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ANNUAL REPORT 2021

भाकृअनुप
ICAR

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

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PREFACE

Mountains play a crucial role in sustaining approximately 10 per cent of the world population directly. The major mountain ranges in India are the Himalayas and the Western Ghats. They traverse an arc of about 2500 km between the Indus and the Brahmaputra rivers. Considering the poor scope for industrialisation in mountains and perspective of rural livelihood, agriculture remains an important sector for livelihood and economic growth despite its declining share in the economy. In view of its potential for economic growth and development of rural sector within the hill region and role of hills in providing life sustaining water and environmental services, hill agriculture has started receiving renewed attention of voluntary agencies and government. The hill agriculture has its own unique characteristics and the growth potential of hill agriculture has remained under-exploited due to various mountain specificities like undulating topography, lack of system specific technologies, poor marketing and processing infrastructure. However, hilly states have a lot of potential to accelerate agricultural growth through diversification. Demand for attribute based products that can be produced only in hill ecosystem is rising rapidly. These offer tremendous scope for enhancing the farm income, addressing gender issues and creating job opportunities. Organic farming still remains a viable option for export of specialized commodities especially vegetables. Further, it has a potential for quality seed production particularly of temperate vegetables. Though we have several constraints in hill agriculture, yet we have opportunities to harness the production potential of surface water and agro-climatic diversities that favour cultivation of high value cereals, vegetables and crops of industrial importance.

The institute is uniquely suited to address the needs of the farmers and other stakeholders for agricultural development in the region. The institute has 02 KVKs, one each in Kumaon and Garhwal division of Uttarakhand, through which various newer technologies are demonstrated and disseminated. In addition, the institute regularly backstops the State Governments technically on farming, livelihood security, natural resource management, disease and pest management, skill building and rural development. The institute developed various technologies which have potential to augment the agricultural development landscape of the region. Overall, a total of 04 varieties were notified; 05 genetic stocks were registered and a patent "A sampling apparatus for *in situ* volatile collection" (Patent IN 373714) was granted during the period under report. A total of 34 germplasm accessions were added in the gene bank during the reporting year for further utilization in crop improvement programme. To popularize the newly developed varieties, front line demonstrations (FLDs) were conducted covering 13.68 ha area across the state. The newly released cultivars of various crops recorded yield advantage of 19 to 87% over the popular varieties at farmers' field. A total of 500.26 q quality seeds was produced and 398.48 q seed was supplied to government seed production agencies, NGOs, farmers, research organizations and private partners in 24 states across the country. For skill development of farmers, 88 trainings were organized in addition to 04 exposure visits benefitting 2,846 farmers.

The scheduled tribes and scheduled caste farmers are being served through Tribal Sub Plan (TSP) and Scheduled Caste Sub Plan (SCSP) programs, respectively in the unprivileged remote locations. Under these programmes, various physical assets *viz*., low cost polyhouses, polytanks, portable polyhouses, vegetable seeds, various implements, light traps, mushroom units etc. were demonstrated and distributed among different stakeholders. The technology basket of the institute, through its outreach activities, reached even the far-flunged villages in North Eastern Himalayan regions through NEH programme. The Institute worked on various aspects of yield improvement of agricultural and vegetable crops, their production and protection technologies. In addition, focus on water harvesting, securing nutrition and drudgery reduction of women farmers, off-farm income generation, farm mechanization, innovative extension methods using ICT were more precise and location specific. Several new technologies were tested and introduced based on their effectiveness and ease of use.

I wish to place on record my sincere gratitude to the Secretary (DARE) & Director General (ICAR), Additional Secretary (DARE) & Secretary (ICAR), Financial Advisor (DARE) for their encouragement. I am obliged to the Deputy Director General (Crop Science), Assistant Director General (Seed) for their wholehearted support and guidance to ICAR-VPKAS. I express my sincere appreciation to the Editorial Board, PME Cell, all my colleagues and staff members of the institute for their dedicated effort and unflinching cooperation in carrying out various activities of the institute.

Place: Almora
Date: January, 2022

(Lakshmi Kant)
Director

Unity of Life in the words of Padamabhusan Professor Boshi Sen

Padma Bhushan Professor Boshi Sen
01.01.1887 to 31.08.1971

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

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

In July 1968, the then Prime Minister released a stamp titled 'Wheat Revolution'. I then wrote to Boshi Sen that his blessings in April 1964 had provided the spiritual force behind the wheat revolution. Dr Anderson and I also called on him to express our gratitude. It is sad that both Drs Boshi Sen and Anderson are no more. They were both not only great scientists but equally great humanists. Boshi Sen started getting worried about the future of the Vivekananda Laboratory which he, ably assisted by Gertrude, had built up with love and dedication. After I became the director general of the Indian Council of Agricultural Research (ICAR), Boshi Sen asked me whether ICAR could take over the Institute in order to ensure its long term sustainability. I welcomed the idea with enthusiasm and got the approval of the Governing Body of ICAR for incorporating the Vivekananda Laboratory into ICAR family. Boshi Sen made only the following two requests.

First, the name Vivekananda should always be associated the institution. Second, Kundan House should be available to Gertrude during her lifetime for her stay. Both these conditions were accepted and I requested Gertrude to serve as honorary advisor to the institute, in which position she served until her death. Today, the seed sown by Boshi and Gertrude Sen in the form of the Vivekananda Laboratory has grown into a large institute known as *Vivekananda Parvatiya Krishi Anusandhan Sansthan*".

M.S. Swaminathan

CONTENT

Bacterial consortia-inoculated crop of kidney bean (rajmash) at farmer's field in Parsari, Joshimath (Chamoli)

Executive Summary

During the period, three varieties of rice and one of maize were notified. Three varieties of quality protein maize (QPM) and one variety of garden pea were released/identified. The notified rice varieties include one centrally released variety VL *Dhan* 69 (4,255 kg/ha) and two state released varieties, VL *Dhan* 210 (2,157 kg/ha) and VL *Dhan* 211 (2,088 kg/ha). VL *Dhan* 69 is notified for cultivation in mid hills of Uttarakhand, Sikkim and Jammu & Kashmir under irrigated transplanted condition. It has reddish brown decorticated grain colour which may fetch higher price in the market. VL *Dhan* 210 and VL *Dhan* 211 are notified for rainfed upland spring sown organic conditions of Uttarakhand hills. VL *Dhan* 211 has long slender grain and is the first variety in this segment with long slender kernels. QPM variety VLQPMH 59 has average yield of 3,327 kg/ha with tryptophan and lysine content of 0.77% and 3.33%, respectively, and is notified for organic conditions of Uttarakhand Hills. It is the second QPM variety after *Vivek* QPM 9 that has been developed using marker-assisted selection (MAS). The released QPM Hybrids, VLQPM Hybrid 45, VLQPM Hybrid 61 and VLQPM Hybrid 63 have higher tryptophan (0.70-0.76%) and lysine content (3.17-3.30%) and higher yield (4.1-4.4 q/ha) and are recommended for cultivation in *kharif* season under organic conditions in Uttarakhand Hills. Among these, VLQPMH 45 is an EDV (QPM version) of popular normal corn hybrid *Vivek* Maize Hybrid 45 and has been developed by introgressing *opaque 2* allele using marker-assisted backcrossing (MAB) method. The garden pea variety VL *Sabji Matar* 17 is an early maturity variety identified for zone I (states of UK and HP and UTs of Jammu & Kashmir and Ladakh) and has high green pod yield (115.5 q/ha), high shelling percentage (>50%) and 8-9 seeds per pod. Three genetic stocks of finger millet (VL 384, VL 386 and VL 399) and two of barnyard millet (VB 19-16 and PRB 903) were also registered for various traits. To popularize the newly developed varieties, front line demonstrations (FLDs) were conducted in a total of 13.68 ha area across the state. The newly released cultivars of various crops recorded yield advantage of 19 to 87% over the popular varieties in farmer's field. During this period, 500.26 q quality seed of various categories was produced and 398.48 q seed was supplied to government seed production agencies, NGOs, farmers, research organizations and private partners in 24 states across the country.

A 5-year experiment on rainfed wheat-soybean cropping system to ascertain the level of nutrients to harvest economic optimum yield with different nutrient sources revealed that the economic optimum wheat equivalent grain yield of 10,688 and 10,787 kg/ha through farmyard manure (FYM) and vermi-compost (VC) were produced with application of 50.1 and 48.6 kg P/ha per season, which were 30 and 31% higher than the recommended NPK, respectively. The net return from economic optimum yield through FYM and VC will, however, provide 9.6 and 8.6% less net return compared to NPK, respectively. Comparison of zero-tillage with conventional tillage in wheat-rice rotation system showed higher wheat yield (2,793 kg/ha) under zero tillage in comparison to conventional tillage (2,537 kg/ha). Among different types of mulch, average highest wheat yield (2,854 kg/ha) was recorded under FYM mulch followed by walnut mulch (2,655kg/ha). The water use efficiency and water productivity followed the same trend in the experiment. In case of soybean, higher yield (2,657 kg/ha) was recorded under conventional tillage in comparison to zero tillage (2,364 kg/ha). The average highest soybean yield (2,690 kg/ha) was recorded under FYM mulch followed by *Artemisia* mulch (2,617kg/ha). Application of varying nitrogen levels in splits to finger millet variety VL *Mandua* 379 produced highest grain yield of 2,224 kg/ha with three different splits (1/4+3/8+3/8) of urea at basal, 30 DAS and 60 DAS under rainfed conditions followed by three equal splits (2,106 kg/ha). Maximum grain yield (2,350 kg/ha) was recorded at 80 kg N/ha which was at par with 60 kg N/ha (2,307 kg/ha). In soybean varieties, VL *Soya* 47 and VL *Soya* 89 grain yield increased with increasing levels of phosphorus upto 105 kg P_2O_5/ha (2,330 kg/ha), however, the increment was significant upto 80 kg P_2O_5/ha (2,250 kg/ha). Soybean variety VL *Soya* 89 (2,150 kg/ha) gave higher yield than VL *Soya* 47 (2,090 kg/ha). Among different nutrient sources in buckwheat, significantly higher yield was obtained by supplying NPK through urea+SSP+MoP (1,400 kg/ha) and calcium nitrate+SSP+MoP (1,366 kg/ha). Evaluation of finger millet and buckwheat for assessing their suitability for contingency planning revealed that significantly higher grain yield (3,288 kg/ha) was obtained in finger millet sown on June 25 followed by July 5 (2,983 kg/ha) and July 25 (2,587 kg/ha). The highest yield was recorded by July 5 sown VL *Mandua* 378 (4,102 kg/ha) followed by VL *Mandua* 379 (3,706 kg/ha), whereas VL *Mandua* 376 performed better (3,668 kg/ha) when sown on 25 June. VL *Mandua* 352 (2,902 kg/ha) and VL *Mandua* 347 (1,120 kg/ha) were found most suitable varieties for 15 July and 25 July sown condition, respectively. Analysis of grain quality parameters in a long-term experiment revealed that long term exposure of fertilizer and manure significantly influenced grain quality parameters *viz.* crude protein, crude ash, crude fat and crude fibre content of both crops soybean (VL *Soya* 63)-wheat (VL 804) cropping system under irrigated condition. For reducing manual labour in sowing, a manually operated multi-crop sowing device (VL Multi-crop sowing device) was developed for crops like finger millet, barnyard millet, foxtail millet, wheat, rice, maize, pea, soybean, lentil, pigeon pea and some vegetable crops. In addition, VL Manual Weeder was refined and tested. The refined version showed working efficiency of 75-80 per cent in garden pea.

