmers in quality seed production and building their agro-technological capacity to accomplish the twin goals of introducing quality seed production as a component of enhancing their income and supplementing the state and national seed production programmes in bridging the wide gap existing between demand and availability of quality seed of hill varieties in the state. Sustained efforts over last five years have resulted in considerable enhancement in the income and capacity of the tribal farmers besides production of farmer participatory quality seed of hill varieties in significant quantity. The financial and marketing capabilities of the farmers have been strengthened through formation of a farmers' group "*Rana Kisan Club*" to facilitate credit inflow through banks and undertake organized marketing of farm produce. A brief description of activities undertaken during the year 2018-19 is as follows.

7.5.2.1. Farmer Trainings and Exposure Visits

A 3-day training programme on "*Janjatiya krishakon ka beejotpadan mein kaushal vikas*" was organized during February 19-21, 2019 which was attended by 34 tribal farmers and farm women. During the programme, farmers were imparted practical information on seed production process and distribution system in various cereal and pulse crops, insect-pest management in seed production, seed storage, seed processing, vegetable production and mushroom production. Exposure visits were conducted for 32 tribal farmers during *Kisan Mela* organized in the institute on September 27, 2018

Training programme

Stall of Rana Kisan Club in *Kisan Mela*

and February 24, 2019. Women farmers of Rana Kisan Club displayed their traditional handicraft items in their stall, which was the focus of attraction for the buyers at the *Kisan Mela*.

7.5.2.2. Seed Production Programme and Demonstrations

During the year, farmer participatory seed production of wheat (VL *Gehun* 829, VL *Gehun* 907 and VL *Gehun* 953) and lentil (VL *Masoor* 126 and VL *Masoor* 133) varieties was undertaken in 12.9 and 6.2 ha, respectively. In addition, a new tribal village clusters *Nakulia* in Sitarganj block was selected for quality seed production demonstrations. Demonstrations of wheat variety VL *Gehun* 953 were organized in 50 ha in this new cluster. Inputs like quality seed of wheat and lentil varieties, NPK, urea, weedicide and micronutrients were distributed to the farmers to help them to raise a clean and healthy seed crop.

Seed and input distribution

7.5.2.3. *Krishak Goshthis* and Farmer-Scientist Interactions

A Krishak gosthi on "*Unnat uttapadan takniki va beejotapadan*" was conducted on November 04, 2018 at Jhankat in which the features of new wheat varieties were shared with the farmers and their knowledge of quality seed production methodology

***Krishak Gosthis* conducted at *Jhankat* and *Nakulia* village**

Krishak goshthi-cum-field demonstrations on '*Gehun me kharpatvarnashi ka prayog'* were conducted with the active participation of farmers on November 29, 2018 at Jhankat and on December 07, 2018 at

Awareness creation on the use of weedicides in wheat

Nakulia village. During the *goshthi*, mode of action of the weedicide, dose and method of application and precautions required during application were explained/demonstrated to the farmers. Farmers feedback on farmers participatory seed production were obtained during various visits. Farmers expressed satisfaction with the performance of improved wheat and lentil varieties. It was found that some farmers in nearby villages have also approached them and showed their interest in seed production programme.

7.5.2.4. Farm Schools

Farm Schools on '*Beejotpadan fasal mein shudhdhta ka rakh-rakhaw*' were organized at Jhankat and Nakulia. During the Farm Schools, the importance of roguing in seed production plots was impressed by the farmers and the farmers were explained the method of identifying off-type plants in the wheat and lentil varieties at different growth stages on the basis of distinguishing morphological characters of the varieties. Regular monitoring visits were conducted to ensure quality of the seed production, the farmers were also given hands-on training in roguing in wheat and lentil seed production plots.

7.5.2.5. Seed Procurement

At the end of the season, 170 q quality seed of wheat varieties (VL *Gehun* 953, VL *Gehun* 907 and VL *Gehun* 829) and 1.22 q seed of lentil varieties (VL *Masoor* 126 and VL *Masoor* 133) were procured from the farmers.

Farm School on Roguing in wheat seed production

8. Success Stories

8.1. Incidence and Management of *Tuta absoluta* in Tomato in Uttarakhand

The Challenge

Insect pests are always been a limiting factor for crop production. Besides many native insect pests affecting the crops, various exotic pests also cause serious damage time to time. The tomato pinworm, *Tuta absoluta* is one of the serious pests of tomato causing extensive damage in many countries. The larva mine between the epidermis of leaves and make irregular blotches. It also feeds on stem, buds, calyx and fruits. In fruits, they make pin holes and mine inside. It is reported in brinjal, potato, capsicum, etc. Adults are small brown moth (5-7 mm) with silvery and black spots and reportedly lay 250 eggs. The pest was first reported in India in 2014. It was noticed during May 2018 in Bhagartola and Sunkiya (Nanital) in tomato crops grown under polyhouses.

Damage caused by *Tuta absoluta*

The Solution

Owing to the importance of the pest, ADG (Plant Protection), ICAR, New Delhi was consulted, and the survey and management of the pest was carried out under his guidance. An awareness programme for the officials of the state department of Agriculture was conducted on the identification, biology and management of the pest at ICAR-VPKAS, Almora. The guidance of Director and scientists of ICAR-National Bureau of Agricultural Insect Resources, Bengaluru was also taken. Subsequently, pheromone traps and parasitoid, *Trichogramma achaea* were obtained from ICAR-NBAIR, Bengaluru for use against *T. obsoluta* in Uttarakhand. The farmers of the affected area were made aware about the identification of the pest and the potential damage.

Surveys undertaken

On-farm trainings conducted

The Application

Training and awareness programmes were conducted both on farm and at farmer's fields. Joined surveys were conducted along with state department of agriculture to combat the spread of the pest. Severely infested polyhouses were sprayed with the insecticide, chlorantraniliprole @ 0.3 ml/L. Since there is only one chemical insecticide available for the management, the pesticide shops were informed/ alerted to have the insecticide (Chlorantraniliprole) in stock, which was purchased by the institute, state department and farmers themselves for use in pest combat. Pheromone traps were brought from ICAR-NBAIR, Bengaluru and installed in polyhouses to capture male moths, thus minimizing the pest problem. Frequent visits were made to the affected area and pest problem was brought under control.

Interaction meet with agriculture department

The Impact

Early detection coupled with immediate warfoot action taken with proper guidance from experts has averted a greater damage which would have otherwise caused by tomato pinworm infestation in the region. Pinworm reportedly cause up to 50% damage in tomato even causing complete crop failures in rare cases. The damage by this exotic pest was halted because of combine action of the institute and the district administration, especially the department of agriculture.

Interaction meet with agriculture department

Lessons Learned

- Time to time survey on pests and diseases in farmer's field is necessary along with contact of progressive farmers who can inform field situations/ abnormalities in time.
- Immediate actions are helpful in combating pest like *Tuta obsoluta,* which are usually fast spreading/ infestation in nature.
- Combined action of research institute along with different stakeholders like line departments (agriculture/ horticulture etc), yields more benefit in times of urgent needs.

8.2. Nutritional Security of Farmwomen through Nutri-gardens

The Challenge

Prevailing malnutrition in rural areas of Uttarakhand and particularly in hill districts is a serious issue. The crop productivity in the hilly areas of Uttarakhand is low due to scattered land holdings, low soil fertility and mostly rainfed agriculture. Farmers are still practising traditional subsistence farming comprising of mainly cereal crops which cannot sustain farm families for more than three to four months in a year. There is a large-scale migration of men towards plains, due to which the rural areas contain significantly higher female population and has led to demographic imbalance in the region. An imbalance diet and inadequate nutrient uptake coupled with strenuous physical tasks results in malnutrition among women farmers of hill region. As per National Family Health Survey 2015-16, 42% of women in Uttarakhand have anemia including 31% with mild anemia, 10% with moderate anemia and 1% with severe anemia. Low nutritional status makes women more prone to certain ailments.

The Solution

One of the solutions to this prevailing problem can be "Local need meet locally". Climatic conditions of hill region are suitable for seasonal and off seasonal vegetable and fruit production, which are rich in micronutrients. Keeping these facts in view, the institute introduced some technological interventions to improve health and nutritional status of farm women in hills. Concept of nutri-garden was initiated in Pithoragarh and Uttarkashi districts to encourage women to cultivate healthy food crops in their backyards. A well planned nutri-garden ensures regular supply of fresh vegetables rich in nutrients. Fruits and vegetables are rich source of vitamins, minerals, protein and carbohydrates which are essential in human nutrition.

Nutri-garden at farmer's field

The Application

Anthropometric analysis of women and the information about their dietary diversity was collected for analysis of nutritional status. To demonstrate nutri-garden, an area of 100-200 m^2 was selected at the backyard of their home. The initial necessary inputs, seed kits of different diversified vegetable groups, fruit plants and scientific knowledge were provided to them. Some other interventions were also made in their nutri-gardens such as demonstration of nursery preparation, installation of poly tunnels, and preparation of vermi-compost and gender friendly farm tools and seedling trays to meet out protein requirement, mushroom cultivation was introduced. To enhance pollination in vegetables and for production of honey, bee boxes were installed.

The Impact

Initially 20 farm women were involved in establishing nutri garden but gradually the number of respondents has been increased and reached up to 80 farm women. The main objective of this model is to achieve nutritional security and the empowerment of farm women through increased participation in vegetable cultivation practices and earn by selling the excess produce in local markets.

These interventions have helped farm women to get balanced nutrition in addition to saving their hard-earned money. This concept of nutri-garden will diversify the area under wheat-rice or finger millet rotation besides improving livelihood of the people.

8.3. Boosting Finger Millet Production through Improved Technologies

The Challenge

Small millets, particularly finger millet is the most important crop next only to rice during *kharif* season in North Western Himalayan hills. In-spite of this fact, its production and productivity is quite low, mainly due to non-availability of quality seeds of improved varieties, less crop management and crop care by the farmers and poor post-harvest processing technologies.

The Solution

Improved high yielding varieties developed by the institute, *viz.*, VL *Mandua* 352 and VL *Mandua* 324 have an average yield potential of 25-30 and 18-20 q/ha, respectively are a boon for the hill farmers. VL *Mandua* 352 is highly resistant to leaf, neck and finger blast and VL *Mandua* 324 is especially released for organic farming conditions. Besides high yielding varieties, agronomic practices like spacing, fertilizer dose and applications are standardised by the institute besides crop protection aspects. White grubs are the major insect pests of millets, grown under rainfed conditions and thus the management practices like VL white grub beetle trap and the entomopathogen, *Bacillus cereus* WGPSB2 holds good for the management. 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 10 villages of Tipola cluster, where finger millet is being grown under large scale. With all the efforts of the institute, the average crop yield in the cluster was 18 q/ha which was 46.6% more than the base year. Vivek millet thresher was introduced in the village cluster for post harvest activities of the produce.

Demonstration and training on finger millet cultivation and threshing

The Impact

Farmers realised a significant yield increase in the finger millet by growing improved varieties. The income from 1 acre of finger millet cultivation increased from ₹ 14,730 to ₹ 21,600 with net benefit of ₹ 14,923 in the improved practice. The benefit cost ratio rose from 1.09 to 2.34 with the interventions. Overall, the farmers earned additional benefit of ₹ 6,870 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.

8.4. 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 of 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 filed 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.

8.5. Climate Smart Village: Farmers Harnessing Better Yields against the Vagaries of Climate Change

The Challenge

It is not unusual for farmers to give up agriculture when repeatedly having to deal with erratic and extreme weather events and hill farmers are no exception. Severely affected by changes in the summer temperatures and delayed and erratic rainfall which severely affects crop planning and farm income, farmers usually migrate from the villages in search of alternate livelihood options. Shortage of fodder and feed is another problem and women are bound to walk over 3-4 km for fodder collection. Farmers are witnessing the climate change impact on the crop yields and are willing to adopt climate resilient technologies but lack of technological know-how, lack of knowledge on on-farm and off-farm climate resilient livelihood alternatives and lack of capital remains major hindrance.