"A sampling apparatus for *in situ* volatile collection" (patent IN 373714) was granted for *in situ* headspace sampling apparatus to collect volatiles directly without having an entrainment chamber for entraining the volatiles releasing samples from insects. High infestation of fall army worm in maize was recorded with per cent damage of 60-80% in the vegetative stage and 20-30% damage in the reproductive stage. In millets, damage of grass hoppers and ear head caterpillars was recorded with high severity (20-30%). In tomato, the damage of *Tuta absoluta* and russet mite showed significant increase that of the previous years and the severity of up to 40% was recorded under polyhouse conditions. For management of lentil wilt under organic conditions, *Trichoderma* isolate Tr-202 exhibited significantly higher inhibition (72.2%) compared to isolate Tr-28 (65.5%). In a study on insect pollinators in brinjal, pollination of brinjal by both *Apis indica* + *A. mellifera* showed synergism and lead to a 54.97% fruit set, with resultant increase in yield of 44.36-49.98% and was followed by *A. indica* (37.28-38.66%) and *A. mellifera* (23.93-24.41%). In onion, per cent seed set per umbel was highest in open control (85.99%), followed by *Apis cerana indica* (46.79%) and *A. mellifera* (36.46%). For tackling the meance of hornet pest of honey bees, a low-cost trapping device was designed for their eco-friendly management. The device recorded a benefit cost ratio of 12.30:1, which was significantly superior over traditional method (1.64:1) of manual swatting of hornets in apiary. A food poison bait technique devised for the management of polyphagous cutworm (*Agrotis segetum*) reduced cutworm population to a tune of 65% in Rajma in Niti and Mana village clusters of Uttarakhand, India. Molecular characterization of the local specimen of fall armyworm {*Spodoptera frugiperda* voucher specimen Hawalbagh (UK) maize MW357423} revealed its close identity with *Spodoptera frugiperda* isolate TNAU Maize (MH779591.1). An indigenous entomo-pathogenic nematode (*Heterorhabditids indica* VLEPN01) was identified for eco-friendly management of insect pests. *H. indica* VLEPN01 was found capable of causing 100% mortality in early instars of fall armyworm

(*Spodoptera frugiperda*), white grub (*Holotrichia* spp.) and tobacco caterpillar (*Spodoptera litura*) under laboratory conditions.

A study on technological interventions for mitigating drudgery and improving nutritional status of hill farm women revealed that a short, targeted educational programme supplemented with nutrition gardening is effective for improving dietary diversity among rural households. Yield gap analysis in finger millet varieties revealed that variety gap and technology gap was higher in VL *Mandua* 376 (750 and 243 kg/ha) compared to VL *Mandua* 379 (733 and 187 kg/ha). In finger millet, traditional practice of mixed cropping (RBQ 89.3) was found the most important factor that constraints the adoption of line sowing. In a study on preference of farmers for wheat varieties, VL *Gehun* 953 and VL *Gehun* 967 were the most preferred varieties mainly due to their higher yield and timely maturity. Economic analysis of different sowing methods in wheat crop showed that improved variety with line sowing was more profitable (B:C ratio 2.49) followed by improved variety with broadcasting and local variety with broadcasting with B:C ratio of 2.21 and 1.85, respectively. Farm advisory services are provided regularly through toll-free Farmers' Helpline Service (Telephone No. 1800-180-2311), Need based SMS service, *m-Kisan* portal and *Krishi Samridhi* radio programmes. Farmers are registered for receiving SMS and are grouped based on crop grown, location and activities engaged in. Presently 11,126 farmers are registered for *mKisan*, Whatsapp and need based SMS services. Need based information are being sent to the farmers on different contents like crop varieties, crop protection measures, nutrient management, farmers fairs/field days, seed production and availability, government schemes etc.

INTRODUCTION

ICAR-VPKAS, Almora Campus

Experimental Farm, ICAR-VPKAS, Hawalbagh

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 (*viz*., Himachal Pradesh and Uttarakhand) and Union Territories (*viz.,* Jammu-Kashmir & Ladakh) of India. It also extends its technological support to other hilly regions (*viz.,* North Eastern States) of the country. The growth and development of the institute over the years has been phenomenal. Established by Padamabhusan Professor Boshi Sen, the institute originally functioned as a 'one man' laboratory with limited resources. In 1959, the laboratory was transferred to U.P. Government, and subsequently to ICAR in 1974. The institute headquarter is located at Almora (29°33' N and 79°39' E and 1,600 m amsl) in Uttarakhand. The experimental farm is located at 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 98 years of service to the nation, has several pioneering achievements to its credit. The most notable ones are:

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

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

viii. Insect trap (White Grub Beetle Trap) (Patent IN290170) patented.

ix. Formulation of *Bacillus thuringiensis* (VLBt6) (Patent IN336230) patented.

x. A sampling apparatus for *in situ* volatile collection (Patent IN 373714) patented.

1.1 Mission

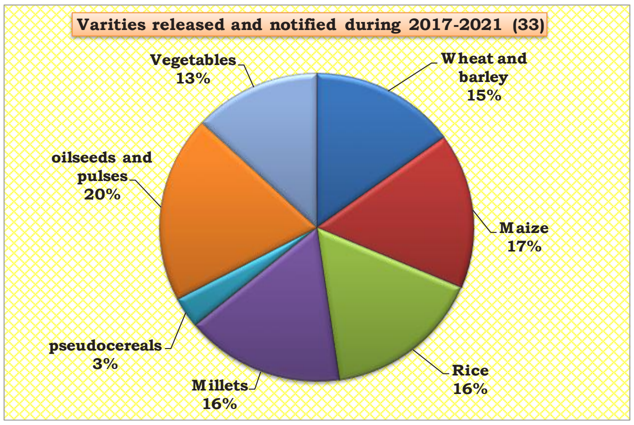
Enhancing productivity and ecological sustainability of hill agriculture through niche-based diversification

1.2 Mandate

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

1.3. Historical Perspective & Salient Accomplishments

Till date, total 175 high yielding disease resistant varieties of 25 crops have been developed and notified by the institute. However, during last five years, 33 improved varieties of various crops were notified and released for cultivation. The institute has also developed matching production and protection technologies for these varieties.



VL QPM Hybrid 59 is the 2nd MAS derived QPM hybrid developed by the institute after the first MAS derived QPM hybrid of the country *i.e., Vivek* QPM 9. VL *Mandua* 382 developed by a cross of WR2/VL 201 by the institute happened to be the **first white grain** finger millet variety of the Uttarakhand. It has been released for rainfed organic cultivations. It has high protein percentage (8.8%) compared to brown grain finger millet varieties (6.0%). The yield potential of this variety is 1,600 kg/ ha under organic rainfed condition. The variety also possesses excellent chapati making quality and palatability compared to commonly consume brown ragi chapati. VL Cherry Tomato 1, developed by the institute by selection from exotic germplasm line EC461693 is the **first public sector cherry tomato variety** of the country. It is an open-pollinated variety which can be grown both under polyhouse and open-field conditions. Its average yield is 25,000-30,000 kg/ha under open-field conditions and 40,000-50,000 kg/ha under polyhouse conditions. Fruits are small, attractive red colour with oval shape; better in nutritive traits (Vitamin C- 86mg/100g and TSS -7° Brix), good taste. Barley variety, VLB 130, is the **first dual purpose** (green fodder cum grain) variety of Uttarakhand hills. It is recommended for organic rainfed conditions. It yields 1,800-2,000 kg/ha and possesses resistance to yellow rust and stripe diseases. VL Sweet Corn 1 is the first widely adapted sweet corn hybrid released from public sector. The hybrid possesses a TSS range of 15.5-16% and moderately resistant to turcicum leaf blight. During last five years, a total of **853.51** q breeder seed and **1704.81** q of TL seed of 85 varieties belonging to 19 crops were produced. The seed share of VL varieties in major crops ranged from **16.7** per cent in rice to **93.5** per cent in small millets in Northern Himalayan Zone. In the hill region of Uttarakhand state, the breeder seed share of VL varieties were more than **80** per cent.

The matching agro-techniques for realizing full potential of improved crop varieties and managing the constraints were standardized. Cropping sequence, spring rice–wheat–finger millet–toria attained 200% cropping intensity against 150% of the traditional spring rice–wheat–finger millet–fallow sequence in two-year cropping system. Among one-year crop sequences, soybean–lentil, maize–pea, maize–wheat, rajmash-french bean–toria, pigeon pea–wheat, colocasia–coriander–tomato, soybean–pea and soybean–wheat was found more remunerative. Intercropping of soybean 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, sloping silvi-horti and oak high density plantation have been introduced. Low cost polyhouse technology has been developed for protected cultivation. Crops and seedlings can successfully be grown during winter in the polyhouses, 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 of portable polyhouse has been developed and standardized. Low cost LDPE film-lined water storage tank, conveyance system and drip irrigation system have been developed for growing off-season high value vegetables.

Survey and surveillance showed prevalence of yellow rust, loose smut, powdery mildew and hill bunt in wheat; stripe disease and covered smut in barley; blast, brown leaf spot and false smut in rice; neck and finger blast in finger millet; turcicum leaf blight and maydis leaf blight in maize; powdery mildew, rust and white rot in pea; buckeye rot and powdery mildew in tomato, root rot, rust and anthracnose in bean; purple blotch and stemphylium blight in onion and garlic; wilt in lentil, and frogeye leaf spot as well as anthracnose in soybean. Constant vigil is kept to-prevent wide-spread damage by new pests like tomato pin worm (*Tuta absoluta*), fall army worm (*Spodoptera frugiperda*) etc. Indigenous *Trichoderma* strains (Tr-28 and Tr-202) have been isolated from the NW Himalayan region, characterized and found effective against the soil-borne plant pathogens. White grub, a polyphagous pest, which devastates several rainfed *kharif* crops, is the most menacing insect of the region. More than 80 species of this insect have been recorded in Uttarakhand. Insect trap (Patented: IN290170) and the entomopathogenic *Bacillus cereus* WGPSB2 are the potential alternatives to manage the white grubs. In addition, stem borer and leaf folder in rice and small millets; hairy caterpillar and sucking bug in soybean; leaf miner in garden pea and pod borer in pea and gram; fruit borer in tomato; blister beetle in beans and pigeon pea; black cut worm (*Agrotis segetum*) in rajmash 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. The invention process for the mass production of *Bacillus thuringiensis* (Bt) biocide using millet grain based agro-medium for the early, profuse sporulation and the process for the mass production of bio-insecticide, *Bacillus thuringiensis* has been granted patent (No. IN336230). In addition, "A sampling apparatus for *in situ* volatile collection" (patent IN 373714) was granted for *in situ* headspace sampling apparatus to collect volatiles directly without having an entrainment chamber for entraining the volatiles releasing samples from insects.