The Solution

Under the project National Mission for Sustaining Himalayan Ecosystem (Task Force 6) the institute identified Jur Kafun village (29°34′23.9″N, 79°35′29.4″E) of Hawalbag block of Almora for technological interventions and developed it as a 'Climate Smart Village'. Location specific climate smart technologies are demonstrated in the village alongwith capacity building programmes with hands-on practices on on-farm livelihood activities. Believing that a combination of strategies is likely to be more effective than a single strategy in adapting to the impact of climate variability and change, a few scalable strategies and technologies have been devised at the farmers' field in Jur Kafun to bring about climate smartness in the village

The Application

Multiple climate smart interventions like modified poly tanks for water conservation, poly-cum-net shed house, low polytunnels were introduced in the village. Seven polythene lined (LDPE) tanks of total capacity 224 m^3 and three polythene lined tanks of total capacity 80.35 m^3 constructed in the village which can collectively irrigate about a total of 0.61 ha of area by one filling, thus helping to combat the problem of poor irrigation. Eleven poly tunnels have also been established for improving the yield of vegetable crops. Nursery and leafy vegetables like coriander, spinach, *lahi*, fenugreek, etc are being grown in the tunnels. For increased fodder availability, hybrid napier and azolla cultivation was promoted. Alternative livelihood activities like apiculture, pisciculture, poultry rearing and processing and value addition of millets and Soybean, Kiwi plantation were also demonstrated and capacity building programmes in these activities were organised. Field trials on improved varieties of crops of *rabi* and *kharif* season were laid in the village and varieties performing well against climatic conditions were promoted further. Skill trainings on apiary management were organized for the interested farmers and farmwomen of Jur Kafun at experimental farm, Hawalbagh. Bee colonies were distributed to the trained farmers, so that they can manage it in their farms. Demonstrations on the processing of soybean, which is widely grown in the village was conducted. A corpus fund of Rs. 22,000/- has been saved in the bank, which members of SHG are using for financing their small purchases. For mainstreaming womens concerns in climate change adaptation, a collective of women named as 'Jai Durga' SHG is started in 2017 and the members were provided low poly tunnels for nursery raising, drudgery reducing tools and implements for saving their labour, demonstrations on value addition and processing and seeds of improved varieties of vegetables and crops.

The Impact

Participatory water conservation work started under NMSHE project for improving water availability in the village for agricultural purpose has led to multiple other initiatives like pisciculture, apiculture, horticulture, etc. Before the introduction of the project, the farmers at the Jur Kafun village focused less on *rabi* crops. After the demonstration of climate resilient crop varieties, the average yield of lentil and barley was recorded 16.63 and 15 q/ha, respectively in the rabi season 2017-18. Hence, the crop diversification at Jur Kafun village adds broadly to its climate smartness. The yield of fenugreek and coriander were more than the experimental yield (open field yield) by 32.45% and 51.50%, respectively which is helping famers to meet their consumption needs apart from sale of vegetables. Besides value added products like soymilk, tofu (paneer) are being produced by the farmers. Barnyard millet produced in the village is collectively procured, threshed and processed. Good packaging was made and thus able to sell it for high price with a brand of quality. With technological backstopping by the Institute, a chain of benefits has unfolded.

9. Farmers' Feedback

I am from Baitholi village in Berinaag block of district Pithoragarh. We were engaged in traditional farming. The nutrition related technological interventions provided by the institute have brought drastic change in the dietary diversity of my family. Apart from having good vegetables in our diet, we are selling the produce in the local market for a good price.

Smt. Pooja Karki
Village: Baitholi

I adopted the multiple water use model of the institute besides growing improved varieties of crops both in kharif and rabi season. The new technologies helped me to expand my area under vegetable crops. In addition, I started fish farming, apiculture and kiwi plantations. I am happy now as I am getting a good income from diverse agricultural produces besides good food for my family.

Shri. Bhairav Tiwari
Village: Jur Kafun

I used to grow local Rajmash variety for a long time. Due to poor productivity of these varieties, I received very low profit. With the help of the institute, I along with other farmers started producing seeds of improved vegetable bean varieties. It has yielded significantly higher than local varieties. I have received good profit from seed production of bean and garden pea as compared to Rajmash production.

Shri. Avtar S. Foniya
Village: Ghamshali

With the technological assistance received from ICAR-VPKAS, I am now earning profit by button mushroom cultivation. With the use of 2 q compost, I produced 60 kg of fresh button mushroom. I am now cultivating oyster mushrooms in unutilized vacant houses. In addition, I have started value addition to mushroom by making pickles. Moreover, I am happy to help other mushroom growers in my village.

Smt. Preethi Bhandari
Village: Khatyadi

Impressed by the participatory seed production of the ICAR-VPKAS in Jhankat village, I contacted the institute for initiating a similar programme in my village. I, along with other farmers, cultivated improved wheat variety (VL Gehun 953) in 50 ha area. I have received a good profit by selling quality seeds to the institute. We are also benefitted by the trainings and field demonstrations conducted by the institute.

Shri. Ram Bharose
Village: Nakulia

10. Trainings & Capacity Building

Training of Institute Personnel

The following institute personnel were deputed for different HRD programmes as per Annual Training Plan (ATP) during 2018-19 (Table 10.1).

Table 10.1. Details of trainings undergone by institute staff

Duration	Participant	Topic	Venue
Scientific Staff			
International Trainings			
September 29- October 9, 2018	Dr. K.K. Mishra	Training course on stem rust	Njoro, Kenya
National Trainings			
August 20-24, 2018	Dr. Nirmal Chandra and Er. Jitendra Kumar	Training on role of technology in community level disaster mitigation	LBSNAA, Mussorie, Uttarakhand
August 27, 2018	Dr. P.K. Mishra	One day J-gate@CeRA Regional Ambassador training program for Libraries of North Zone Agricultural Universities & institutes of ICAR	PAU, Ludhiana
October 5-25, 2018	Er. Shyam Nath	Winter school training programme on Recent engineering interventions in food and by-product processing for sustainable growth and profitability	ICAR-CIPHET, Ludhiana
November 22- December 12, 2018	Dr. D.C. Joshi	CAFT training programme on Application of molecular markers in crop breeding	TNAU, Coimbatore
December 17-22, 2018	Dr. J.K. Bisht	MDP for PME In-charges of ICAR Institute for Priority Setting, Monitoring and evaluation	ICAR-NAARM, Hyderabad
December 18-29, 2018	Dr. S.C. Pandey	MDP on Leadership development (a pre-RMP programme)	ICAR-NAARM, Hyderabad
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
Technical Staff			
April 24-25, 2018	Shri. T.B. Pal	National Workshop and training on *Bhartiya Krishi Anusandhan Parishad mein Rajbhasha Prabandhan Avam Nayee Dishayen*	CRIDA, Hyderabad.
July 17-23, 2018	Shri. Harish Pandey	Automobile maintenance/ repair of office vehicle/ tractor and farm implements	ICAR-CIAE, Bhopal, M.P.
August 28, 2018	Dr. Gaurav Papnai	Training programme for handling of mobile app KVK-Sandesh under ICAR-TCS project	GBPUA&T, Pantnagar

September 4-8, 2018	Smt. Nidhi Singh	Training on Extension of women entrepreneurial skill for agricultural development	MANAGE, Hyderabad
October 3-10, 2018	Shri. Rajendra Parsad & Jaiprakash Gupta	Model training course on IPM in major hill crops.	ICAR-VPKAS, Almora, Uttarakhand
October 8-13, 2018	Shri. Vijay Pal Singh & Neeraj Kumar Pandey	ICAR sponsored human resource development programme on enhancing personal effectiveness at workplace	ICAR-IARI, New Delhi
January 2-11, 2019	Shri Govind S. Bisht	Good Agricultural Practices	ICAR-IARI, New Delhi
Februrary 4-15, 2019	Shri. Omkar Pratap	13th Capacity building Programme for technical personnel	IIPA, 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.
Administrative Staff			
June 11 to July 6, 2018	Ms. Usha Birdi	Training course for newly recruited Assistants	ISTM, New Delhi
December 10-14, 2018	Shri. L.M. Tiwari	Refresher course on administrative and finance management for SO/AAOs/ AFAOs/ Assistants of ICAR Head Quarter/ Institute	ICAR-NIASM, Baramati, Maharastra
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 program	ICRA-VPKAS, Almora-263601, Uttarakhand

11. Awards & Recoginitions

- Dr. Jitendra Kumar, Scientist received IARI Merit Medal for outsatanding academic performance in Ph.D. degree during 2018.

- Small millets research team of ICAR-VPKAS, Almora received the **"Best Performing Centre Award" 2017-2018 for small millets research** at 29th Annual Group Meeting of Small Millets held at IGKV, Raipur (April 12- 13, 2018).

- Dr. J. Stanley was conferred with Fellow of Plant Protection Association of India, Hyderabad on April 20, 2018.
- Drs. Salej Sood, R.K. Khulbe, D.C. Joshi, Rajashekhara H., L. Kant and A. Pattanayak received Best Poster Award in National conference on "Doubling Farmers Income: Challenges and Strategies" (April 23-24, 2018) at CSKHPKV, Palampur
- Dr. A.R.N.S. Subbanna received Young Scientist Award from Society for Scientific Development in Agriculture & Technology, Meerut (UP) in an International Conference on "Global Research Initiatives for Sustainable Agriculture and Allied Sciences" held at RARI, Durgapura, Rajasthan from October 28-30, 2018.
- Dr. R.P. Yadav was awarded Best Thesis -2018 by Agricultural Technology Development Society (ATDS), Ghaziabad, Uttar Pradesh (India).
- 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.

- The Institute contingent participated in the ICAR North Zone Sports Tournament – 2018 held at ICAR – Central Institute for Research on Buffaloes, Hisar from November 14-16, 2018 and received 13 medals (5 Gold, 4 Silver and 4 Bronze) in different events. Overall, the Institute stood 3rd among 24 institutes participated in the tournament. The gold medals were won by Ms. Usha Birdi in Chess and high jump, Mr. Rajender Prasad Meena in 800 and 1500 m race and team of Drs. Rajeshekra H., Vijay Singh Meena, Shyam Nath and Rajender Prasad Meena in 4 x 100-meter (men) relay race. The silver medals were won by Ms. Usha Birdi in 100 and 200 m race, Mr. Rajender Prasad





Meena in 400 m race and Dr. Ankita Kandpal in carom. Dr. Vijay Singh Meena won bronze medals in high jump, javelin throw, disc throw and Ms. Usha Birdi won in long jump.

- The Institute contingent participated in the ICAR Inter-Zonal Sports Tournament – 2018 held at ICAR – Indian Veterinary Research Institute, Izatnagar, Bareilly from 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.

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 Maize Research, New Delhi
- ICAR- Indian Institute of Pulses Research, Kanpur, 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, Jhanshi, Uttar Pradesh
- ICAR-North Eastern Hill Complex, Barapani, Megalaya
- 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, Syria
- 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 Agricultural and Cooperation
- North Eastern Hill State Departments

13. Important Committees of The Institute

13.1. jktHkk"kk dk;kUo;u lfefr

- डॉ0 अरूणव पट्टनायक – निदेशक अध्यक्ष
- डॉ0 जे. स्टेनली – वैज्ञानिक सदस्य
- 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

13.2. Quinquennial Review 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), CSKHPKVV]; 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.S.D., Garhwal University, Srinagar (Garhwal); 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

Chairman – Director

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

Members (Staff Side) – Mr. Vishnu Dutt Pandey, SSS; 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 & 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; 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 Sanjay Kumar, Principal Scientist, ICAR-Indian Agricultural Institute, New Delhi; In-Charge, NBPGR Regional Station, Nainital; Dr. J.K. Bisht, ICAR-VPKAS, Almora; Dr. Lakshmi Kant, ICAR-VPKAS, Almora; The Finance & Accounts Officer, IVRI, Bareilly; Shri Nagendra Kumar, Non-Official/ farmer member; Shri. Sushil Tyagi, Non-Official/ farmer member

Member Secretary – Sr. Administrative Officer

13.6. Institute Research Council (IRC)

Chairman – Director

Members – All the Scientists of ICAR-VPKAS, Almora

Member Secretary – In-charge/ 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

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, Crop Production Division; R.K. Khulbe, Sr. Scientist; Sher Singh, Sr. Scientist; Finance and Accounts Officer

13.9. Study Leave Committee

Chairman – Dr. Lakshmi Kant, Head (CID) (upto Dec. 11, 2018), Dr. J.K. Bisht, Head, CPD (*w.e.f.* December 12, 2018)

Member – Drs. K.K. Mishra, Pr. Scientist and Sher Singh, Sr. Scientists (upto Dec. 11, 2018)

Drs. P.K. Mishra, Pr. Scientist and Nirmal Chandra, Pr. Scientist (*w.e.f.* Dec. 12, 2018)

Member Secretary – Shri Y.S. Dhanik, Sr. Administrative Officer

13.10. PERMISNET/PIMSICAR/HYPM

Nodal Officer – Dr. Renu Jethi, 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

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

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

13.13. Grievance Cell

Chairman - Dr. Lakshmi Kant, Pr. Scientist

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

13.14. Women Cell

Chairman - Dr. Renu Jethi, Scientist

Members (upto 25.12.2018) - Dr. N.K. Hedau, Pr. Scientist, Smt. Anju Pangti, Announcer, AIR, Almora; Shri. H.L. Meena, I/c FAO, Mrs. Radhika Arya, Assistant Administrative Officer

Members (w.e.f 26.12.2018) - Dr. Ankita Kandpal, Scientist; Mrs. Radhika Arya, AAO; Mrs. Renu Sanwal, T.O.; Ms. Usha Birdi, Assistant

13.15. Internal Complaint Committee

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)

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 (w.e.f. 25.06.2018)

Member Secretary - Administrative Officer (Store)

13.17. Standing Purchase Committee (SPC)

Chairman – Dr. Lakshmi Kant, HoD, CID

Members – Drs. Ramesh Singh Pal, Scientist ; Renu Jethi, Scientist ; Finance & Accounts Officer; Shri. Sanjay Kumar Arya' ACTO (w.e.f. 25.06.2018)

Member Secretary - Administrative Officer (Store)

13.18. Technical Vetting/ Screening Committee

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

Members – Drs. A.R.N.S. Subbanna, Scientist ; V.S. Meena, Scientist; Anirban Mukherjee, Scientist (up to July 13, 2018); Ramesh Singh Pal, Scientist (*w.e.f.* July 18, 2018); Shri. Sanjay Kumar Arya' ACTO (*w.e.f.* 25.06.2018)

Member Secretary - Administrative Officer (Store)

13.19. Institute Bio-safety Committee (IBSC)

Chairman – Director, ICAR-VPKAS, Almora

Members – Dr. S.K. Nandi, Scientist (F), GBPHED, 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

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

Members –Dr. B.M Pandey, Pr. Scientist; Mr. H.L. Meena, Administrative Officer

Member Secretary – Mr. T.B. Pal, ACTO

13.21. Public Information Cell

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

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

Program Coordinator, KVK, Bageshwar

Program 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

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

Member – Dr. Kushagra Joshi, Scientist and Mr. T.B. Pal., ACTO

13.26. Human Resource Development

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

13.27. Research Data Management

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

Co-Nodal Offcier- Dr. Renu Jethi, Scientist

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

13.28. Institute Germplasm Identification Committee

Chairman- Dr. L. Kant, Pr. Scientist & Head, Crop Improvement Division

Member- Drs. P.K. Mishra, Pr. Scientist; K.K. Mishra, Pr. Scientist and R.K. Khulbe, Sr. Scientist

13.29. Innovation Cell

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

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

14. List of Publications

14.1. Scientific Paper Published in Peer Reviewed Journals/ Proceedings

Research Papers	NAAS Rating
Yadav, R.P., Gupta, B., Bhutia, P.L., Bisht, J.K. and Pattanayak, A. (2019). Biomass and carbón budgeting of land use types along elevation gradient in central Himalayas. *Journal of Cleaner Production*, 211: 1284-1298.	11.65
Joshi, D.C., Sood, S., Hosahatti, R., Kant, L., Pattanayak, A., Kumar, A., Yadav, D. and Stetter, M.G. (2018). From zero to hero: the past, present and future of grain amaranth breeding. *Theoritical and Applied Genetics*, 131: 1807-1823.	9.93
Joshi, D.C., Chaudhari, G.V., Sood, S., Kant, L., Pattanayak, A., Zhang, K., Fan, Yu., Janovská, D., Meglič, V. and Zhou, M. (2019). Revisiting the versatile Buckwheat: Reinvigorating genetic gains through integrated breeding and genomics approach. *Planta*, DOI: 10.1007/s00425-018-03080-4.	9.25
Sood, S., Joshi, D.C., Chandra, A.K., Kumar, A. (2019). Phenomics and genomics of finger millet: current status and future prospects. *Planta*, https://doi.org/10.1007/s00425-019-03159-6.	9.25
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*, DOI: 10.1007/s00425-019-03196-1.	9.25
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*, DOI: 10.1007/s00425-019-03184-5.	9.25
Stanley, J., Chandrasekaran, S., Preetha, G., Kuttalam, S. and Jasmine, R.S. (2018). Management of cardamom borer, *Conogethes punctiferalis* and thrips, Sciothrips cardamomi using diafenthiuron and its residues in fresh and cured cardamom capsules. *International Journal of Pest Management*, DOI: 10.1080/09670874.2018.1468579.	7.09
Singh, S., Bawa, S.S., Singh, S., Sharma, S.C., Sheoran, P., Sardana, V. and Salaria, A. (2019). Long-term effect tillage and nitrogen management for improving productivity and profitability of a rainfed maize-wheat system in north western Himalaya. *Journal of Environmental Biology*, 40(1/2): 36-44.	6.73
Subbanna, A.R.N.S., Khan, M.S., Srivastava, R.M., Mishra, P.K., Babu, B.K. and Venkateswarlu, V. (2018). Interspecies diversity of *Bacillus thuringiensis* isolates native from North Western Indian Himalayas. *Journal of Environmental Biology*, 39: 306–313.	6.73
Stanley, J., Chandrasekaran, S., Preetha, G. and Subaharan, K. (2018). Evidence of Male Pheromone in *Conogethes punctiferalis* (Lepidoptera: Pyralidae). *Journal of Entomological Science*, 53(4): 455–466.	6.68
Mukherjee, A., Mondal, T., Bisht, J.K. and Pattanayak, A. (2018). Farmers' preference of fodder trees in mid hills of Uttarakhand: a comprehensive ranking using analytical hierarchy process. *Range Management & Agroforestry* 39(1): 115-120.	6.64

Research Papers	NAAS Rating
Tiwari, P., Pant, K.S., Guleria, A. and Yadav, R.P. (2018). Socioeconomic characteristics and livelihood of agroforestry practitioners in north-west Himalayas, India. *Range Management & Agroforestry*, 39(2): 289-295.	6.64
Sood, S., Gupta, A., Khulbe, R.K., Pandey, B.M., Chandrashekara, C., Rajashekara, H., Bisht, G., Panchpal, D.S. and Kanwal, R.S. (2018). Finger millet variety VL Mandua 379. *Indian Journal of Plant Breeding*, 78(3): 399.	6.41
Bhartiya, A., Aditya, J.P., Kumari, V., Kishore, N., Purwar, J.P., Agrawal, A., Kant, L. and Pattanayak, A. (2018). Stability analysis of soybean [*Glycine max* (L.) Merrill] genotypes under multi-environments rainfed condition of North Western Himalayan hills. *Indian Journal of Genetics and Plant Breeding*, 78(3): 342-347.	6.41
Hedau, N.K., Pal, R.S., Sood, S., Chaudhari G.V., Kant, L. and Pattanayak, A. (2018). Biochemical characterization and variability in garden pea (*Pisum sativum* var. hortense) under cool hilly weather conditions. *Indian Journal of Agricultural Sciences*, 88 (9): 1442–1448.	6.23
Yadav, R.P., Gupta, B., Bhutia, P.L. and Bisht, J.K. (2018). Sustainable agroforestry systems for livelihood security and their economic appraisal in Indian Himalayas. *Economic Affairs*, 63(3): 01-07.	5.90
Chandra, N., Roy, M.L., Mukherjee, A., Jethi, R., Joshi, P. and Kharbikar, H.L. (2018). Information and communication technology for dissemination of agricultural information in hills: A critical overview. *Indian Journal of Extension Education*, 54(3): 19-25.	5.32
Singh, Sukhbir, Sahoo, D.C., Singh, Sher, 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
Pande, K.K. and Dimri, D.C. (2018). Study on different nitrogen regimes through neem coated urea and calcium sprays on physico-chemical attributes and maturity of peach fruits. *Journal of Pharmacognosy and Phytochemistry*, 7 (2): 1747-1753.	5.21
Preetha, G., Stanley, J. and Manoharan, T. (2018). Harvest time residues of imidacloprid in cotton seed, lint, oil and bhendi (Okra) fruits. *Journal of Entomological Research*, 42(3): 391–393.	5.05
Sunetha, S. and Papnai, G. (2018). Information needs and constraints faced by farm women in hill region of Uttarakhand. *The Anthropologist*, 33(1-3): 73-79.	5.00
Arya, M., Sachan, V.K., Limbu, R., Nautiyal, P. and Papnai, G. (2018). A study on the knowledge of Anganwadi workers of Uttarkashi district in Uttarakhand about Integrated Child Development Services (ICDS). *The Anthropologist*, 32(1-3): 8-15.	5.00
Pal, R.S., Hedau, N.K., Kant, L. and Pattanayak, A. (2018). Functional quality and antioxidant properties of tomato genotypes for breeding better quality varieties. *Electronic Journal of Plant Breeding*, 9 (1): 1- 8.	4.97
Sood, S., Pal, R.S., Sharma, A., Kant, L. and Pattanayak, A. (2018). Characterization of amaranth genetic resources for agro-morphological and nutritional traits in submontane Himalayan region of India. *Electronic Journal of Plant Breeding*, 9(4): 1484-1496.	4.97
Aditya, J.P., Agrawal, P.K., Stanley, J., Pandey, B.M., Mishra, K.K., Lal, Devendra, Verma, P.C., Arya, J.K., Panchpal, D.S., Rawat, K.S. and Singh, Anand. (2018). VL Dhan 158: An early maturing rice variety for rainfed uplands of North-West Himalayas. *Electronic Journal of Plant Breeding*, 9(4): 1378-1386.	4.97

Research Papers	NAAS Rating
Pande, K.K. and Dimri, D.C. (2018). Effect of different nitrogen levels through neem coated urea and calcium sprays on growth and yield of peach cv. Red June. *Journal of Hill Agriculture*, 9 (2): 137-143.	4.94
Pande, K.K., Dimri, D.C. and Kumar, S. (2018). Effect of different nitrogen levels through neem coated urea and calcium sprays on leaf and soil NPK and Ca status and phyto-toxicity in peach. *International Journal of Agricultural Sciences*, 14 (2): 381-388.	4.82
Roy, M.L., Chandra, N., Mukherjee, A. Jethi, R. and Joshi, K. (2018). Extent of use of ICT tools by hill farmers and associated social factors. *Indian Research Journal of Extension Education*, 18 (3): 27-31.	4.81
Sharma, R.K. and Singh, Sher. (2018). Host range and abundance of blister beetle [*Mylabris pustulata* (Thunberg)] in sub-mountainous Punjab. *Agricultural Research Journal*, 55(4): 696-700.	4.71
Yadav, R.P., Bisht J.K., Mondal, T., Meena, V.S. and Chaudhary, M. (2018). Peach based horti-pastoral system of forage production on marginal land in Indian Himalaya. *Indian Journal of Agroforestry*, 20(2): 63-67.	4.53
Bisht, J.K., Yadav, R.P., Pandey, B.M., Mishra, P.K., Mahanta, D., Meena V.S. and Pattanayak, A. (2018). Long term impacts of different land uses on forage grasses under degraded land of north-west Himalaya, India. *Forage Research*, 44 (2): 129-136.	4.48
Mahanta, D., Bisht, J.K. and Pattanayak, A. (2018). Optimization of sowing time for adaptation to climate change and higher productivity of barley in the mid-Himalayas. *Wheat and Barley Research*, 10(3): 123-127.	4.42
Arya, M., Sachan, V.K., Limbu, R., Nautiyal, P. and Papnai, G. (2018). Effect of training on nutritional knowledge of Anganwadi workers of Uttarkashi district in Uttarakhand. *Journal of Krishi Vigyan*, 7(1): 105-108.	4.41
Joshi, K., Pandey, B.M., Khulbe, R.K. and Pattanayak, A. (2018). Women's drudgery and maize sheller intervention: A case of tribes of Jaunsar region of Uttarakhand. *Indian Journal of Hill Farming*, (Special issue): 96-100.	4.39
Joshi, K., Pandey, B.M., Khulbe, R.K. and Pattanayak, A. (2018). Occupational stress perceived by hill farmwomen of Jaunsar in manual chaff cutting. *Indian Journal of Hill Farming* (Special issue): 108-111.	4.39
Yadav, R.P., Gupta, B., Bhutia, P.L., Bisht, J.K., Meena, V.S. and Choudhary, M. (2018). Along elevation phytosociology of ground vegetation in natural land use systems of central himalayas. *International Journal of Agriculture Sciences*, 10 (16): 6930-6937.	4.20
Shivashankara, Srivastava, R.M. and Subbanna A.R.N.S. (2018). Pollination potentiality and foraging activity of Tetragonula laeviceps bees on coriander crop. *Trends in Biosciences*, 10(48): 9671.	3.94
Nautiyal, P, Papnai, G. and Arya, M. (2018). Impact of adoption of mulching technology in higher apple production in Uttarakhand. *Progressive Horticulture*, 49(2): 204-207.	3.53
Joshi, K. (2018). Assessment of training needs of farmwomen: A case of Western Uttar Pradesh. *TECHNOFAME- A Journal of Multidisciplinary Advance Research*, 7(1): 106–109.	3.38
Upadhyay, A.P., Papnai, G. and Singh, P. (2018). Problems and prospects of Guava producers in Allahabad district of Uttar Pradesh, India. *IOSR Journal of Humanities and Social Science*, 23 (06): 01-07.	3.17

14.2 Papers in Proceedings

Pattanayak, A., Singh, S., Bisht, J.K., Mahanta, D., Pandey, B.M., Yadav, R.P. and Mishra, P.K. (2018). Improving income of farmers of hill regions through agronomic interventions. In: Doubling farmers income through agronomic interventions under changing scenario (Yadav, R.L., Ghosh, P.K., Shiva, Dhar, Rathore, S.S., Singh, R.K., Singh, T., Choudhary, A.K., Sepat, S., Bana, R.S., Upadhyay, P.K., Ranjana, G.A., Kumar, D. and Nath, C.P.). XXI Biennial National Symposium of Indian Society of Agronomy, 24-26 October 2018 at MPUAT, Udaipur, Rajasthan. Indian Society of Agronomy, IARI, New Delhi 110012, pp: 33-40.

14.3. Book/ e-Book

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.