Demonstrations of improved agricultural technologies were the major programme for agricultural development. More than 4,000 field demonstrations were conducted under various institute's outreach programmes to show the benefits of latest agro-technologies in the adopted villages. Two FPOs developed by the institute are serving as models for effective marketing system. The institute has to its credit a technological options publication entitled, "उत्तर पश्चिमी पर्वतीय क्षेत्रों में कृषि उत्पादकता की वृद्धि के लिए उन्नत तकनीकें" which is very popular among farmers and extension workers. The publication was awarded prestigious **Dr. Rajendra Prasad Purushkar** of Indian Council of Agricultural Research in the year 2004. E-books have been created for important technological bulletins. *Vivek* Thresher-1 for pearling and threshing of *Mandua/ Madira* won **NRDC's Meritorious Invention Award** for the year 2006 by National Research Development Corporation (NRDC), New Delhi and Institute's scientists won **Hari Om Ashram Trust Award 2007** of ICAR for this invention. A team of scientists won **Outstanding Team Award of ICAR** as a recognition to the work in the area of enhancing productivity and profitability of rice-wheat system in NW Himalayan States. Scientists of the institute also received **World Intellectual Property Organization (WIPO) Gold Medal in 2009**, for development of "Eco-friendly novel technology for managing white grubs in North West Himalayas" which was identified as the **best invention of the year 2008**. This work also won the **Societal Innovation Award of NRDC in 2008**. In 2010, the institute scientists got **ICAR Outstanding Team Research Award in the subject area of Natural Resource Management**. The Institute received **Mahindra Krishi Samridhi India Agri Award 2012** for developing dual purpose (green fodder cum grain) variety VL *Gehun* 829 and early maturing pigeonpea variety VL *Arhar* 1 and it popularization among farmers. The Institute has been judged as the **best institute for Application of plastics in Agriculture under AICRP** and received

appreciation from **IIMR** for its **outstanding contribution in maize improvement.** The institute has been honoured for the development of **landmark varieties of maize (VL *Makka* 54 and HIM 128)** and **wheat (VL *Gehun* 421)** during the Platinum Jubilee Celebration of ISGPB on February 11, 2017. These varieties contributed towards food and nutritional security of the country. The Institute has been adjudged as the "**Best Performing Centre Award" for the year 2017-18 for small millets research**. On 91st Foundation Day function of Indian Council of Agricultural Research, the scientists of ICAR-VPKAS, Almora were conferred three national awards namely, **Fakhruddin Ali Ahmed Award for Outstanding Research in Tribal Farming Systems** and **Pandit Deen Dayal Upadhyay Zonal Krishi Vigyan Protshahan Puraskar** to institute's Krishi Vigyan Kendra, Chinyalisaur (Uttarkashi) for its outstanding work in the area of agricultural technology, extension and farmers training among 71 KVKs of union territories (Jammu-Kashmir, Ladakh) and states (Himachal Pradesh, Punjab and Uttarakhand) in Zone I; and second Best KVK Award 2019 in Zone I to Krishi Vigyan Kendra, Bageshwar.

A hybrid maize—*Pusa Vivek* QPM 9 Improved that is claimed to be the world's first ever rich in lysine and tryptophan as well as pro-vitamin A was developed as a collaborator with IARI, New Delhi. Normal maize kernels have 8-10% protein and, within that, 1.5-2.5% lysine and 0.3-0.4% tryptophan. Pro-vitamin A content, too, is only 1-2 parts per million (ppm). The new maize hybrid has 2.67% lysine and 0.74% tryptophan in the protein (as was in *Vivek* QPM9), besides 8.15 parts ppm of pro-vitamin A. "The original hybrid (*Vivek* QPM 9) was developed by the ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan at Almora, Uttarakhand. The improved version retains the *Opaque-2* gene that enhances lysine and tryptophan content, and another gene *crtRB1*, which results in higher levels of carotenoids (β-carotene, alpha-carotene and β-cryptoxanthin) that convert into vitamin A in the body. The bio-fortified hybrid is not genetically modified, as both the *Opaque-2* and *crtRB1* genes are incorporated from maize lines and not any alien/unrelated plants or microorganisms. It has been mainly developed for J-K, Ladakh, Himachal Pradesh, Uttarakhand and the North-East states (original recommendation zone of *Vivek* QPM9) with 93-95 days maturity and average and potential yield of 5.6 and 8 tonnes per hectare, respectively. It is also suited for growing in the southern states and Maharashtra, where the average and potential yields are higher (5.9 and 9.4 tonnes) with only 83-85 days duration.

1.4. Institute Facilities

Laboratories and Research Farm

The institute has well-equipped laboratories for biotechnology, agricultural chemistry and microbiology at Almora campus and Boshi Sen Field Research Platinum Jubilee Laboratory with plant breeding, entomology, plant pathology, biochemistry, agronomy, soil science, quality testing, agricultural engineering, mushroom spawn production, germplasm storage module, seed processing plant at Hawalbagh.

Research Farm

Prof. Boshi Sen Field Research Laboratory and Research Farm is located at Hawalbagh about 13 km from Almora on the Almora-Kausani-Ranikhet Road at an elevation of 1250 m amsl. 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.*

Incubation Centre–Cum- Fabrication Unit

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

Institute Library

A total of 4,210 books of various subjects related to the scientific activities of the institute are available in the library. In addition, reports and bulletins were received on exchange /complementary basis from other institutions of the country and abroad. The library subscribed 16 foreign and 57 Indian periodicals until 2016. At present the library subscribes to 10 Indian journals. There are about 4,000 bound periodicals in the library. The library is also providing current awareness services to the scientists 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)

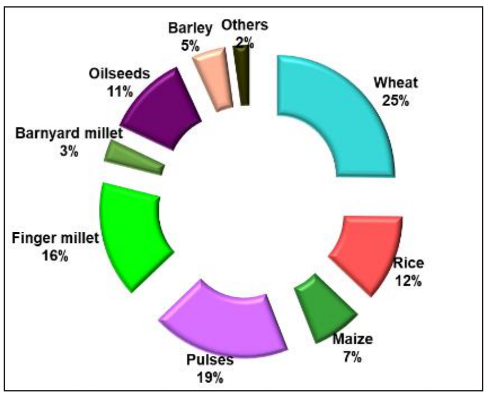
Local Area Network has been set up at the institute consisting of more than 100 nodes with 50 Mbps Internet Lease line connection at Almora campus and Hawalbagh campus. AKMU maintains institute website which can be accessed at http://vpkas.icar.gov.in. AKMU also provides toll free Farmers' Helpline Service 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 services since July 2016. Farmers are registered for receiving SMS and are grouped based on crop grown, location and activities engaged in. Presently 11,126 farmers are registered for *mKisan*, Whatsapp and need based SMS services. Need based information are being sent to the farmers on different contents like crop varieties, crop protection measures, nutrient management, farmers fairs/field days, seed production and availability, government schemes etc.

Institute Technology Management Unit

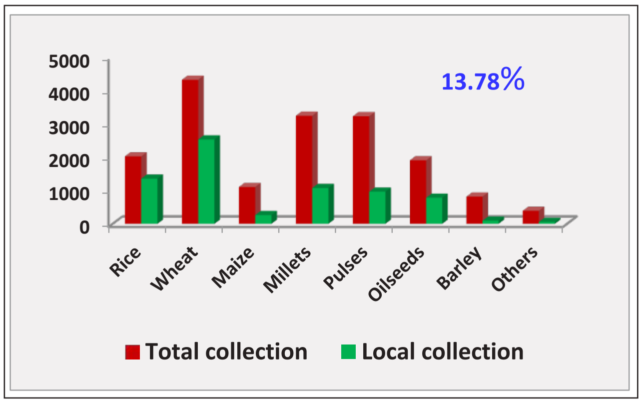
The unit co-ordinates activities of institute technologies to showcase institute technologies to industry and other stakeholder for further mass multiplication and commercialization through Agri-innovate India Ltd, New Delhi. Technology License Agreement (TLA) for manufacturing and commercialization of VL-White Grub Beetle Trap-1 was signed with Parashar Agrotech Bio Pvt. Ltd., U.P. for 4 years. Another TLA was signed with G.T. Bio-sciences Pvt. Ltd., Maharashtra for 4 years. A TLA with Punjab Agricultural Implements (P) Ltd., U.P. was signed for manufacturing and commercialization of VL Paddy Thresher for 4 years; with Jai Shankar Agro Inputs Pvt. Ltd., Delhi for the commercialization of *Vivek* QPM 9 for 5 years. A greenhouse effect creating VL portable polyhouse designed and developed by Institute. Its manufacturing and commercialization was facilitated by signing a TLA with Aerotech Eng. Works Pvt. Ltd., West Bengal for 3 years. TLA was signed with Green Tech Solution, UK for the commercialization of VL Small Tool Kit for 3 years. VL *Syahi Hal* is another popular implement developed and its TLA was signed with Faith Enterprises, Delhi for its manufacturing and commercialization for 03 years. Another TLA was signed with Tyaagi Implements and Manufacturer Private Limited, U.P. for the manufacturing and commercialization of VL Maize Sheller for 3 years.

Gene Bank/ Medium Term Storage (MTS) Module

In the MTS module of ICAR-VPKAS, Almora, presently 17,098 germplasm accessions of 25 crops have been maintained. Among these, 7,135 are unique hill germplasm collections including landraces during the last five years. The genetic diversity of hill crops was further enriched with the indigenous collection of over 2000 accessions from North West and North Eastern Himalayan region. The germplasm comprised land races, obsolete varieties, genetic stocks, promising breeding lines and seed of national and international nurseries. A total 34 germplasm accessions, comprising soybean (5), horsegram (10), amaranth (15) and rajmash (4) were deposited in the gene bank during 2021-22 for further utilization in crop improvement programme.



Share (%) of germplasm accessions of different crops in gene bank



Share of germplasm collected from hills in total germplasm maintained at MTS module

Staff

The staff position of the Institute as on December 31, 2021 is given below:

Positions	Sanctioned	Filled	Vacant
RMP	1	0	1
Scientific	55	33	22
Technical	44	27	17
Administrative	35	17	18
Supporting	35	34	1
Supporting CLTS	0	9	0
Total	**170**	**111**	**59**

Finance

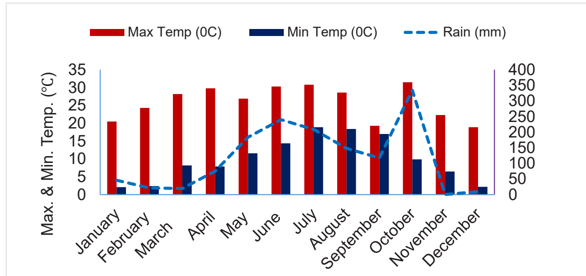
The budget outlay for January to December 2021 (Rs. in lakhs) is given hereunder:

Item	Allocation	Expenditure
Grant-in-General	370	320

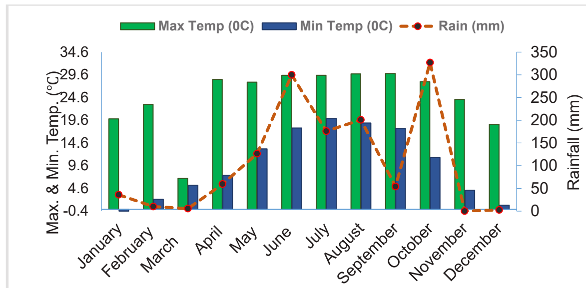
1.5 Weather and Crop Season

The mean maximum temperature ranged from 18.9^{0}C (December) to 31.5^{0}C (October) and mean minimum temperature varied from 2.1^{0}C (January) to 18.9^{0}C (July) in Almora. During the month of October about 334.4 mm rainfall was received which was an extreme disastrous event.

At the Experimental Farm, Hawalbagh, the mean maximum temperature ranged from 6.8^{0}C (November) to 29.9^{0}C (September) and mean minimum temperature varied from -0.4^{0}C (January) to 20.0^{0}C (July). During the month of October about 327.0 mm rainfall was received.