Stanley, J. Mishra, K.K., Subbanna, A.R.N.S., Rajashekhara, H. and Pattanayak, A. (2019). Integrated Pest Management in Major Crops. Pp272, ISBN 978-93-5321-912-3.

14.4. Popular Articles

Bhartiya, A., Pal, R.S., Singh, S. and Kant, L. (2018). 'VL Bhat 201' soybean – A high-yielding nutrition rich black variety. *Indian Farming,* 68(07): 14-16.

Khulbe, R.K., Sood, S., Sharma, A., Bisht, G.S., Joshi, D., Kant, L. and Pattanayak, A. (2018). *Paramparkik Vidhiyon se Mandua va Anya Kadannon mein Mulyavardha*. *Kheti* 71: 51-52.

Mishra, K.K., Stanley, J. and Rajashekara, H. (2018). *Dhingri mushroom ke rog va keet tatha prabandhan*. *Kisan Bharti*. Nov., 27–29.

Nautiyal, P. and Sachan V.K. (2018). *Nichle parvatiya shetron evam ghatiyoon me aam ki vaigyanik kheti.* National Mango Festival (workshop and exhibition), 2018.

Nautiyal, P., Gupta J.P. and Singh, V. (2018). *Kadann phaslon ki kheti evam unke mulyvardhit utpad. Kisan Jyoti,* 6(2): 22-26.

Pande, K.K., Joshi, H.C. and Singh, N.K. (2018). *Safalta Gatha- Samekit krishi pranali se bane sakcham kisan*. *Phal Phul*, 39 (6): Cover II and III.

Pande, K.K., Singh, M.P., Singh, N.K. and Joshi, H.C. (2018). *Madhya avam nichle parvatiya chhetro me aru ki vaigynik bagwani kar labh kamaye*. *Kisan Bharati*, 49 (11): 39-44.

Rajashekara, H, Mishra, K.K, Subbanna, A.R.N.S., Stanley, J. and Pattanayak, A. (2018). *Kadann phasalon mein lagne wale pramukh rog evam keet*. *Kheti*. 71 (6): 47–50.

Singh, M.P., Singh, N.K. and Joshi, H.C. (2018). *Kharif faslon ki buwai avam beej shodhan ka mahatva*. *Kisan Bharati*, 49 (8): 4-6.

Singh, N.K., Joshi, H.C. and Singh N. (2018). *Samekit krishi pranali se aay doguni*. *Kheti*, 71 (3): 3-5.

Singh, N.K., Joshi, H.C. and Singh, M.P. (2018). *Sankar nasal ke pasupalan se dairy vyavasay ki aay doguni*. *Kisan Bharati*, 50 (3): 20-24.

14.5. Book Chapters

Mukherjee, A., Joshi, K., Joshi, P., Shubha, Roy, M.L., Jethi, R. and Chandra, N. (2018). Status of major pulses crop and its importance in nutritional security. *In:* Climate Risks Management Sustainable Pulse Production. pp. 169–180.

Arya, M., Bora, L., and Rajput, H. (2018). Hi-Tech Horticulture: Value addition and post harvest management. *In:* Packaging Material Technique, 6: 73-104p.

Rajput, H., Goswami, D., Arya, M. and Randhawa, A. (2018). Hi- Tech Horticulture: Value addition and post harvest management. *In:* Technology for canning, 6: 135-151p.

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.), 245-252.

Stanley, J., Subbanna, A.R.N.S. and Preetha, G. (2018). Extraction and identification of pheromones of the borer, *Conogethes punctiferalis* (Crambidae: Lepidoptera). *In:* The Black spotted, Yellow Borer, *Conogethes punctiferalis* Guenée and Allied Species, pp. 307–332, Springer, Singapore.

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. Merillon, J. & Ramawat, K.J. (eds.), pp. 1-28, Springer.

Bisht, J.K. and Singh, S. (2018). Improved crop production technology and pest management. *In:* Integrated pest management in major hill crops. Stanley, J., Mishra, K.K., Subbanna, A.R.N.S., Rajashekara, H. and Pattanayak, A. (eds.), 191-205 pp. Published by ICAR-VPKAS, Almora.

Yadav, R.P., Bisht, J.K., Meena, V.S. and Choudhary, M. (2018). Sustainable agroecosystems for livelihood security in Indian Himalaya. *In:* Sustainability of Agroecosystem. De Oliveira, A.B. (ed.) 63-77 pp.

Choudhary, M., Ghasal, P.C., Yadav, R.P., Meena, V.S., Mondal, T. and Bisht, J.K. (2018). Towards plant-beneficiary rhizobacteria and agricultural sustainability. *In:* Role of Rhizospheric Microbes in Soil. Meena, V. (ed.), 1-46. Springer, Singapore.

Bisht, J.K., Yadav, R.P. and Pattanayak, A. (2018). Fodder production and management in hills of Uttarakhand. *In:* Fodder Crops: approaches for value addition & enhancing income. Jindal, Y., Chhabra, A.K. and Roy, A.K. (eds.), 136-145 pp. Earth Vision Publications, Gurugram-122002, Haryana, India.

Pattanayak, A., Bisht, J.K., Yadav, R.P. and Pandey, B.M. (2018). Fodder tree-based agroforestry systems in Hills of Uttarakhand. *In:* Agroforestry for Climate Resilience and Rural Livelihood. Dev, I., Ram, A., Kumar, N., Singh, R., Kumar, D., Uthappa, A.R., Handa, A.K. and Chuaturvedi, O.P. (eds.), 65-81 pp. Scientific Publishers, New Delhi, India.

Mahanta, D., Bisht, J.K. and Bhatt, J.C. (2019). Organic farming in hill and mountain ecosystem. *In:* Organic Farming. Gopinath, K.A. and Ramanjaneyulu, A.V. (Eds.), 277-293 pp. Daya Publishing House, Astral International Pvt. Ltd. New Delhi.

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., Rajashekara, H. and Pattanayak, A. (eds.), 201-214 pp. ICAR-VPKAS, Almora.

Joshi, K., Jethi, R. and Chandra, N. (2018). Occupational health hazards in wheat cultivation among hill farm women. *In:* Humanizing work and work Environment. Singh, L.P., Singh, S. and Bhardwaj, P.A. (eds.), 484-486pp. GIAP Journals.

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. Prakash, O., Mukharjee, A. and Joshi, P. (eds.) 1-10pp. Today and tomorrow's printers and publishers, New Delhi.

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. Prakash, O., Mukharjee, A and Joshi, P (eds.) 63-72pp. Today and tomorrow's printers and publishers, New Delhi.

Mukharjee, A., Joshi, K., Joshi, P., Shubha, Roy, M.L., Jethi, R. and Chandra, N. (2018). Status of major pulses crop and its importance in nutritional security in North Western Himalaya, *In:* Climate Risks Management Sustainable Pulse Production. Srivasatava, A.K. and Yograjan (eds.) 69-180pp. Daya Publishing House, New Delhi.

Joshi, K. (2019). Indigenous technical knowledge in pest management. *In:* Integrated Pest Management in major crops. Stanley, J., Mishra, K.K., Subbanna, A.R.N.S., Rajshekhara, H. and Pattanayak, A. (eds.) 233-244pp. ICAR-VPKAS, Almora.

Arya, M., Bora, L., and Rajput, H. (2019). Hi-Tech Horticulture: Value addition and post harvest management, *In*: Packaging Material Technique. Tyagi, S. (ed.) 6:73-104. Sachin Tyagi, New India Publishing Agency (NIPA), New Delhi.

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14.6. Institute Publications

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

14.7. Extension Literature

- *Parvatiya Kshetron me Aaloo ki Vaigyanik Kheti* (113/2018)
- *Gehun ki Vaigyanik Kheti* (114/2018)
- *Parvatiya Kshetron mai Polytank Nirman* (115/2018)
- *Paramparik Gyan ke Upyog se Mandua va Anya Mote Anaajon mein Mulyavardhan* (116/2018)
- *Krishi Vigyan Kendra, Bageshwar – Ek Parichay* (117/2018)
- *Makka Sheller ke Samavesh se Kathin Shram Nyoonikaran* (118/2019).
- *Parvatiya Mahilaon hetu Poshan Suraksha ka Mahatva*
- *Soil Health Card*

14.8 Technical Bulletin

Stanley, J., Subbanna, A.R.N.S., Mishra, K.K. and Pattanayak, A. (2018). Butterflies of Almora. Technical Bulletin No. 41 (2/2018). ICAR-VPKAS, Almora, Uttarakhand. 101p.

Jethi, R., Joshi, K. and Mukherjee, A. (2018). *Parvatiya kshetron mein krishakon ki samasyain evam Samadhaan*. (FAQs), 54p.

Sachan, V.K., Nautiyal P., Tiwari, R.K., Papnai, G., Arya, M., Singh, N.K., Pandey, K., Gupta, J.P. and Singh, M.P. (2018). *Vivekananda Krishak Prasnnottari* KVK (ICAR-VPKAS), Technical Bulletin. 123p

14.9. T. V. Talk

- "*Haldi Ki Kheti*" for *Khet Khaliyan* programme of DD Kisan Television Channel on 28 May, 2018 which was broadcast on 6 June 2018.
- *"Badlte Jalvayu ke Paripakshe main Kadan Faslon ki Kheti"* for *Khet Khaliyan* programme of DD Kisan Television Channel on 28 May 2018, which was broadcast on 6 June 2018.
- *"Parvatiya Kheshtro mai Vriksho se Chara Utpadan"* TV Talk, *Khet Khaliyan*, DD Kisan, New Delhi on 30 May, 2018
- "*Fodder Production in Hills*" TV Talk, *Khet Khaliyan*, DD Kisan, New Delhi on 31 May, 2018

14.11. Peer recognition to ICAR-VPKAS scientists

Above NAAS Rating 8

- Science of the Total Environment (10.90), *Nature Scientific Report* (10.5), Renewable Energy: An International Journal (Solar and Wind Technology) (10.36), Chemosphere (10.21), Environmental Research (9.84), PLOSOne (8.81), Applied Soil Ecology (8.79), Plant Physiology & Biochemistry (8.72), Archives of Agronomy and Soil Science (8.14),

Above NAAS Rating 7

- Journal of Microbiology (7.92), Crop Protection (7.83), Journal of Economic Entomology (7.82), Environmental Monitoring and Assessment (7.69), Scientia Horticulture (7.62), Current Microbiology (7.32), 3Biotech (7.36), Journal of Apicultural Research (7.36)

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, A-biotic 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 – C. Ganesh Vasudeo]*
- Genetic Improvement of Pulses & Oilseeds for Higher Productivity, Quality, Biotic and Abiotic Stresses for North-Western Himalayan Hills *[Dr. Anuradha Bhartiya (on maternity leave w.e.f., Nov. 30, 2018 to 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

- 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)]*
- ICAR-CRP on Molecular Breeding in Maize *[Drs. R.K. Khulbe, R.S. Pal, Rajashekara H. & Rakesh Bhowmick (on study leave)]*
- 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)]*

15.2.3. 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]*

15.2.4. DUS project

- DUS/GOT trials in Kidney Bean *[Dr. Anuradha Bhartiya (on maternity leave w.e.f., Nov. 30, 2018 to 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 (w.e.f., April 15, 2017), Dr Kushagra Joshi]*
- Use of Plastics in Agriculture Particularly in Protected Cultivation, Water Harvesting and Packaging *[Drs. Sher Singh, Shyam Nath & Jitendra Kumar (w.e.f., April 15, 2017)]*
- All India Network Project on Soil Arthropod Pests *[Drs. J. Stanley & A.R.N.S. Subbanna]*
- Network Project on Organic Farming (NPOF) *[Drs. Dibakar Mahanta, P.K. Mishra, K.K. Mishra, J. Stanley, V.S. Meena & Venkatesan M. (upto June 26, 2018)]*

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. ICAR-FCI Sponsored Project

- Study on Determining Storage Losses of Food Grains in FCI and CWC Warehouses and to Recommend Norms for Storage Losses in Efficient Warehouse Management *[Dr. Sher Singh]*

15.2.8. NMHS Project

- Identification, Assessment and Enhancement of Soil Carbon and Nitrogen Sequestration Potential of Different Ecosystems in the Central Himalayan through a Community Participatory Approach *[Drs. V.S. Meena, B.M. Pandey, A. Mukherjee, T. Mondal (on study leave), R.P. Yadav, N.K. Singh, H.C. Joshi, P. Nautiyal & G. Papnai]*
- Strategies to Improve Health and Nutriotional Status of Hill Farwomen through Technological Interventions *[Drs. Renu Jethi, Nirmal Chandra, Pankaj Nautiyal & Manisha Arya*

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]*

15.2.10. DST Funded SERB Young Scientist Project

- Habitat Management of Non-Apis Bee Pollinator Conservation *[Dr. J. Stanley]*

15.2.11. NABARD Funded Project

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

15.2.12. DAC Funded Project through ICAR-NCIPM

- Efficacy of Phosphine Fumigant Against Storage Pests of Pulses, Wheat, Rice and Coffee Beans; and Residue Analysis for Quarantine and Long-term Storage Purpose *[Dr. J. Stanley]*