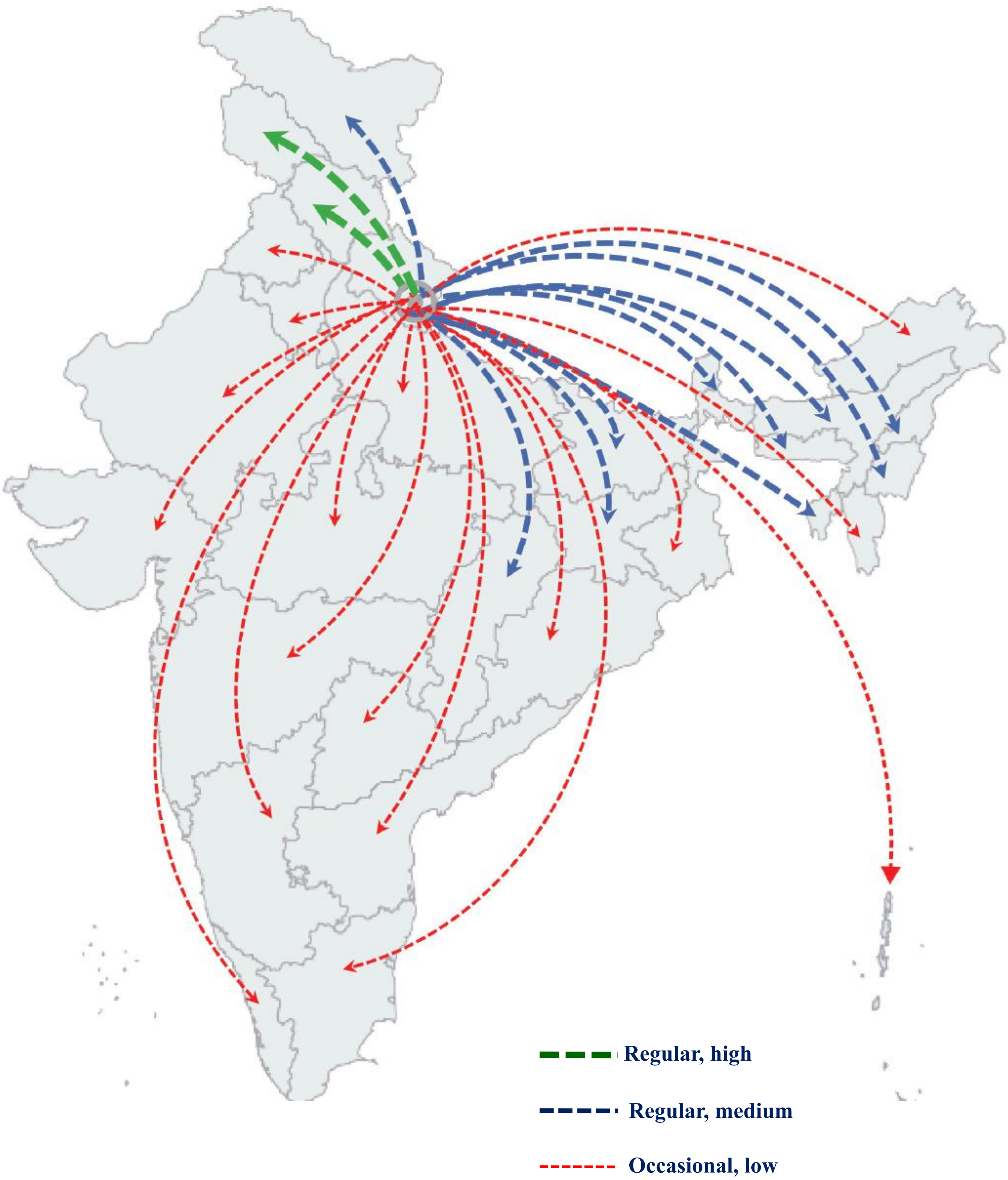
Meteorological data of ICAR-VPKAS, Almora



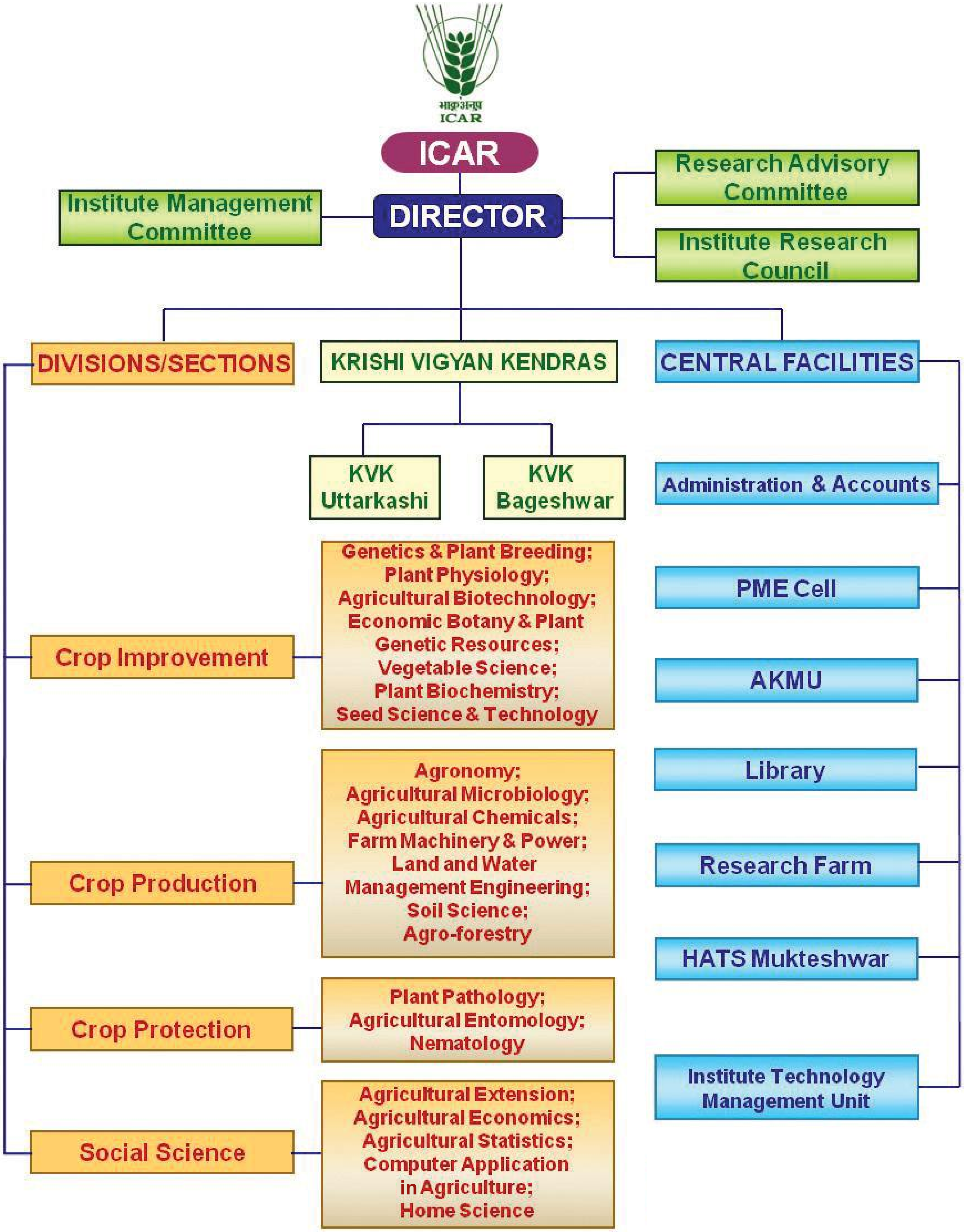
Meteorological data of Experimental Farm, Hawalbagh

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

Since 2017, 33 improved varieties of various crops were developed. The recommendation domain of these varieties includes the states beyond the mandate area of institute *viz.*, western and southern states of the country including Gujarat, Rajasthan, Chattisgarh, Madhya Pradesh, Punjab, Delhi Haryana, Western Uttar Pradesh, Karnataka, Tamilnadu, Telengana, Andhra Pradesh, 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 as well as various plain regions of the country. It also showed that the institute is marching towards a status of Centre of Excellence in varietal development for hills.



Technology Delivery Map of ICAR-VPKAS Technologies



Organizational Setup, ICAR-VPKAS, Almora, Uttarakhand

Frontline Demonstration of Biofortified Maize Hybrid VLQPMH 59 in Jaunsar Tribal Area of Dehradun

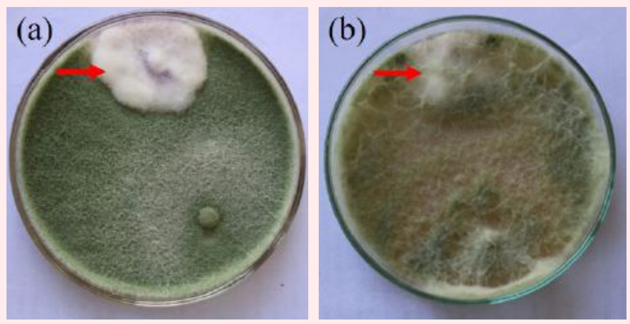
Farmer Participatory Seed Production of VL *Gehun* 953 in Bailpadao, Ramnagar (Nainital)

ACHIEVEMENTS

VLQPM Hybrid 59

Crop of Quinoa

VL *Lahsun 2* Crop Produced using Bulbils as Planting Material



Mycoparasitic Action of *Trichoderma* Isolates on *Fusarium oxysporum* f. sp. *lentis*; (a) Tr-28 and (b) Tr-202