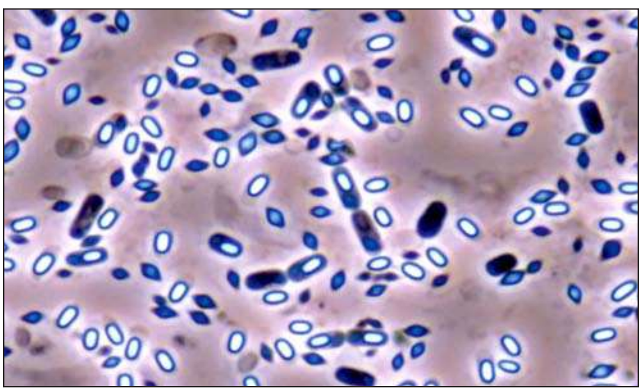
15.2.12. National Food Security Mission (NFSM) Funded Project

- Enhancing Breeder Seed Production to Increase Indigenous Production of Millets in India *[Dr. D.C. Joshi]*

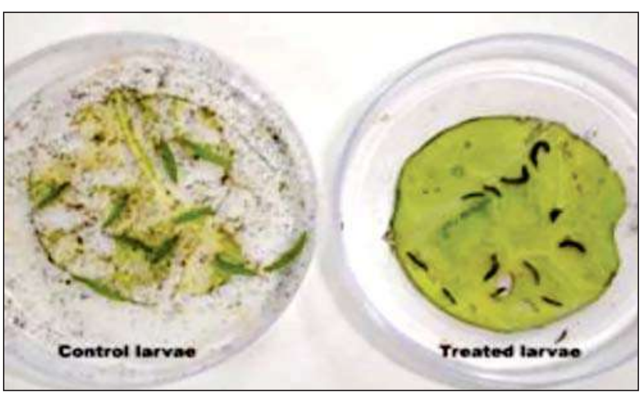
16. Consultancy, Patents & Commercilization of Technology

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 agro based medium comprised of (a) 0.06 to 3.2 % by weight of finely ground finger millet grain powder; (b) 60 and 85% tap water; (c) 0.2 to 4.0 % by weight of finely ground defatted soybean; (d) 0.0 to 4.6% by weight of cow dung (e) 0.0 to 3.0 % by weight of cow milk and (f) 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 (Decision from Assistant Controller of Patents and Designs on 27.02.2018) subjected to approval from National Biodiversity Authority (NBA). The NBA has approved the grant of patent on 01.03.2019.



Sporulated culture of VLBt 6



Bioassay with VLBt 6 on *Plutella xylostella*

16.2. Commercialization of Institute Varieties and Machines

CMVL Baby Corn 2, a potential baby corn hybrid has been commercialized with Bioseed Research India (A Division of DCM Shriram Ltd), Plot No-234, B Block, Kavuri Hills, Phase-II, Hyderabad-500033, Telangana, India for production and distribution of CMVL Baby Corn 2 seeds through signing a Material Transfer Agreement (MTA) on 9.08.2018 for four years.

VL-White Grub Beetle Trap-1 is a popular patented technology of the institute. It is very effective in trapping white grub beetle. A Technology License Agreement (TLA) for manufacturing and commercialization of VL-White Grub Beetle Trap-1 was signed on 4.05.2018 between ICAR-VPKAS, Almora and M/s Doon Trunk House, Jakhan Devi, Almora for four years. VL *Syahi Hal* (Iron plough) is another popular implement of the institute. A TLA between ICAR-VPKAS, Almora and *Navsrijan Bahuuddeshiya Swayatt Sahkarita*, Almora was signed on 8.06.2018 for manufacturing and commercialization of VL Syahi Hal for 3 years. *Vivek* Millet Thresher-cum-Pearler has become popular across the country. A TLA was signed between ICAR-VPKAS, Almora and Punjab Agricultural Implements Private Limited for manufacturing and commercialization of *Vivek* Millet Thresher-cum-Pearler on 9.08.2018 for 3 years.

Technology commercialization

Distribution of commercialized VL Whitegrub Beetle Trap to Parsari farmers

17. QQR, RAC, IMC & IRC Meetings

17.1. Quinquennial Review (QQR) Committee 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.

The first meeting of the committee was held on July 20-22, 2018 at ICAR-VPKAS, Almora. The Chairman sensitized the Institution's staff (scientific and non-scientific) on areas, the review committee would specifically be looking for. Subsequently, Dr. A. Pattanayak, Director, presented very comprehensive overview of various activities of the Institute followed by detailed presentations of Divisional Heads on scientific achievements of their respective Divisions. Later, the committee visited experimental farm, laboratories and took stock of other facilities of the Institute and had joint as well individual interaction with scientists of the Institute to understand about the working facilities/ environment in the Institute.

Meeting of QQR committee at ICAR-VPKAS

Field visit of QQR committee at ICAR-VPKAS

The QQR committee visited KVK Uttarkashi at Chinyalisaur, District Uttarkashi and KVK Bageshwar at Sinduri-Baskhola (Kafligair), District-Bageshwar (Uttarakhand) as well as head quarter, ICAR-VPKAS, Almora during December 3-6, 2018 to review outreach activities of the Institute through its KVKs and to have joint as well as individual interaction with non-scientific staff. During these visits, the team members also held several discussions with the concerned scientists on the problems of agricultural research in the hills.

QQR Meeting at KVK, Bageshwar

QQR visit to KVK, Uttarkashi

In final meeting held on March 14-15, 2019 at ICAR-VPKAS, Almora, the committee drafted the final report. The signed report submitted to ICAR authorities on April 15, 2019.

17.2. Research Advisory Committee (RAC) Meeting

The XXII Research Advisory Committee (RAC) meeting of ICAR-VPKAS, Almora was held on September 14, 2018 under the Chairmanship of Dr. K.R. Dhiman, Ex. Vice Chancellor, Dr. Y.S. Parmar

RAC Meeting and field visit at experimental farm, Hawalbagh

University of Horticulture & Forestry, Nauni, Solan. The RAC members present in the meeting were Dr. Hemendra Chandra Bhattacharyya, Ex. Director of Extension Education, Assam Agricultural University, Jorhat; Dr. Arun Kumar Sharma, Ex. Director, ICAR-NBAIM, Mau; Dr. K.K. Satpathy, Ex. Director, ICAR-NIRJAFT, Kolkata; 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. Dr. K.R. Dhiman, RAC Chairperson, in his opening remark appreciated expansion of institute's work in other states of North Western and North Eastern regions and stressed upon the need of working in parallel with other stakeholders sharing the similar resource base and challenges. RAC suggested that varieties for natural production system and organic production should have genetic resistance so as to avoid/ zero down the application of pesticides. Collaboration may be initiated with KVK Chamba, Himanchal Pradesh for strengthening buckwheat improvement programme.

17.3. Institute Management Committee (IMC) Meeting

The Institute Management Committee Meeting was held on July 28, 2018 under the chairmanship of the Director, ICAR-VPKAS, Almora.

IMC meeting

17.4. Evaluation of Experiments by Field Monitoring Team

The monitoring of field experiments conducted in *rabi* 2017-18 and *kharif* 2018 was done on March 17, 2018 and September 19, 2018, respectively at Experimental Farm, Hawalbagh. All the scientists participated and monitored the experiments. The progress was reviewed by the Director.

Field monitoring during *rabi* 2017-18

Field monitoring during *kharif* 2018

17.5. Institute Research Council (IRC) Meeting

The Institute Research Council (IRC) meeting for *kharif* 2018 and *rabi* 2018-19 were held on June 5, 2018 and October 25, 2018, respectively under the Chairmanship of the Director ICAR-VPKAS, Almora.

***Kharif* 2018 IRC meeting**

***Rabi* 2018-19 IRC meetings**

17.6. Institute Bio-safety Committee (IBSC) Meeting

The Institute Bio-safety Committee (IBSC) meeting was held on June 30, 2018 under the chairmanship of the Director, ICAR-VPKAS, Almora.

Institute Bio-safety Committee (IBSC) meeting

18. Participation of Scientists in Conferences, Seminar, Workshop, Symposia & Meetings

Name	Conference/Seminar/Workshop/Symposia/ Meetings
Dr. R.P. Yadav	Meeting with District Magistrate related to Kosi river rejuvenation on April 02, 2018 at District Magistrate office, Almora.
Drs. A. Pattanayak and R.P. Yadav	Meeting with Hon'ble Chief Minister and district officials related to Kosi river rejuvenation strategies and progress on April 04, 2018 at circuit house, Almora.
Dr. N.K. Hedau	Meeting with Hon'ble Member of Parliament, Almora at New Delhi regarding improved vegetable technologies for NW Himalayas and long day garlic scenario on April 4, 2018.
Dr. R.K. Khulbe	Annual Maize Workshop at CSKHPKV HAREC, Bajaura on April 7-9, 2018.
Dr. D. Mahanta	Monitoring of AICRP wheat crop at IARI-RS, Shimla, CSKHPKV, Berthin, Una, Akrot, Bara, Kangra, Malan, Palampur, Bajaura and Katrain, Himachal Pradesh on April 10-13, 2018.
Dr. D.C. Joshi	Twenty Ninth Annual group meeting of small millets held at IGKV, Raipur on April 12-13, 2018.
Drs. Sher Singh and Jitendra Kumar	Represented exhibition of Institute in the Ex-Serviceman Rally at Berinaag (Pithoragarh) organized by 13th Sikh Regiment on April 22, 2018.
Dr. N.K. Hedau	Committee for case of Plagiarism at GBPNIHESD, Almora on April 25, 2018.
Dr. R.K. Khulbe	*Kharif* SVT Workshop at Directorate of Agriculture, Dehradun on April 28, 2018.
Dr. Chaudhari Ganesh Vasudeo	*Kisan Kalyan Diwas* and *Kisan gosthi* organized by the State Agriculture Department, Uttrakhand at Basot, Bhikyasen on May 02, 2018.
Drs. R.P. Yadav and D. Mahanta	*Kisan Kalyan Diwas* at Harna, Sult and Raun on May 02, 2018.
Dr. Sher Singh	*Kisan Kalyan Diwas* at village Kharsari, Nayay Panchayat Nanai in the Mori block of Uttarakashi district of Uttarakhand under the '*Gram Swraaj Abhiyan'* on May 02, 2018.
Dr. L. Kant	Joint group meeting of 33rd AGM of AICRP-NSP(Crops) and 13th ARM of ICAR Seed Project at Panjancoa, Karaikal on May 9-11, 2018.
Ms. Manisha Arya	International workshop on Nutri Sensitive Agriculture and Nutrition Literacy at Bhopal on May 14-16**, 2018.**
Dr. Chaudhari Ganesh Vasudeo	Multi-crop exploration programme organized by ICAR-NBPGR, New Delhi in the Pangu area of Uttarakhand on May 16-24, 2018.
Dr. S.C. Panday	Review meeting of NMSHE project at ICAR-VPKAS Almora on May 17, 2018.
Dr. Sher Singh	5th Meeting of Indian Grain Storage Working Group (IGSWG), New Delhi on May 21, 2018.
Dr. N.K. Hedau	XXXVI Group Meeting of All India Coordinated Research Project on Vegetable Crops at RARI, Durgapura on May 18-21, 2018.
Dr. Lakshmi Kant	Annual Review Meeting of 33rd CRP on Agrobiodiversity at NBPGR New Delhi on May 18-19, 2018.
Dr. Pankaj Nautiyal	State level Annual Action Plan Meeting at GBPUA&T, Pantnagar on May 18**, 2018.**
Dr. Pankaj K. Mishra	Half Day workshop with Hon'ble DG ICAR, NASC Complex, New Delhi on May 25, 2018.
Dr. N.K. Hedau	*Sansadiya Rajyabhasha Committee Ki Doosari Upsamiti* at ICAR-DCFR on June 02, 2018.
Dr. Chaudhari Ganesh Vasudeo	IXth Annual Group Meeting of All India Network Research Project (AINRP) on Onion and Garlic, at PAU, Ludhiana on June 08-10, 2018.