Prototype of VL Multi-crop Sowing Device

Skill Development Programme

2. Enhancement in the Productivity of Major Hill Crops

Research Projects

- Genetic Enhancement of Maize for Yield and Nutritional Quality Using Integrated Breeding Approach *[Drs. R.K. Khulbe, Devender Sharma, Jeevan B., Amit Kumar, R.S. Pal, Rakesh Bhowmick]*
  - **Sub-project**: Identification of Potential Lines and Hybrid Combination for High Fe and Zn Content in Maize through Biochemical and Molecular Approach *[Dr. Devender Sharma (PI)]*
- Enhancement of Genetic Potency of Rice for Productivity, Biotic and Abiotic Stresses for North West Himalayas *[Drs. J.P. Aditya, Rajashekara, H., Anuradha Bhartiya, Manoj Parihar & Asha Kumari (upto 18.10.2021)]*
- Genetic Improvement of Wheat and Barley for Higher Productivity, Quality Traits, Abiotic and Biotic Stresses *[Drs. L. Kant, Navin Chander Gahtyari, K.K. Mishra, Amit Kumar & Asha Kumari (upto 18.10.2021)]*
  - **Sub-project**: Inheritance Studies for Transgenerational Stress Memory in Wheat Induced by Late Sowing [*Dr. Navin Chander Gahtyari (PI)]*
- Trait Mining and Genetic Improvement of Small Millets and Potential Crops in the Context of Climate Change *[Drs. D.C. Joshi, Rajashekara, H. (upto 12.02.2021) & R.P. Meena]*
- Genetic Improvement of Pulses & Oilseeds for Higher Productivity, Quality, Biotic & Abiotic Stresses for North-Western Himalayan Hills *[Drs. Anuradha Bhartiya, Sher Singh, A.R.N.S. Subbanna (upto 12.02.2021), J.P. Aditya, R.S. Pal, Jeevan B. & Amit Umesh Paschapur]*
- Enhancement of Genetic Potency in Important Vegetables Crops for North Western Himalyan Ecosystem *[Drs. N.K. Hedau, Chaudhari Ganesh Vasudeo (upto 12.02.2021), K.K. Mishra, B.M. Pandey, R.S. Pal, Ashish Kumar & Amit Umesh Paschapur]*
  - **Sub-project**: Heterosis Breeding in Onion *[Dr. Chaudhari Ganesh V. (PI) (upto 12.02.2021)]*
  - **Sub-project**: Capsicum Heterosis Breeding *[Dr. Chaudhari Ganesh V. (PI) (upto 12.02.2021)]*
  - **Sub-project**: Collection, Evaluation, Identification and Documentation of Underutilized Vegetable Crops for North-West Himalayan Ecosystem *[Dr. Rahul Dev (PI)]*
- Germplasm Evaluation in Major Hill Crops for Nutritional and Physiological Parameters Through Basic Techniques *[Drs. Ramesh Singh Pal, Anuradha Bhartiya, J.P. Aditya, Manoj Parihar, Devender Sharma, Navin Chander Gahtyari & Asha Kumari (upto 18.10.2021)]*
  - **Sub-project:** Evaluation and Identification of Major Hill Crops of North-West Himalayas for Abiotic Stress Management [*Dr. Asha Kumari (PI) (upto 18.10.2021)*]
  - **Sub-project:** Identification and Utilization of Important Genes/Alleles/Markers in Hill Crops [*Dr. Rakesh Bhowmick (PI)]*
- Seed Production *[Drs. L. Kant, R.K. Khulbe, Chaudhary Ganesh V. (upto 12.02.2021) & Devender Sharma]*

2. Enhancement of Productivity of Major Hill Crops

2.1 Enhancement of Genetic Potency of Rice for Productivity, Biotic and Abiotic Stresses for North West Himalayas

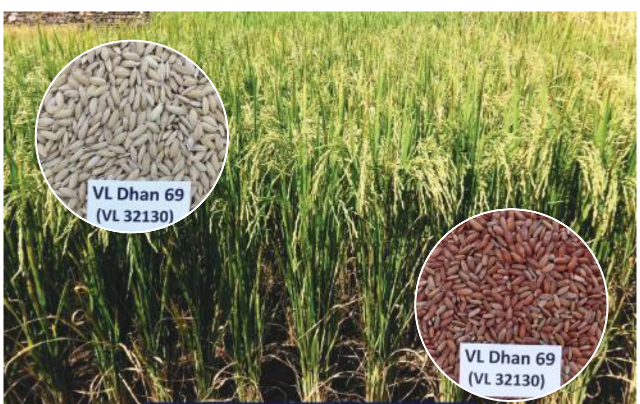
In North-Western Himalayan hills, rice is the major *kharif* crop and is grown in 0.60 m ha with production of 1.38 mt and productivity of 2,315 kg/ha. The Union Territory of Jammu & Kashmir possess the highest area of rice (0.28 m ha), however, production (0.65 mt) and productivity (2,665 kg/ha) were highest in Uttarakhand. The area and production of rice is higher in NE Himalayan states compared to NW Himalayan states. The productivity, however, is higher in NW (2,315 kg/ha) as compared to NE Himalayan states (2,213 kg/ha). Both NW and NE Himalayan regions are lagging behind the national average productivity (2,722 kg/ha), therefore, development of high yielding varieties with resistance to major biotic and abiotic stresses is required for specific elevations like low, medium and high hills under rainfed upland and irrigated ecosystem.

2.1.1. Varietal Improvement

2.1.1.1. Variety Notified

VL *Dhan* 69 (IET 26596, VL 32130): This variety was notified and released by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops, New Delhi vide S.O. 8(E) dated 24th December, 2021 for cultivation in Uttarakhand, Sikkim and Union Territory of Jammu and Kashmir for cultivation in mid hills under irrigated transplanted condition. It has been developed from the cross VL 10689/ UPRI2005-15. It has unique decorticated grain colour (reddish brown) which may fetch higher price in the market. It recorded 79.9% hulling, 69.1% milling, 55.4% head rice recovery, intermediate ASV (5.0) and amylose content of 26.78%. It has shown moderate resistance to leaf blast, neck blast, brown leaf spot and sheath rot. It has short bold grain, plant height of 95-105 cm, 125-130 days maturity and high number of panicles/m^2 (282). Over three years of testing, VL *Dhan* 69 with average grain yield of 4,255 kg/ha in medium hills showed 18.22 per cent superiority over the best check VL *Dhan* 65.

VL *Dhan* 210 (VL 11364, IET 28929): This variety was notified and released for organic conditions of Uttarakhand by the Central Sub-Committee on Crop Standards Notification and Release of Variety for Agricultural Crops, New Delhi vide S.O. 8(E) dated 24th December, 2021. The average grain yield of this variety under organic conditions was 2,157 kg/ha, which was 37.6% higher than the best check VL *Dhan* 207 (1,569 kg/ha). This variety was developed from cross VLD 207/VL 30424. It has plant height of 90-110 cm and has shown resistance against leaf and neck blast, brown leaf spot, sheath rot, leaf scald, false smut, stem borer and leaf folder under natural condition. It has intermediate plant height, semi-erect and non-lodging plant type. It also exhibited better quality characteristics like high hulling (78%), milling (67%), HRR (58%) and amylose content (22.8%). It has long slender grain

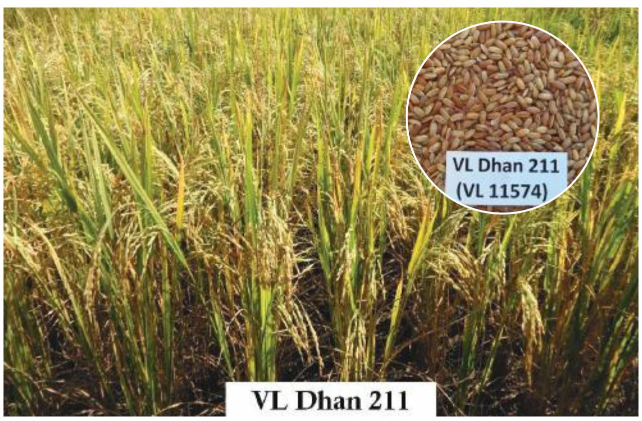


VL *Dhan* 69(VL 32130)

VL Dhan 210

kernel length (7.96 mm) and kernel breadth of 2.38 mm and L/B ratio of 3.34.

VL *Dhan* 211 (VL 11574, IET 28924): This variety is also notified for rainfed upland spring sown organic conditions of Uttarakhand hills by the Central Sub-Committee on Crop Standards Notification and Release of Variety for Agricultural Crops, New Delhi vide S.O. 8(E) dated 24th December, 2021. This was a cross between VL *Dhan* 209 and VL 30424. It has short bold grain and is resistant to leaf and neck blast diseases. It has shown average yield of 2,088 kg/ha under organic conditions, giving 33.20 per cent advantage over VL *Dhan* 207. It has plant height of 100-110 cm and has very good and acceptable grain qualities *viz*., 80% Hulling; 69% Milling; 60% HRR, 24.8% amylase content, 5.62 mm kernel length; 2.68 mm kernel breadth and L/B ratio of 2.09.



2.1.1.2. Elite lines under All India Coordinated Rice Improvement Programme

In irrigated early duration trial AVT-1E (H), VL 32585 (5,267 kg/ha & 5,771 kg/ha) and VL 32560 (5,318 kg/ha & 4,813 kg/ha) performed better than the best check (national check VL *Dhan* 86 - 4,685 kg/ha and local check - 4,536 kg/ha) in both lower and medium elevated hills, respectively, hence promoted to the third year of testing. In IVT-E (H), VL 32554 (4,125 kg/ha), VL 32558 (3,847 kg/ha), VL 32678 (3,819 kg/ha) performed better than the best check (Shalimar Rice-3 3,375 kg/ha) in northern low elevation, whereas, performance of entries VL 32678 (4,990 kg/ha), VL 32554 (4,865 kg/ha), VL 32699 (4,583 kg/ha) was superior than the best check (local check, 4,083 kg/ha) in northern medium elevation, and VL 32654 (8,500 kg/ha), VL 32561 (5,625 kg/ha), VL 32678 (5,250 kg/ha) were superior to best check (Shalimar Rice-3 4,500 kg/ha) in southern medium elevation. In IVT-M, VL 32605 (4,726 kg/ha) and VL 32606 (4,826 kg/ha) performed better than the best check (zonal check 4,387 kg/ha) in northern medium altitude and hence promoted to the second year of testing.

2.1.1.3 Breeding materials/Development of new strains

The elite lines selected from advance station trials were VL 32850 (5,099 kg/ha) and VL 32848 (5,186 kg/ha) in irrigated medium duration (check VL *Dhan* 68 - 4,712 kg/ha); VL 32736 (4,754 kg/ha) and VL 32835 (4,615 kg/ha) in irrigated early duration conditions (check VL *Dhan* 86 - 4,448 kg/ha) and VL 20986 (2,652 kg/ha) and VL 20867 (2,933 kg/ha) in rainfed upland June sown condition (check VL *Dhan* 157-2,188 kg/ha). The selected lines exhibited desirable plant height (<110 cm) and maturity (100-120 days in irrigated early sown and rainfed upland June sown conditions; 125-140 days in medium irrigated conditions) along with resistance against major diseases leaf blast (1-3 score) and brown leaf spot (1-5 score).

Segregating Breeding Materials

Based on desirable agro-morphological traits like early duration (100-120 days) and medium duration

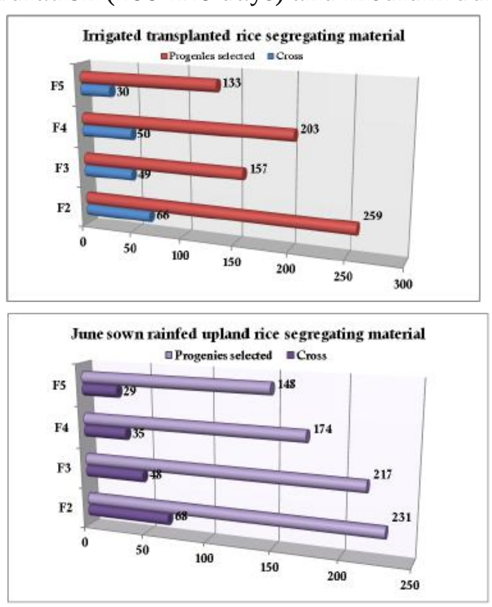


Fig 2.1.1. Segregating material under rainfed upland and irrigated transplanted ecosystem

(121-140 days) maturity, semi dwarf (irrigated <110 cm, upland <90 cm) to intermediate (irrigated 110-130 cm, upland 90-125 cm) plant height, drought tolerance (0-3 score of leaf drying), diseases (0-5 score) and insects resistance (0-3 score), a total of 2,073 progenies derived from 468 crosses were selected in F_2 to F_5 generations under rainfed upland and irrigated transplanted ecosystem (Fig. 2.1.1).

2.1.1.4. Frontline demonstrations

The frontline demonstrations of released variety VL *Dhan* 68 were conducted under irrigated condition during *kharif* 2021 in 1.6 ha area among 30 farmers of 3 villages of Bageshwar district. Average yield of improved cultivar VL *Dhan* 68 (42.30 q/ha) was 26.45% higher than the local check Thapachini (33.4 q/ha).