Name	Conference/Seminar/Workshop/Symposia/ Meetings
Dr. N.K. Hedau	Hindi Rajbhasha sub-committee meeting at ICAR-DCFR on June 08-09, 2018.
Dr. Lakshmi Kant	Annual Review Meeting of CRP Molecular breeding project Wheat at IARI, New Delhi on June 09, 2018.
Dr. R.K. Khulbe	CRP Molecular Breeding Review Meeting at IARI, New Delhi on June 09, 2018.
Dr. L. Kant	Regional committee No 1 meeting held at SKUAST Srinagar on June 11-12, 2018.
Dr. R.K. Khulbe	Visited Rishikesh and Nainital and acted as Protocol officer of Sh. Laxmi Narayan Yadav (MP and member of Committee of Parliament on Official Language) from June 11-14, 2018.
Dr. R.P. Yadav	Participated in Kosi river rejuvenation meeting with Chief Minister, Uttarakhand and district officials on June 11, 2018 at Majkhali.
Dr. S.C. Panday	Biennial scientist meets of AICRP—IWM and GWM held at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth Dapoli (Maharashtra) on June 13-15, 2018.
Dr. R.P. Yadav	RAC meeting of Uttarakhand Forest Research Institute, Haldwani on June 28, 2018 at Dehradun.
Dr. D.C. Joshi	Project meeting of enhancing breeder seed production millets for indigenous production of millets in India at Indian Institute of Millets Research, Hyderabad on July 03, 2018.
Dr. J.K. Bisht	SAPC-meeting of GBPNIHESD, Katarmal as a member of the committee in New Delhi on July 27, 2018.
Dr. Chaudhari Ganesh Vasudeo	QQR meeting of AINRP Onion and Garlic at ICAR-DOGR, Pune on July 30, 2018.
Dr. R.K. Khulbe	*Rabi* Seed Meeting at Directorate of Agriculture, Dehradun on August 06, 2018.
Dr. L. Kant	Brain storming session on Blast proofing in Agriculture at IIWBR, Karnal on August 08, 2018.
Dr. D.C. Joshi	One day workshop on finger millet product design and management workshop on August 13, 2018.
Dr. A. Pattanayak	Visited Nepal as ICAR nominee in the Indo-Nepal Joint Working Group on Agriculture during August 16-17, 2018.
Dr. J.K. Bisht	Review meeting of KVK Bageshwar taken by Hon'ble State Minister of Textile, Shri Ajay Tamta at Kafaligair, Bageshwar on August 25, 2018.
Dr. L. Kant	57th AII India Wheat and Barley Research Workers meeting at BAU, Ranchi on August 24-26, 2018.
Drs. Pankaj Nautiyal & Gaurav Papnai	ASCI orientation programme for skill development trainings held at PAU Ludhiana on August 30 to September 01, 2018.
Drs. J.K. Bisht and R.P. Yadav	National group meeting of AICRP on forage crops, CCSHAU, Hisar on September 7-8, 2018.
Dr. R.K. Khulbe	*Kharif* 2018 AICMIP monitoring of MPKV, Rahuri on September 18-21, 2018.
Drs. L. Kant, D.C Joshi & Renu Jethi	Small millet field day at Tunakot on September 19, 2018.
Dr. Dibakar Mahanta	Monitoring of AICRP *kharif* maize crop at PJTSAU, Rajendranagar, Hyderabad; PJTSAU-RS, Karimnagar, Telengana and ANGRAU, Peddapuram, Andhra Pradesh on September 25-27, 2018.
Dr. L. Kant	*Rabi* SVT meeting held at Directorate of Agriculture, Dehradun on September 26, 2018.
Drs. A. Pattanayak, L. Kant, J.K. Bisht, R.K. Khulbe & Kushagra Joshi	National Seminar on Development of Hill Agriculture: Policy and Institutional Imperative at SKUAST-K, Srinagar on October 01, 2018.
Dr. Pankaj Nautiyal	Apple festival at Harshil, Uttarkashi on October 01, 2018.
Dr. R.K. Khulbe	13th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security at PAU, Ludhiana on October 08-10, 2018.
Dr. R.K. Khulbe	CRP Biofortification meeting at PAU, Ludhiana on October 09, 2018.

Name	Conference/Seminar/Workshop/Symposia/ Meetings
Drs. Sher Singh and Shyam Nath	Brain storming Session on "Problem Identification and New Project Formulation" at ICAR-CIPHET Ludhiana on October 15, 2018.
Drs. Renu Jethi and Ankita Kandpal	*Mahila Kisan Diwas* programme organised at Vikas Bhawan, Almora, Uttarakhand on October 15, 2018.
Drs. A. Pattanayak, J.K. Bisht, S.C. Panday, R.P. Yadav & V.S. Meena	Environment Summit-2018 at GBPNHIED, Kosi, Almora on October 20, 2018.
Dr. L. Kant	Meeting with Dr G B Singh, Ex Chairman, ASRB, New Delhi on October 24, 2018.
Dr. J.K. Bisht	IInd biennial Agronomy National Symposium "Doubling Farmers Income through Agronomic Intervention Under Scenario at MPRAU, Udaipur on October 24-26, 2018.
Drs. A. Pattanayak, L. Kant, K.K. Mishra & Renu Jethi	Meeting with officials of state department of Agriculture, Jammu and SKUAST Jammu as a follow up of the action point of RCM1 on October 29, 2018.
Dr. D. Mahanta	International Symposium and IPNI Cooperators' Meet on "Advancement in Soil, Water and Plant Nutrition Research", VANAMATI, Nagpur on November 2-3, 2018.
Dr. L. Kant	RAC meeting of IIWBR, Karnal as Zonal Coordinator of NHZ on November 12, 2018.
Dr. R.P. Yadav	Kosi River Rejuvenation at Vikas Bhawan, Almora on November 15, 2018.
Drs. Sher Singh, Shyam Nath & Jitendra Kumar	Meeting on Operational Guidelines for Innovation and Agri-Entrepreneurship Cell under RKVY-RAFTAAR at New Delhi on November 22, 2018.
Dr. Dibakar Mahanta	3rd QRT Meeting of Network Project on Organic farming, SKUAST, Jammu, November 22-23, 2018.
Dr. Pankaj K. Mishra	13th All India Network Project on Organic Farming (NPOF) Group Meeting at TNAU, Coimbatore on November 27-29, 2018.
Dr. J.K. Bisht	QQR Meeting at KVK, December 03, 2018 Chinyalisaur, Uttarkashi
Dr. Pankaj K. Mishra	Two-day Workshop of Officer In-charge Data Management at ICAR-IASRI, New Delhi on December 04-05, 2018.
Dr. J.K. Bisht	QQR Meeting at KVK, Kafligair, Bageshwar on December 05, 2018.
Dr. S.C. Panday	Review meeting of NMSHE Project at NASC, New Delhi on December 06, 2018.
Dr. R.K. Khulbe	Review meeting of NASH DH Maize project by ADG (NASF) on December 13, 2018.
Dr. R.K. Khulbe	1st National Genetic Congress at IARI, New Delhi on December 15-16, 2018.
Scientists of ICAR-VPKAS	14th Annual Workshop of AICRP on Plasticulture Engineering & Technology, ICAR-VPKAS, Almora, December 18-19, 2018.
Dr. S.C. Panday	IMC meeting of ICAR-DFMD, Mukteshwar at ICFMD Bhubaneswar on January 19, 2018.
Dr. S.C. Panday	International Conference on Sustainability of Small Holders Agriculture in Developing Countries Under Changing Climatic Scenario at Chandra Shekhar Azad University of Agriculture & Technology Kanpur on February 14-17, 2018.
Dr. S.C. Panday	*Gosthi* on Water Day organized in Vikash Bhavan, Almora on March 22, 2018.
Scientists of ICAR-VPKAS	Workshop on Development and Sensitization of the Academic Community of the Uttarakhand-Almora on Formulation of the S&T proposal on Location Specific Challenges on January 20, 2019.
Drs. Renu Jethi & R. P. Yadav	2nd National Seminar-cum-Monitoring & Evaluation (M&E) Workshop of NMHS on February 4-7, 2019.
Drs. J.K Bisht, J. Stanley & Renu Jethi	XIV Agricultural Science Congress at New Delhi on February 20-23, 2019.
Dr. Kushagra Joshi	Annual Review meeting of NASF funded project at NASC, New Delhi on February 27, 2019.
Dr. S.C. Panday	Seminar on "Emerging trends in Hi tech horticulture in climate change" under NMSHE at ICAR-CITH Muketshwar on March 6-7, 2019.
Dr. Pankaj Nautiyal	Spring Festival at Rajbhavan Dehradun on March 9-10, 2019.

19. Workshops, Seminars, Farmers' Days Organized

Parliamentary Committee on Official Language Inspected the Work of Rajbhasha of the Institute

Second subcommittee of Committee of Parliament on Official Language inspected the work of Official Language of this Institute on 12.06.2018 at Nainital. First of all, the Committee visited the stall of Institute publication and books exhibited in the committee room and Dr. Arunav Pattanayak, Director of the Institute appraised the Hon'ble members about the Institute activities. Dr. Satendra Singh, Senior Research Officer of the committee secretariat appraised about the committee and its functioning. Dr. Arunav Pattanayak, Director of the Institute welcomed the Hon'ble members of the committee and assured that follow up action and compliance on the suggestion of the committee will be taken up on priority.

Release of Parvatiya Krishi Darapan during Parliamentary Committee on Official Language

In the meeting Dr. Devendra Kumar Yadav, Assistant Director General (Seed) Mrs. Seema Chopra, Director (Official Language) and Mr. Manoj Kumar, Asstt. Chief Technical Officer (OL) represented the ICAR and Dr. Arunav Pattanayak, Director, Dr. Brij Mohan Pandey, Principal Scientist, Shri. Hajari Lal Meena, Administrative Officer and Shri. Tej Bahadur Pal, Asstt. Chief Technical Officer (OL) represented the Institute. On the occasion 21st edition (Part-2 July to December 2017) of Institute Newsletter *'Parvatiya Krishi Darpan'* was released by the Hon'ble convener of the committee Dr. Prasanana Kumar Patsani (Member of Lok Sabha).

Second meeting on Technology Exchange and Joint Research in between Hill Region of ICAR Institutes

Second meeting on Technology Exchange and Joint Research in between Hill Region of ICAR Institutes was organized at ICAR-VPKAS, Almora

Second subcommittee of Parliamentary Committee on Official Language

2nd meeting on Technology Exchange and Joint Research between ICAR Institutes of hill regio

on May 17, 2018. This meeting was chaired by Dr. B.P. Bhatt, Director, ICAR Research Complex for Eastern Region, Patna. Dr. A. Pattanayak, Director, ICAR-VPKAS welcomed the members and presented the action taken report of the first Meeting of Hill Consortium of ICAR Institutes. Dr Rajbir Singh, Director, ATARI, Ludhiana; Dr. N. Prakash, Director, ICARRC for NEH Region, Umiam, Meghalaya; Dr. B.C. Deka, Director, ICAR-ATARI, Zone III, Umiam, Meghalaya; Dr. A.K. Tripathi, Director, ICAR-ATARI, Zone VI, Guwahati, Assam; Dr. Vinod Kapoor, Head, ICAR-CPRI, Shimla, Himanchal Pradesh; Dr. B.L. Attri, ICAR-DMR, Solan, Himanchal Pradesh; Dr. N.K. Sharma, ICAR-IISWC, Dehradun, Uttarakhand; Dr. Prem Kumar, ICAR-DCFR, Bhimtal, Uttarakhand; Dr. M.A Ramakrishnan, ICAR-IVRI Regional Station, Mukteshwar; Dr. M.A. Raut & Dr. S.A. Khulapa, ICAR-PDFMD, Mukteshwar; Dr. Rajnarayan, ICAR-CITH, Mukteshwar and scientific staff of ICAR-VPKAS, Almora discussed technology exchange and collaborative research among ICAR institutes which are working on hill regions. The committee discussed sharing of new technologies, germplasm exchange, inclusion of special research agenda of KVKs in the future research programme of participating research institutes.

World Environment Day Celebration at ICAR-VPKAS, Almora

- Institute and its KVKs celebrated world environment day on June 5, 2018. Saplings of different multipurpose tree species (~300nos.) were planted at experimental farm, Hawalbagh on the occasion.

Plantation of saplings at experimental farm, Hawalbag

Plantation of saplings at experimental farm, Hawalbag

Live Telecast of Hon'ble Prime Minister's Interaction with Farmers

The arrangement for viewing the live telecast of the Hon'ble Prime Minister's interaction with farmers on June 20, 2018 was made at ICAR-VPKAS, Almora, Experimental Farm, Hawalbag, KVKs at Uttarkashi and Bageshwar. More than 300 farmers, staff and other officials viewed the speech of Hon'ble PM.

Participants at Almora Campus of ICAR-VPKAS

Participants at Hawalbag Campus

Participants at KVK, Uttarkashi

Participants at KVK, Bageshwar

International Day of Yoga Organized at ICAR-VPKAS, Almora and Experimental Farm at Hawalbagh

International Day of Yoga was organized on June 21, 2018 at ICAR-VPKAS Headquarter, Almora, Experimental Farm at Hawalbagh, KVKs at Chinyalisaur and Bageshwar as per the Common Yoga Protocol (CYP) developed by the Ministry of AYUSH, Government of India. At the start of the Yoga programme, Dr. Sher Singh, Sr. Scientist and Nodal Officer of the programme briefed the participants about the general guidelines of the Common Yoga Protocol (CYP). The Yoga programme began with the prayer followed by loosening exercises, *Yogaasana*, *Kapaalbhaarati*, *Pranayama*, *Dhyana*/Meditation under supervision of Dr. P.K. Mishra. The programme ended with *Sankalp*a followed by *Shaanti Paatha*.

International Day of Yoga

95th Foundation Day

ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan celebrated its 95th Foundation Day on July 4, 2018 with great enthusiasm. Shri. Ajay Tamta, Minister of State for Textiles and Member of Parliament (MP) from Almora constituency was the Chief Guest on the occasion.