2.1.2. Crop Protection Investigations

During *kharif* 2021, different rice entries from station and coordinated trials were evaluated for leaf blast, neck blast and brown leaf spot diseases under natural conditions. The blast disease was evaluated under Uniform Blast Nursery (UBN) and brown leaf spot screening was performed in sick plots (Table 2.1.1).

Table 2.1.1. Promising lines identified for blast and brown leaf spot disease

Trial/Nursery	No of Entries	Promising lines identified		
		Brown leaf spot (≤ 3 score)	Leaf blast (1 score)	Neck blast (1 Score)
Advance Station Trial for transplanted rice	20	--	VL 32744, VL *Dhan* 68, VL 32802, VL 32829, VL 32848	VL 32737
VL Rice Blast Screening Nursery (VLRBSN)	91	VL 8654, VL 8657, VL 20298, VL 31615, BL 122, BL 245, IRBLA-A	VL32678, *O. minuta*, GSR-124, GSR 142	VL20302, VL31451, VL31674, VL32131, VL32606, VL32678, VL32722, RIL-10, PB-1, GSR-102, GSR-106, GSR 124, GSR 125, IRBL-Sh 1, IRBL-BL-150/2, BAU/IRIR-497, IRBLA-A
National Screening Nursery for Hills (NSNH)	118	2424, 2426, 2504, 2602, 2606, 2707, 2715, 2717, CH 45, Benibhog, Co 39, Tetep	2633	2302, 2306, 2507, 201, 2613, 2619, 2625, 2627, 2629, 2714
National Hybrid Screening Nursery (NHSN)	112	2801, 2804, 2806, 2811, Tetep	--	3002
Donor Screening Nursery (DSN)	291	19144, VP R 40, VP R 43, VP R 44, VP R 45, VP R 243, VP R 264, VP R 278, VP R 297, IBTGM4, TBTR189, MTU 1010, TELLA, KNM 12505, KNM11520, WGL1289, WGL 1629, JGL 38053, JGL 38125, JGL 38162, JGL 38180	RNR 31679, RNR 39025, RNR 39028, RP Patho 3, RP Patho 5, RP Bio Patho 12, RP Bio Patho 13	--
National Screening Nursery (NSN-1)	303	NA	3534, 3535, 5610	NA
National Screening Nursery (NSN-2)	625	NA	3640, 5420	NA

2.1.3. Agronomic investigations

Nutrient response of various rice entries under high and low input management

Two new genotypes (IET 28200 and IET 28206) were evaluated against three checks (Shalimar rice 3, VL *Dhan* 86 and VL *Dhan* 85) under two fertility levels (low input-50% RDF and medium input-100% RDF) in the AVT-2 Early Hill (EH) trial (Fig. 2.1.2). IET 28200 produced highest mean grain yield under both low (5,740 kg/ha) as well as medium input (6,575 kg/ha) and recorded yield advantage of 6 to 13% over the best check VL *Dhan* 86. In the AVT-2 upland (UH), one new genotype (IET 28230) was evaluated against Bhalum 1, Sukardhan 1, VL *Dhan* 154 and VL *Dhan* 156 under two fertility levels. The mean maximum grain yield of 3,028 kg/ha and 2,597 kg/ha was recorded for low and medium input, respectively, with IET 28230 (Fig. 2.1.3).

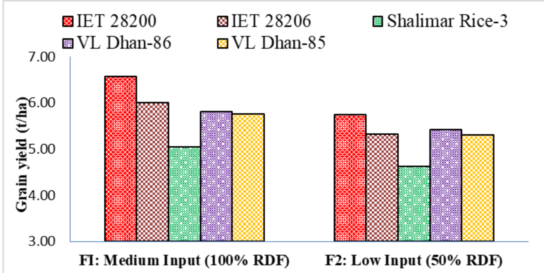


Fig. 2.1.2. Effect of nutrient levels on grain yield of early hill rice cultivars

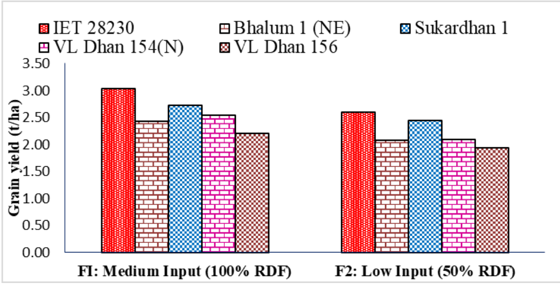


Fig. 2.1.3. Effect of nutrient levels on grain yield of upland rice cultivars

2.2. Genetic Improvement of Wheat and Barley for Higher Productivity, Quality Traits, Abiotic and Biotic Stresses

Wheat is the most important cereal crop of *rabi* season and is grown over an area of 0.32, 0.28 and 0.31 million hectare in Himachal Pradesh, Jammu & Kashmir and Uttarakhand, respectively with an average productivity of 1,970 kg/ha, 1903 kg/ha and 2,696 kg/ha, respectively. Its average productivity in NW Himalayas (2,190 kg/ha) is much below the national productivity of 3,424 kg/ha during 2020-21. These levels of production and productivity can be raised if high yielding varieties having resistance/ tolerance to biotic (yellow rust, brown rust and loose smut) and abiotic (drought and cold) stresses are adopted along with suitable production and protection technologies.

Wheat

2.2.1. Varietal Improvement

2.2.1.1. Elite Lines under All India Coordinated Wheat Improvement Program

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

Rainfed condition

In AVT timely sown trial, the test entry VL 2041 yielded 2,140 Kg/ha at Almora centre. Overall, in the NHZ, VL 2041 (2,790 Kg/ha) was the highest yielding entry numerically superior to the best check HS 562 (2,740 kg/ha). Due to quality parameters like higher grain protein content (12.5%) and low hardness index (29.18) (soft wheat), it was advanced to AVT timely sown rainfed trial of 2021-22. In timely sown IVT trial, test entry VL 2044 (2,920 kg/ha) and VL 2043 (2,870 kg/ha) were the two top yielding entries having significant superiority over thebest check HS 562 (2,670 kg/ha) across NHZ. In late sown restricted irrigation AVT (pre-sown irrigation only) trial, test entry VL 3025 (1,964 kg/ha) yielded statistically superior to the best check VL *Gehun* 892 (1,808 kg/ha).

Irrigated condition

In AVT timely sown trial, test entry VL 2041 was the top yielder (7,580 kg/ha) exhibiting significant superiority over the best check HS 562 (6,540 kg/ha).

2.2.1.2. Elite Lines under State Wheat Improvement Programme

Rainfed organic condition

In SVT organic timely sown trial, VL 2041 (3,571 Kg/ha) recorded higher yield compared to the best check VL *Gehun* 907 (3,357 Kg/ha). Based on the previous two seasons pooled data, VL 2041 (2,699 Kg/ha) having 5.09% yield advantage over the best check VL *Gehun* 953 (2,569 Kg/ha) was advanced to the final year of testing.

Irrigated organic condition

In irrigated SVT organic timely sown trial, VL 2043 (3,240 Kg/ha) was significantly superior to the best check VL *Gehun* 967 (2,800 kg/ha) by 15.76 % in grain yield across different locations and was promoted to 2nd year of testing.

2.2.1.3. Elite Lines under Station Trials

In timely sown rainfed trial, test entries VW 2011 (3,118 kg/ha), VW 2001 (3,042 kg/ha) and VW 2004 (2,729 kg/ha) were the top three entries and were significantly superior to the best check HS 562 (1,917 kg/ha). In late sown restricted irrigation (pre-sown irrigation only) trial, VW 2044 (2,870 kg/ha) and VW 2053 (2,830 kg/ha) were the top two entries outyielding the best check HS 490 (2,710 kg/ha). In irrigated timely sown trial, entries VW 2003 (7,188 kg/ha), VW 2019 (6,868 kg/ha) and VW 2022 (6,840 kg/ha) were better in grain yield than the best check HS 562 (6,787 kg/ha). Based on overall performance, seven high yielding 2,460 to 3,670 kg/ha) and disease resistant entries were nominated to coordinated trials.

Development of new strains/breeding materials

Three hundred and thirty-two fresh crosses [176 spring x spring (S×S) and 156 winter × spring (W×S) wheat] including direct crosses, back crosses and three-way crosses were successfully made by utilizing diverse donors of winter and spring wheats. One hundred sixty-eight better performing F_1 hybrids, consisting of 51 S×S and 117 W×S were identified after evaluation of 277 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 eighty-one F_2s (67 S×S and 114 W×S) and 398 bulk progenies of 398 crosses (268 W×S and 130 S×S) in F_3 to F_5 generations and 496 single plant progenies of 117crosses (50 SxS and 67 WxS) in F_6 and subsequent generations were planted for evaluation and further selection. The heavy rust infection facilitated the selection and on overall basis, 465 bulk and 528 individual plant progenies from F_3 generations onward were selected.

2.2.1.4. Breeding for Reduced Anti-Nutritional Factors and Improved Grain Quality

For protein percentage (>12.5%), seven entries *viz.* VL 3004, VL 3019, DBW 93, QLD 101, QLD 102, QLD 103 and RAJ 4501; for biscuit quality one entry, *viz.*, HS 490; for sedimentation value, three entries *viz.* DBW 173, QLD 73 and QLD 100; for

Table 2.2.1. Promising F_6 bulks with desirable quality parameters

Entry No	Iron (Cateogory)	Protein (%)	Carbohydrate (%)	Fat (%)	Moisture (%)	beta carotene (ppm)	Zeleny sedimentation value (ml)	Polyphenols (mg GAE/g)
1284	High	11.3	69.5	3.5	13.6	1.6	30.0	0.32
1101	Medium	11.3	66.9	3.5	13.9	1.7	20.0	0.34
1280	Medium	11.2	69.4	3.4	13.7	1.6	35.0	0.31
1404	Medium	11.2	72.7	3.4	13.7	1.8	60.0	0.30
1100	Low	11.1	67.3	3.5	13.8	1.7	63.0	0.32
1406	Medium	11.1	70.9	3.4	13.7	1.6	58.0	0.28
1409	High	11.0	70.7	3.4	13.8	1.8	30.0	0.30
1311	High	11.0	68.5	3.4	13.7	1.7	25.0	0.31
1114	High	10.9	68.6	3.6	13.7	1.5	57.0	0.28
1115	Medium	10.9	69.5	3.4	13.8	1.6	25.0	0.30

chapatti quality, four entries *viz*. PBW 757, HD 2967, VL *Gehun* 907 and VL *Gehun* 858; for high iron, eleven entries *viz*. HI 1609, GW 1339, HI 1621, DBW 107, HD 3237, DBW 221, FLW 10, CG 1018, DBW 252, HS 562, Raj 4083; and for high zinc, two entries *viz*. WH 1105, MP 3366 were used as donors for the respective traits and were crossed with well adapted genotypes. Twenty-three F_1 crosses attempted during the previous season for quality (*rabi* 2019-20) were evaluated during *rabi* 2020-21. Additionally, ninety-four fresh crosses (30 WxS and 64 SxS) were attempted during *rabi* 2020-21. Quality analysis of 218 F_6 bulks derived from such crosses was completed. The quality parameters of promising F_6 bulks are given in Table 2.2.1.