95th Foundation Day programme

Model Training Course on IPM in Major Hill Crops conducted

ICAR-VPKAS conducted a Model Training Course (MTC) on Integrated Pest Management in Major Hill Crops during October 03-10, 2018. Nineteen participants from five states of the country *viz.*, Uttarakhand, Himachal Pradesh, Sikkim, Arunachal Pradesh and Kerala attended the program. Total 30 theory lectures and nine practical sessions on concepts and components of IPM, identification of insect pest and diseases

Inauguration of MTC on IPM

Theory classes

Practical class

Field visits

of crops and their management, biointensive pest management, natural enemy conservation, plant quarantine, pesticide selection, safe handling of pesticides, nutrient deficiencies in crop plants, weed management and wild animal management. Lectures on disease forecasting, ITK and ICTs in pest management were also included.

Organization of Sports Activities on Independence Day

Sports programme for staff and their family members was organized on the occasion of Independence Day at Experimental Farm, Hawalbagh on August 15, 2018. Fodder tree saplings were also planted on this occasion.

Sports activities on Independence Day

Plantation of saplings on Independence Day

Organization of *kavi sammalan* and *kavita path pratiyogita*

Rich tribute was paid to Bharat Ratna Late Shri. Atal Bihari Vajpayee on the occasion of first monthly death anniversary by organizing *kavi sammalan* and *kavita path pratiyogita* of his poetries on September 16, 2018 in the auditorium of ICAR-VPKAS, Almora. Poet laurets of hindi literature namely, Dr. Diwa Bhatt, Shri Tribhuwan Giri, Shri Naveen Bisht and Dr. Deepa Gupta graced the occasion by delivering self composed poems and the poetries of Late Shri. Atal Bihari Vajpayee. All the employees of the Institute were present on the occasion.

Kavi sammelan* and *Kavita path pratiyogita

World Soil day

World Soil day was celebrated on December 5, 2018 at Experimental Farm, Hawalbag of ICAR-VPKAS, Almora. On the occasion Dr. M.Y. Zargar, Director (Research), SKUAST, Srinagar was the Chief Guest and Dr. S.P. Sharma, Ex-Director (Research), CSKHPKVV, Palampur was the Guest of Honour.

World Soil day celebrated at Institute

World Soil day celebrated at KVK Bageshawar

World Soil day celebrated at KVK Chinyalisaur

14th Annual Workshop of AICRP on Plasticulture Engineering and Technologies

The 14th Annual Workshop of All India Coordinated Research Project on Plasticulture Engineering and Technologies (AICRP on PET) was organised on December 18-19, 2018 at ICAR-VPKAS, Almora. Dr. R.S. Rawal, Director, GBPNIHESD, Kosi-Katarmal, Almora, was the Chief Guest. Speaking on the occasion, Dr. Rawal highlighted the importance of plastics in agriculture and suggested for preparation of proper plan to mitigate the effect of plastics on the environment. A brief progress report of the project work during 2018-19 was presented by Dr. R.K. Singh Project Coordinator, AICRP on PET & Director, ICAR-CIPHET, Ludhiana. He informed that presently 14 centres at different locations in the country are working in the project. Dr. Pitam Chandra and Dr. Ashwani Kumar, ex-Directors of ICAR institutes were the special guests. They briefed about the history and establishment of the project and highlighted that use of the plastics is a need of the hour for increasing production and water conservation. More than 40 delegates from different institutes and universities participated in the workshop. Eleven technical bulletins/extension books and two video

14th Annual Workshop of All India Coordinated Research Project on Plasticulture Engineering and Technologies

films were also released on this occasion. In the plenary session, Dr. A. Pattanayak, Director, ICAR-VPKAS, Almora explained about the demand of the plasticulture engineering technologies in the India and particularly in Himalayan states.

Training program 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 officials from Almora district attended the program. The program was inaugurated by Dr. A. Pattanayak, Director ICAR-VPKAS and highlighted the importance of diseases and insect-pests in crops especially in rabi crops. He emphasized on the pest management for doubling agriculture production and productivity. There were total 3 lectures on different aspects of diseases and insect-pests management.

Workshop 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 program 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 program 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. On completion of the training programme on March 28, 2019, certificates were distributed to the participants.

Capacity Building Training Program for SSS of ICAR-VPKAS

Capacity Building Training Program for SSS of ICAR-VPKAS

Lectures, demonstrations and hands on by participants

Distribution of certificates to participants

Training program on "Micro Irrigation Technician" under the Skill India Program of Government of India

ICAR-VPKAS has organized one-month training program (200 working hours) on "Micro Irrigation Technician" for twenty farmers/students from December 27, 2018 to January 25, 2019. The program was sponsored by National Skill Development Corporation under the Skill India Program 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. Dr. Jitendra Kumar and Er. D.C. Mishra, were the Course Coordinators of training programme. On completion of training programme, the certificates were distributed to the participants by the Director.

Training program on "Mushroom Growers" under the Skill India Program of Government of India

A twenty-five days training program on "Mushroom Growers" for farmers/students was organized at ICAR-VPKAS during Feb. 01-March 02, 2019. The program 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 etc. amongst participants. In this training a total of twenty participants (16 male and 04 females) from Almora and Nainital districts were participated. The candidates were assessed by external examiner appointed through committee members of Agricultural Skill Council of India New Delhi. Dr. K.K. Mishra, Principal Scientist, Plant Pathology was the Course Coordinator for the training programme. All the candidates have completed the training programme successfully and the Director, ICAR-VPKAS, Almora distributed certificates to the participants.

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 from 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 BHU Agriculture students at ICAR-VPKAS, Almora

A summer training was conducted at ICAR-VPKAS, Almora for thirty B.Sc. (Ag.) students of Banaras Hindu University, Varanasi during May 15-18, 2018. 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

Vigilance Week

The Institute celebrated the Vigilance Awareness Week during October 29-November 03, 2018 at ICAR-VPKAS, Almora and KVKs at Bageshwar and Chinyalisaur. Various outreach programmes were organized to motivate stakeholders to collectively participate in the fight against corruption and also aims at raising public awareness regarding the detrimental consequences of corruption.

Vigilance awareness week at ICAR-VPKAS

Vigilance awareness week at KVKs

Kisan Mela

ICAR-VPKAS organised *kharif* kisan mela at Experimental Farm, Hawalbag on September 27, 2018 with great enthusiasm. Shri. Nitin Bhadoria, District Magistrate, Almora was the chief guest of the function. Institute organised *rabi* Kisan Mela and *Pradhan Mantri Kisan Samman Nidhi* on February 24, 2019 at ICAR-VPKAS, Almora. Shri. Ajay Tamta, Hon'ble 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 Chief guest released one variety of pea, Vivek *Matar* 15 for farmers. More than 500 farmers participated in the Kisan Mela.

***Kharif* Kisan Mela**

Rabi* Kisan Mela and *Pradhan Mantri Kisan Samman Nidhi

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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 राजभाशा कार्यान्वयन समिति का गठन किया गया है। समिति की प्रत्येक तिमाही में बैठक की जाती है। वर्ष 2018–19 के दौरान समिति की बैठकें क्रमशः 29.06.2018, 28.09.2018, 28.12.2018 एवं 30.03.2019 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 75–80 प्रतिशत 'ख' क्षेत्र साथ 65–70 प्रतिशत तथा 'ग' क्षेत्र के साथ 60–65 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 2018 से 13 अक्टूबर 2018 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 14.09.2018 को हिन्दी दिवस समारोह 16.09.2018 एवं 12.10.2018 को संगोष्ठियों का आयोजन किया गया, जिसमें स्वरचित कविता पाठ एवं तात्क्षणिक भाषण प्रतियोगिताओं का आयोजन किया गया। इन कार्यक्रमों में हिन्दी व अहिन्दी भाषी क्षेत्रों के कार्मिकों ने 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 2018–19 के दौरान ये बैठकें 28.07.2018 एवं 14.12.2018 को आयोजित की गयी। वर्तमान में समिति के सदस्य कार्यालयों की संख्या 32 है जिसमें केन्द्र सरकार के शोध संस्थान, विभाग, राष्ट्रीयकृत बैंक, उपक्रम, सक्षस्त्र बल आदि सम्मिलित है। वर्ष के दौरान नराकास का राजभाशा पत्रिका 'हिमानी' के प्रथम अंक का प्रकाशन किया गया। 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

- Dr. Tej Pratap Singh, VC, G.B.P.U.A&T., Pantnagar on July 20, 2018 and March 14, 2019.
- Dr. B.P. Bhatt, Director, ICAR Research Complex for Eastern Region, Patna on May 14, 2018.
- Shri. Ajay Tamta, Hon'ble Minister of State for Textiles and Member of Parliament (MP) on July 4, 2018 & February 24, 2019.

- Dr. K.R. Dhiman, Ex. Vice Chancellor, Dr. Y.S. Parmar University of Horticulture & Forestry, Nauni, Solan on September 14, 2018.
- Dr. G.B. Singh, Ex. ASRB Chairman and Dr. R.K. Singh, ADG Commercial Crops, ICAR, New Delhi on October 24, 2018.

- Padma Shri Anil Joshi visited ICAR-VPKAS, Almora on January 20, 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, Scientist (Plant Breeding)

Dr. Anuradha Bhartiya, Scientist (Plant Breeding)

Dr. Ramesh Singh Pal, Scientist (Biochemistry)

Mr. Rakesh Bhowmick, Scientist (Agriculture Biotechnology) *(on study leave)*

Dr. Chaudhari G. Vasudeo, Scientist (Vegetable Science)

Dr. D.C. Joshi, Scientist (Plant Breeding)

Dr. Hanuman Ram, Scientist (Vegetable Science)

Ms. Asha Kumari, Scientist (Plant Physiology) *w.e.f.* Oct. 08, 2018

Dr. Navin Chander Gahtyari, Scientist (Genetic & Plant Breeding) *w.e.f.* Oct. 09, 2018

Dr. Devender Sharma, Scientist (Genetic & Plant Breeding) *w.e.f.* Oct. 09, 2018

Crop Production Division

Dr. J.K. Bisht, Principal Scientist (Agronomy) & I/c Head

Dr. S.C. Panday, Principal Scientist (Soil Science)

Dr. P.K. Mishra, Principal Scientist (Agricultural Microbiology)

Dr. B.M. Pandey, Principal Scientist (Agronomy)

Dr. Sher Singh, Principal Scientist (Agronomy)

Dr. Dibakar Mahanta, Sr. 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 (Soil and Water Conservation Engineering)

Dr. Manoj Parihar, Scientist (Soil Science)

Mr. Rajendra Prasad Meena, Scientist (Agronomy) *w.e.f.* July 28, 2018

Er. Utkarsh Kumar, Scientist (Land & Water Management Engineering) *w.e.f.* 09.10.2018

Dr. Priyanka Khati, Scientist (Agricultural Microbiology) *w.e.f.* Oct. 09, 2018

Crop Protection Section

Dr. K.K. Mishra, Principal Scientist (Plant Pathology) & I/c

Dr. J. Stanley, Senior Scientist (Agricultural Entomology)

Dr. A.R.N.S. Subbanna, Scientist (Agricultural Entomology)

Dr. Venkatesan, M., Scientist (Plant Nematology) (upto June 26, 2018)

Dr. Rajashekara, H., Scientist (Plant Pathology)

Mr. Amit Umesh Paschapur, Scientist (Agricultural Entomology) *w.e.f.* Oct. 09, 2018

Mr. Ashish Kumar Singh, Scientist (Nematology) *w.e.f.* Oct. 09, 2018

Mr. Jeevan B., Scientist (Plant Pathology) *w.e.f.* Oct. 09, 2018

Social Science Section

Dr. Nirmal Chandra, Principal Scientist (Agricultural Extension) & I/c

Dr. Renu Jethi, Scientist (Home Science Extension)

Mr. Anirban Mukherjee, Scientist (Agricultural Extension) (upto July 13, 2018)

Dr. Kushagra Joshi, Scientist (Home Science/FRM)

Ms. Ankita Kandpal, Scientist (Agricultural Economics) *w.e.f.* July 16, 2018

Mr. Sushil Kumar, Scientist (Agricultural Extension) *w.e.f.* July 28, 2018

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 (Hawalbagh)

Drs. N.K. Hedau & Sher Singh (Mukteshwar)

Vehicle

Mr. T.B. Pal

Guest House

Dr. B.M. Pandey (Hawalbagh)

Mr. T.B. Pal (Almora)

Maintenance

Mr. T.B. Pal

Krishi Samridhi Radio Programme

Dr. Kushagra Joshi

Technical Officers

Shri. T.B. Pal

Shri. L.D. Malkani (upto Dec. 31, 2018)

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. S.L. Arya (upto April 30, 2018)

Shri. G.S. Bisht

Smt. Renu Sanwal

Shri. O.P. Vidhyarthi

Shri. Daya Shankar

Shri. M.S. Rautela (upto Aug. 31, 2018)

Shri. C.S. Kanwal

Shri. B.S. Nagarkoti (upto Jan. 31, 2019)