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

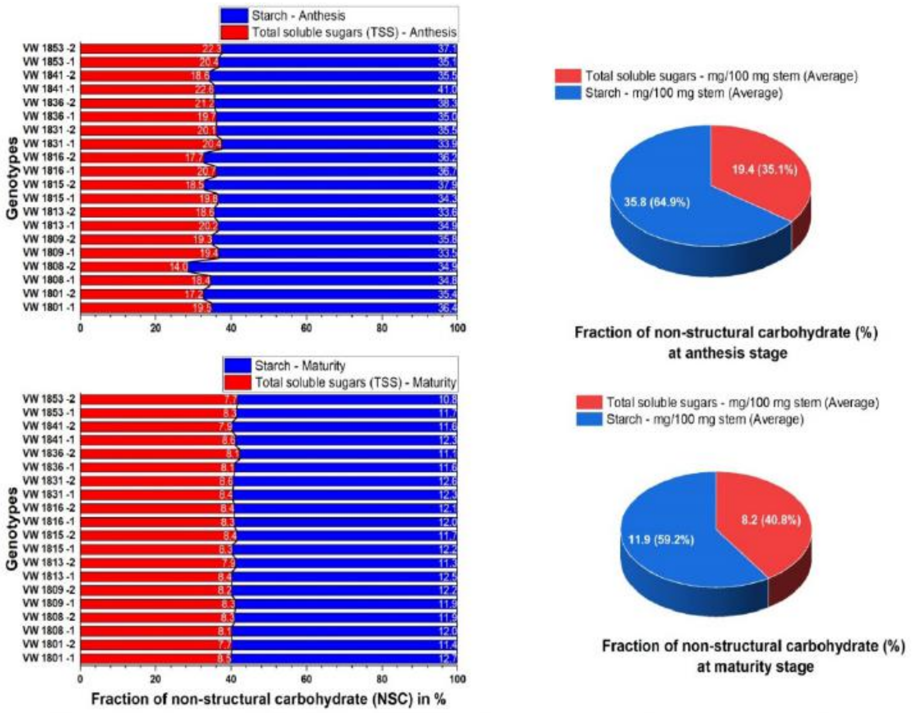
Forty-two winter and facultative wheat were selected and crossed to spring wheats. A total of 156 (winter x spring) crosses including 93 direct crosses, 6 backcrosses and 57 3-way crosses were successfully made during *rabi* 2020-21. In addition to this,114 F_1s made during *rabi* 2019-20 were planted and 107 were retained for growing their F_3 generation during the next crop season (2021-22). A total of 50 F_2s retained during last season (2019-20), were raised during *rabi* 2020-21 and finally, 44 F_2s were bulked. The 44 F_2 bulks were shared with 21 cooperators in five major wheat growing zones (Northern Hills Zone, North Western Plain Zone, North Eastern Plain Zone, Central Zone and Peninsular Zone) of the country through 24th Segregating stock nursery (SSN) for evaluation and further selection under different biotic and abiotic stresses. The utilization report revealed that these materials were used to the tune of 46.2% by different cooperating centers and a total of 3,653 plants were selected.

2.2.1.6. Genetic Resources – Evaluation, Utilization and Maintenance

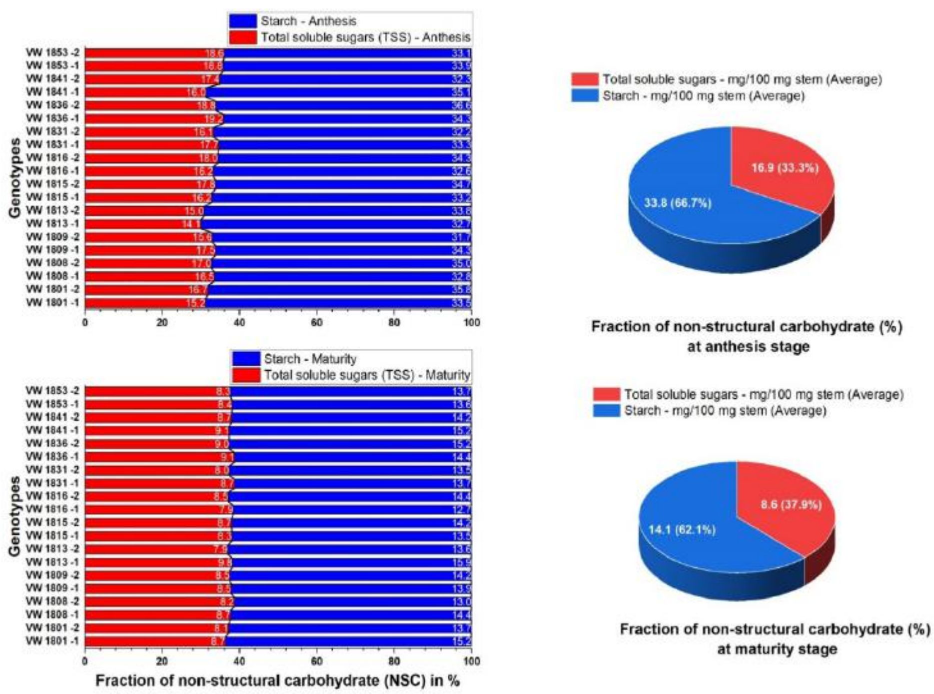
National Genetic Stock Nursery (NGSN) comprising of 90 entries, 22nd IWWYT–SA 2020-21 and 23rd IWWYT–IR–2020-21 of 40 and 50 entries, respectively, and Facultative and Winter Wheat Observation Nursery (28th FAWWON–SA–2020-21) having 90 entries were evaluated. The entries from NGSN were utilized for diverse purposes such as blast resistance (DBW 222, DBW 252, HD 3086, HI 1633), good agronomic base (DBW 71, DBW 303, RAJ 3765, K 1317 and HI 1544), high iron (DBW 107, DBW 110), high protein content (DBW 93, DBW 110), 1000 kernel weight (TAW 185), shorter plant height (DM 6, DM7) and disease resistance (DBW 187, PBW 778). Likewise, 9 entries from 22nd IWWYT–SA, 2020-21; 10 entries from 23rd IWWYT–IR–2020-21; and 6 entries from 28th FAWWON–SA–2020-21 were utilized as donors in the hybridization programme for having good agronomic characteristics including 6 entries having higher protein content (13.3–18.0%).

2.2.1.7. Non-structural carbohydrates stem reserves in wheat stem

The non-structural carbohydrates (NSC) were estimated in the wheat stem (sheath + culm) at two different physiological stages (anthesis and maturity) in 10 different wheat genotypes at two different dates of sowing, *i.e.*, timely (16th November, 2020) and very late (16th January, 2021). During timely sown conditions, the average total soluble sugar (TSS) content at anthesis stage was 19.4 mg (range – 14.0–22.0 mg) which reduced by 57.3% at the physiological maturity stage to reach average value of 8.2 mg (range–7.7–8.6 mg). Likewise, starch component of the NSC at anthesis stage had an average value of 35.8 mg (range –33.5–41.0) which reduced to an average value of 11.9 mg (10.8–12.7 mg), showing 66.7% reduction from the initial levels at anthesis stage. The NSC composition at anthesis was 35% TSS and 65% starch, which changed to 41% TSS and 59% starch at the maturity stage. Compared to timely sown conditions, the same genotypes in late sown conditions showed less amount of NSC, *i.e.,* average TSS content of 16.9 mg (range–14.1–19.2 mg) and average starch content of 33.8 mg (range–31.7–36.6 mg) at anthesis stage. The important observation in the experiment was that the percent reduction in TSS (30.4–55.6%) and starch (51.5–62.8%) at maturity was lower in late sown condition compared to the timely sown conditions.



Non structural carbohydrates (NSC) in wheat stem at anthesis and maturity stages in timely sown conditions.



Non structural carbohydrates (NSC) in wheat stem at anthesis and maturity stages in late sown conditions.

2.2.1.8. Inheritance studies for transgenerational stress memory in wheat induced by late sowing

Ten test entries having low- and high-test weights sourced from the *rabi* 2019-20 timely and late sown trials, respectively were aggregated to constitute a 20-entry trial in two different dates of sowing (timely & very late) during *rabi* 2020-21 to find underlying transgenerational memorization for test weight. The thousand kernel weight was further bifurcated into superior and inferior grains based on the grain filling characteristic of the wheat spike. During timely sown conditions, single grain weight of superior grains ranged from 42.0 to 54.0 mg which was 8.30 % heavier than the inferior grains having average single grain weight of 44.6 mg (range–39.1 to 50.2 mg). The difference between the superior and inferior grains was highest and lowest for genotype VW 1841 (10.2%) and VW 1836 (7.1%), respectively. During the very late sown conditions, the difference between the single grain weight of superior and inferior grains decreased and superior grains were heavier than inferior grains by an average value of 6.4% (range–4.1–9.2%). Genotype VW 1841 had highest reduction in single grain weight for both superior grain (by 16.8%) and inferior grain (by 15.7%) in very late sown conditions compared to the timely sown conditions. Whereas, genotype VW 1801 was least affected in two different dates of sowing, as evident by least reduction of 1.1% for superior grain and -2.6% for inferior grains. In very late sown conditions, the paired t-test for the superior grains showed a significant difference for kernel weight of the same genotype, which is attributable to last season's test weight differences with p values <0.001.

2.2.2. Plant Pathological Investigations

More than 1,900 wheat and barley entries/lines under different coordinated and station nurseries/ trials were screened under artificial epiphytotic conditions. These include Wheat Disease Monitoring Nursery (WDMN), SAARC nursery, Loose Smut Expression Nursery (LSEN), VL Rust Screening Nursery, Powdery Mildew Screening Nursery (PMSN), Hill Bunt Screening Nursery (HBSN), Elite Plant Pathological Screening Nursery (EPPSN), Multiple Disease Screening Nursery (MDSN), National Barley Disease Screening Nursery (NBDSN), Elite Barley Disease Screening Nursery (EBDSN) and Initial Barley Disease Screening Nursery (IBDSN) (Table 2.2.2).

Table 2.2.2: Promising lines of wheat & barley in different disease screening nurseries

Nursery	Promising lines (disease reaction)
WDMN	PBW752 (0S), C 306 (0S), HS 420 (0S), WL1562 (0S) against stripe rust; susceptible check-40S
SAARC	HD 2204 (0S), PBW 660 (0S), Faisalabad 83 (0S) against stripe rust; susceptible check (20S)
LSEN	HS 680 (19.5%), DBW 222 (I) (19%), WH 1124 © (10.7%), DDK 1058 (3.7%), Sonalika (56.5%)
VL Rust Screening	VW 2004, VW 2012, VW 2015, VW 2016, VW 2017, VW 2018, VW 2019, VW 2020, VW 2032, VW 2040, VW 2044, VW 2045, VW 2047, VW 2049, VW 2050, VW 2052, VW 2054 (0S); Infector (40S)
PMSN	VL 2041 (3), HD 3349 (3), DBW 372 (3), PBW 343 (c) (7)
HBSN	VL 907 (6.1%), VL 2041 (11.1%), HS 507 (8.5%)
EPPSN	• DDW47(d)(I), HI 8823(d), HI8627(d), HS 507 (C), HS 679, MPO 1357(d), PBW804, UAS 472(d), DDW49 (d), HUW838, NIAW3170(I) (C), VL 2036 (for all rusts); • NIDW 1149(d), CG1029, DDK1058, DDK1059, GW513, HD2864, HD3377, HI1544, HI1628(I) (C), HI1633, HI1634, HI1636, MACS5054, MACS6752, MP3288, PBW840, RAJ4541 (for stem & leaf rusts); • DBW303*, HD3249(I) (C), HI8805(d)(I) (C), HI8818(d), MP 1358, MP1361, UAS466(d)(I), DDW48 (d)*, HS 680, JKW261, BW329, MACS6747, PBW771(I) (C) (for leaf & stripe rusts); • HD3334, HS 681, VL 3024, DBW296, UP3033 (for stem & stripe rusts)
MDSN	• WH 1270, VL 3020 (Resistant to all three Rust + LB + FS); • DDW 48 (d), DDW 47 (d), VL 3021, PBW 825, PBW 796, DBW 303 (Resistant to Leaf and Stripe Rust + KB + FS)
NBDSN	DWRB222, HUB272, PL927, RD3033, RD3034, RD3039, HBL113 (0S); Infector-60S
EBDSN	RD 2552, KB 1817, DWRB 210 (0S); Infector-60S
IBDSN	BK 2024, BK 2029, BK 2055, BD 1882, BD 1883, BD 1891, BD 1897, BD 1902, BD 1908, HUBL 2023, PKB 2031, NDB 1799, UPBM 11, BL 1865, BL 2083, BL 2088, BL 2092, BL 2095, BL 2102, BL 2105, HB 2001, HB 2004, HB 2005, HB 2007, HB 2008, HB 2009, BBM 861, BBM 868, BBM 888, BBM 890 (0), Infector-60S

2.2.3. Agronomic investigations

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

Productivity of five wheat genotypes (VL 2028, VL 2029, VL 3010, VL 3004 and VL *Gehun* 953) was evaluated under timely and late sown irrigated conditions. In the study the two sowing times were found at par with each other for wheat productivity with no significant sowing time and varietal interaction. As a main effect of genotype, VL *Gehun* 953 and VL 2029 recorded the highest grain yield of 6.30 t/ha and 5.82 t/ha, respectively, under the irrigated ecosystem. Under late planting conditions, significant positive correlation was found between spike length and grain number/spike and 1000-grain weight and grain yield of wheat (Fig 2.2.1 a & b)

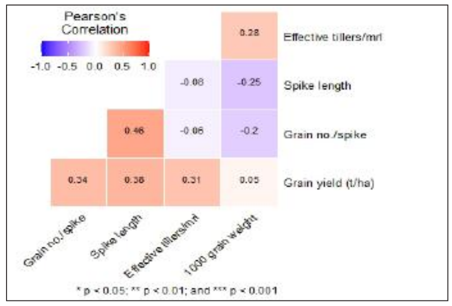


Fig 2.2.1.a. Correlation among different variables for normal sown wheat crop

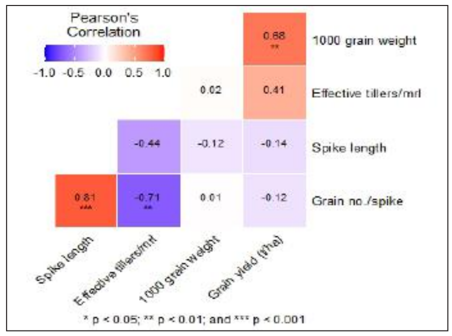


Fig 2.2.1.b. Correlation among different variables for late sown wheat crop

Barley

Barley is cultivated in some traditional areas of North-Western Hills. It is being cultivated in 20.0 thousands hectare area in Himachal Pradesh, 6.7 thousand hectares area in J&K and 22.0 thousand hectare area in Uttarakhand with an average productivity of 1,810 kg/ha, 617 kg/ha and 1203 Kg/ha, respectively in the three states/union territories of NW Himalayas (2020-21). Barley improvement work is focused mainly on the development of high yielding and disease resistant varieties suitable for rainfed conditions of NW hills.

2.2.4. Varietal Improvement

2.2.4.1. Elite lines in all India Coordinated/State/Station Trials

Twenty-eight new bulks generated through institute breeding programme were evaluated in station trials under rainfed condition. Five promising strains having yield potential ranging from 1,880 to 2,290 kg/ha were selected and nominated to the All India Coordinated trials of Northern Hill Zone.

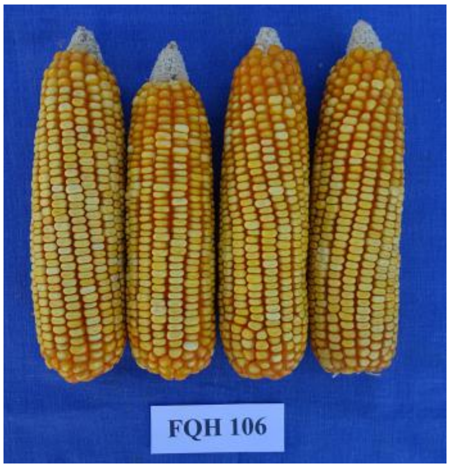
2.3. Genetic Enhancement of Maize for Yield and Nutritional Quality Using Integrated Breeding Approach

Maize is mainly cultivated during the *kharif* season under rainfed conditions in the North-Western Hills. The states of Himachal Pradesh and Uttarakhand (Hills) and UTs of Jammu & Kashmir and Ladakh with a total area of 625 thousand hactare and production of 1,189 th tonnes account for 7.2 and 5.5% of the national area and production, respectively. The productivity is 1,902 kg/ha compared to national average of 2,509 kg/ha. Considering the low yield of local cultivars and short growing period in hills, emphasis was laid on the development of early duration genotypes (85-90 days maturity) 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 and baby corn varieties, in view of the commercial potential of specialty corn in the region. Further, in line with the national thrust on nutritional security, special focus was placed on development of bio-fortified varieties.

2.3.1 Varietal Improvement

Notification of Varieties

VL QPM Hybrid 59 (FQH 106) was notified and released for cultivation in Uttarakhand hills vide S.O.500(E) dated 29.01.21.



Identification of Varieties

Three QPM hybrids namely, FQH 140, FQH 148 and FQH 165 including one EDV (Essentially Derived Variety) were identified for release under organic conditions in Uttarakhand hills at *kharif* SVT workshop held in May 2021.

Variety	Character
FQH 140	This hybrid has been developed by combining VQL 1 and VQL 17, which are MAS-derived versions of normal corn lines CM 212 and V 341. It is an extra early maturing (85-90 days) hybrid. FQH 140 (4,435 kg/ha) exhibited yield superiority of 10.9 % over QPM check Vivek QPM 9 (4,000 kg/ha). It possesses mean tryptophan, lysine and protein of 0.76%, 3.30 and 9.16%, respectively. FQH 140 exhibited moderate resistance against turcicum and maydis leaf blight.
FQH 148	This hybrid has been developed by combining VQL 398 (MAS-derived version of normal corn line V 398) and high tryptophan line V 467. It is an early maturing (90-95 days) hybrid. FQH 148 (4,675 kg/ha) exhibited yield superiority of 16.9 % over QPM check Vivek QPM 9 (4,000 kg/ha). It possesses mean tryptophan, lysine and protein of 0.72%, 3.20% and 9.22%, respectively. FQH 148 exhibited moderate resistance against turcicum and maydis leaf blight.
FQH 165	This hybrid is QPM EDV of popular hybrid VMH 45 and has been developed by combining VQL 373 and VQL 390, which are MAS-derived versions of normal corn lines V 373 and V 390. It is an early maturing (90-95 days) hybrid. FQH 165 (4,342 kg/ha) exhibited 4.02 % yield superiority over the original normal corn hybrid VMH 45 (4,167 kg/ha). It possesses mean tryptophan, lysine and protein of 0.70%, 3.17 and 9.62%, respectively, compared to 0.55%, 2.39 and 8.64%, respectively, in VMH 45. FQH 165 exhibited moderate resistance against turcicum and maydis leaf blight.

2.3.1.1 Elite lines under Maize Improvement Programme

During *kharif* 2021, a total of 229 entries were evaluated in Co-ordinated and Station Trials. The entries performing better than the checks are as follows:

Trial	Promising entries	Checks
AICRP Trials (NHZ)	FQH 186 (8,098 kg/ha) FPVH 1 (7,069 kg/ha)	VMH 53 (7,823 kg/ha) APQH 9 (6,073 kg/ha)
State Varietal Trial (Hills)	FH 3879 (4737 kg/ha) FQH 160 (4,618 kg/ha) FPVH 1 (4,293 kg/ha) FLPH 31 (3,914 kg/ha) FQH 186 (4,798 kg/ha)	VMH 45 (3828 kg/ha) VMH 53 (4,321 kg/ha) Vivek QPM 9 (3,922 kg/ha)
State Varietal Trial (Plains)	FH 3947 (5,109 kg/ha) FH 3861 (5,151 kg/ha) FQH 160 (5,450 kg/ha)	VMH 51 (4,481 kg/ha) PQMH 1 (5,095 kg/ha)
Station Trial		
Normal Corn-I	FH 4071 (7,682 kg/ha) FH 4080 (7,752 kg/ha) FH 4081 (7,350 kg/ha	VMH 45 (7,092 kg/ha) DKC 7074 (6,948 kg/ha)
Normal Corn-II	FH 4091 (8,352 kg/ha) FH 4103 (8,144 kg/ha) FH 4099 (7,952 kg/ha)	DKC 7074 (7,096 kg/ha) VMH 45 (6,864 kg/ha)

Trial	Promising entries	Checks
Sweet Corn	FSCH 218 (24,708 kg/ha) FSCH 212 (22,794 kg/ha) FSCH 209 (21,754 kg/ha)	Sugar 75 (21,222 kg/ha) VLSCH 2 (18,984 kg/ha) CMVLSC 1 (18,226 kg/ha)
Iron-Zinc	FMH 45 (8,818 kg/ha) FMH 52 (8,330 kg/ha)	VMH 45 (7,710 kg/ha) VPQM 9 (7,128 kg/ha)
Inbred	MCA-23-5 (5,922 kg/ha) V 400 (5,706 kg/ha) VQL 373 (5,416 kg/ha) MCB-10-A (5,208 kg/ha)	V 373 (5,273 kg/ha) CM 212 (3,917 kg/ha)
CRP Bio-fortification & Molecular Breeding and NASF DH project		
QPM/ Provitamin A	FPVH 31 (8,986 kg/ha) FPVH 27 (8,292 kg/ha) FWH 1 (8,477 kg/ha)	VPQM 9 (6,909 kg/ha) VMH 45 (8,123 kg/ha)
Low phytate	FLPH 45 (9,511 kg/ha) FLPH 49 (8,202 kg/ha) FLPH 43 (7,464 kg/ha)	VPQM 9 (6,059 kg/ha) VMH 53 (8,034 kg/ha)
Normal Corn-III (DH)	FDH 40 (8,980 kg/ha) FDH 42 (8,485 kg/ha)	DKC 7074 (7,213 kg/ha) VMH 45 (7,082 kg/ha)
Normal Corn-IV (DH)	FDH 72 (8,302 kg/ha) FDH 69 (7,636 kg/ha)	DKC 7074 (7,210 kg/ha) VMH 45 (7,995 kg/ha)

2.3.1.2. Breeding Materials/Development of New Strains

Development of composites

For developing a medium duration composite variety, inter-mating was carried out among individuals with desired ear and kernel traits in C_1 population (derived from local cultivar Kwanu Local). Ears were harvested from selected plants and screened for desired ear and