Shri. J.K. Arya

Shri. Narayan Ram

Shri. Keshav Nautiyal (*w.e.f.,* Dec. 01, 2018)

Shri. Sachin Singh Panwar (*w.e.f.,* Dec. 04, 2018)

Shri. Devendra Singh Karki (*w.e.f.,* Dec. 12, 2018)

Shri. Ajit Bisht (*w.e.f.,* Dec. 13, 2018)

Shri. Sudhanshu (*w.e.f.,* Dec. 27, 2018)

Smt. Monika Yadav (*w.e.f.,* Dec. 31, 2018)

Shri. Deenbandhu Gain (*w.e.f.,* Dec. 31, 2018)

Administration and Finance

Senior Administrative Officers

Mr. Y.S. Dhanik

Administrative Officers

Mr. H.L. Meena (upto Jan. 31, 2019)

Mr. A.K. Joshi (*w.e.f.* Jan. 15, 2019)

Assistant Administrative Officers

Mrs. Radhika Arya

Mr. Lalit Mohan Tewari *w.e.f.* Nov. 27, 2018

Finance & Accounts Officer

Mr. H.L. Meena, I/c FAO (upto May 25, 2018)

Mr. B.C. Pandey, FAO (*w.e.f.* May 26, 2018)

Stores

Mr. H.L. Meena (upto Jan. 31, 2019)

Mr. A.K. Joshi (*w.e.f.* Jan. 15, 2019)

Managerial Staff at KVK, Chinyalisaur

Dr. V.K. Sachan, Programme Coordinator

Dr. Pankaj Nautiyal, ACTO, Horticulture

Ms. Manisha, ACTO, Home Science

Dr. Gaurav Papnai, ACTO, Agril. Extension

Mr. Neeraj Joshi, Farm Manager (w.e.f. Sept. 19, 2018)

Mrs. Khobragade R. Tamradhwaj, PA (computer) (w.e.f. Sept. 22, 2018)

Mr. Varun Supyal, Lab Technician (w.e.f. Oct. 05, 2018)

Managerial Staff at KVK, Bageshwar

Dr. Kamal Kumar Pandey, ACTO, Horticulture

Dr. N.K. Singh, ACTO, Veterinary Science

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 B.C. Pandey, FAO on May 26, 2018
- Ms. Ankita Kandpal, Scientist (Agricultural Economics) on July 16, 2018
- Shri. Rajendra Prasad Meena, Scientist (Agronomy) on July 28, 2018
- Shri. Sushil Kumar, Scientist (Agricultural Extension) on July 28, 2018
- Mr. Neeraj Joshi, Farm Manager, KVK, Chinyalisaur on Sept. 19, 2018
- Mrs. Khobragade Rohini Tamradhwaj, Programme Assistant (Computer) KVK, Chinyalisaur on Sept. 22, 2018
- Mr. Varun Supyal, Programme Assistant (Lab Technician) KVK, Chinyalisaur on Oct. 05, 2018
- Ms. Asha Kumari, Scientist (Plant Physiology) on Oct. 08, 2018
- Mr. Amit Umesh Paschapur, Scientist (Agricultural Entomology) on Oct. 09, 2018
- Er. Utkarsh Kumar, Scientist (Land & Water Management Engineering) on Oct. 09, 2018
- Mr. Ashish Kumar Singh, Scientist (Nematology) on Oct. 09, 2018
- Mr. Jeevan B., Scientist (Plant Pathology) on Oct. 09, 2018
- Dr. Navin Chander Gahtyari, Scientist (Genetics & Plant Breeding) on Oct. 09, 2018
- Dr. Devender Sharma, Scientist (Genetics & Plant Breeding) on Oct. 09, 2018
- Dr. Priyanka Khati, Scientist (Agricultural Microbiology) on Oct. 09, 2018
- Mr. Keshav Nautiyal, Technical Assistant/T-3 (Field/Farm Technician) on Dec. 01, 2018
- Mr. Sachin Singh Panwar, Technical Assistant/T-3 (Field/Farm Technician) on Dec. 04, 2018
- Mr. Devendra Singh Karki, Technician/T-1 (Field/Farm Technician) on Dec. 12, 2018
- Mr. Ajit Bisht, Technician/T-1 (Field/Farm Technician) on Dec. 13, 2018
- Mr. Sudhanshu, Technical Assistant/T-3 (Library) on Dec. 27, 2018
- Mrs. Monika Yadav, Technical Assistant/T-3 (Field/Farm Technician) on Dec. 31, 2018
- Mr. Deenbandhu Gain, Technician/T-1 (Field/Farm Technician) on Dec. 31, 2018

Retirement

- Mr. Shankar Lal Arya, Technical Officer on April 30, 2018
- Dr. V. K. Sachan, Head & Principal Scientist, KVK, Chiyalisaur on Aug. 31, 2018
- Shri Mohan Singh Rautela, Technical Officer on Aug. 31, 2018
- Shri Mahendra Ram, Skilled Supporting Staff on Sept. 30, 2018
- Shri L.D. Malkani, Asstt. Chief Technical Officer on Dec. 31, 2018
- Shri B.S. Nagarkoti, Technical Officer on Jan. 31, 2019

Transfer

- Dr. Venkatesan, M. Scientist (Nematology) transferred to ICAR-CTRI, Rajahmundry, A.P. on June 27, 2018
- Dr. Anirban Mukherjee, Scientist (Agricultural Extension) transferred to ICAR Research Complex for Eastern Region, Patna on July 13, 2018
- Shri H.L. Meena, A.O. transferred to ICAR-CIAH, Bikaner on Jan.31, 2019

Promotion

- Shri Manoj Kumar, UDC to Assistant w.e.f. April 13, 2018
- Shri Abhinav Singh, LDC to UDC w.e.f. April 13, 2018
- Shri Dinesh Chandra Mishra, Assistant Chief Technical Officer *w.e.f.* May 14, 2017
- Dr. Gaurav Papnai, SMS/ACTO (T-7-8) *w.e.f.* Dec. 10, 2017
- Ms. Manisha, SMS/ACTO (T-7-8) *w.e.f.* Dec. 14, 2017
- Shri Harish Chandra Joshi, SMS/ACTO (T-7-8) *w.e.f.* Oct. 05, 2017
- Shri Salim, Technical Assistant (Driver)/ T-3 *w.e.f.* Jan. 02, 2016
- Shri Lalit Mohan Tewari, Assistant Administrative Officer *w.e.f.* Nov. 27, 2018

- Shri Sachin Kumar Pandey, Upper Division Clerk *w.e.f.* Nov. 27, 2018
- Dr. Govind Singh Bisht, STO to ACTO *w.e.f.* Jan. 01, 2018
- Shri Mohan Chandra Pant, STO to ACTO *w.e.f.* Dec. 15, 2017
- Shri T.B. Pal, ACTO to CTO *w.e.f.* June 29, 2018
- Dr. Sher Singh, Sr. Scientist to Pr. Scientist *w.e.f.* Mar. 23, 2018

Regularization

- Smt. Jibuli Devi, Skilled Supporting Staff on Oct. 18, 2018
- Smt. Narayani Devi, Skilled Supporting Staff on Oct. 18, 2018
- Shri Narayan Singh, Skilled Supporting Staff on Oct. 18, 2018
- Smt. Radhika Devi, Skilled Supporting Staff on Oct. 18, 2018
- Shri Ram Singh, Skilled Supporting Staff on Oct. 18, 2018
- Shri Govind Ballabh Joshi, Skilled Supporting Staff on Oct. 18, 2018
- Shri Nandan Singh Jeena, Skilled Supporting Staff on Oct. 18, 2018
- Shri Pratap Singh, Skilled Supporting Staff on Oct. 18, 2018
- Shri Dinesh Chandra Tewari, Skilled Supporting Staff on Oct. 18, 2018
- Shri Bachi Singh, Skilled Supporting Staff on Oct. 18, 2018

Study Leave

- Mr. Rakesh Bhowmick, Scientist upto July 02, 2019
- Mr. Tilak Mondal, Scientist upto Aug. 09, 2019
- Mr. Mahipal Choudhary upto Oct. 31, 2019

Obituary

Dr. S.D. Dubey, Ex Director, ICAR-VPKAS (March 01, 1995 to Sept. 16, 1996) has left us on January 22, 2019.

Shri Amar Singh Jeena, CLTS has left us on May 09, 2018.

Shri Sunder Lal Balmiki, CLTS has left us on July 04, 2018.

23. Human Resource Development (HRD)

A. Physical targets and achievements

Category	Total No. of Employees	No. of trainings planned for 2018-19 as per ATP	No. of employees undergone training during April-Sept 2018	No. of employees undergone training during Oct 2018 to March 2019	Total no. of employees undergone training during April 2018 to March 2019	% realization of trainings planned during 2018-19
Scientist	33	05	03	07	10	200.0
Technical	27	09	03	08	11	122.2
Administrative & Finance	14	06	01	02	03	50.0
SSS	34	11	0	11	11	100.0
Total	**108**	**31**	**07**	**28**	**35**	**112.9**

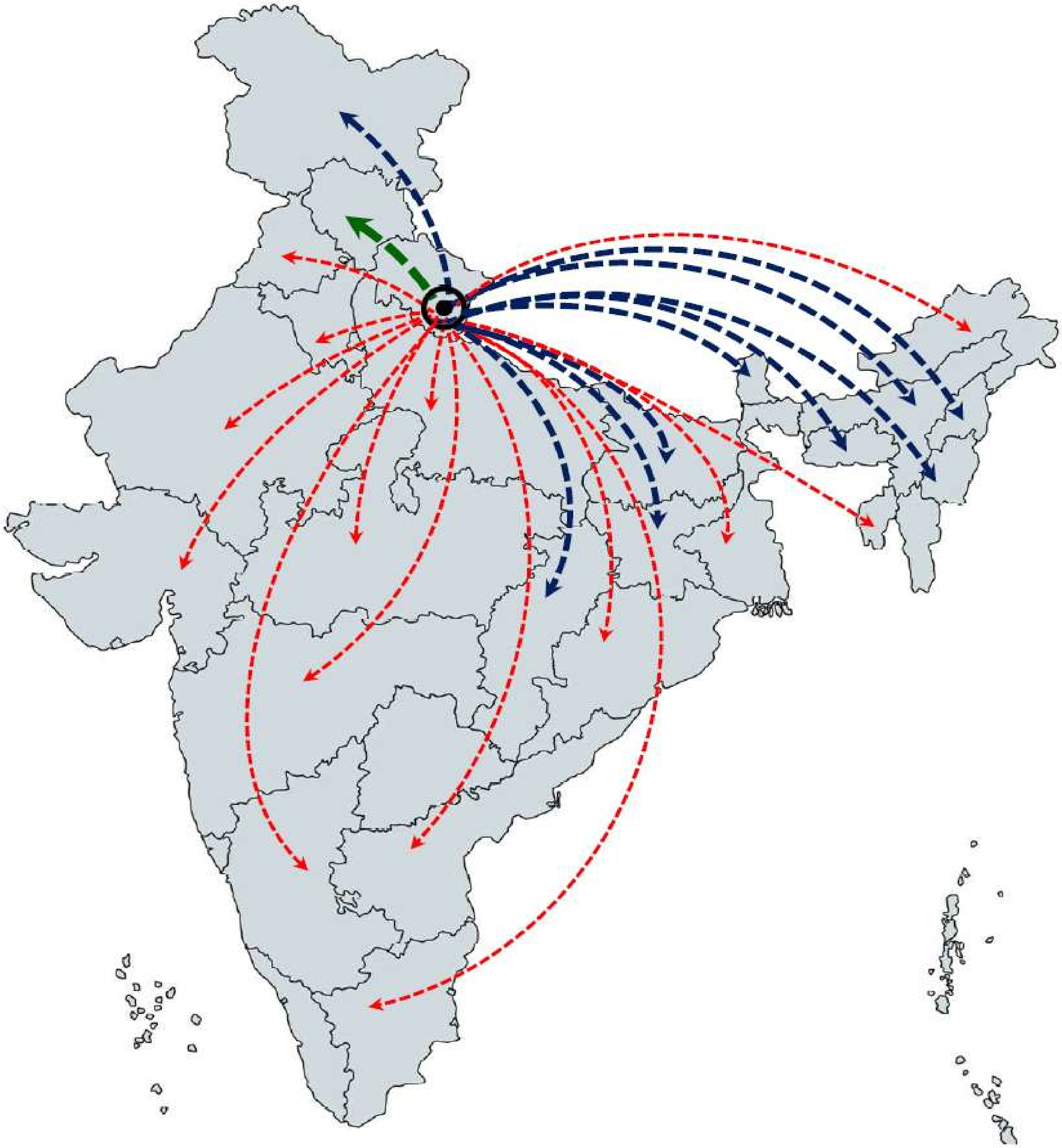
B. Financial targets and achievements (All employees)

RE 2018-19 for HRD (Rs.)	Actual Expenditure up to March 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 April 2018 to September 2018	No. of trainings organized during October 2018 to March 2019	Total no. of trainings organized during April 2018 to March 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**

Technology Delivery Map of ICAR-VPKAS



भाकृअनुप
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch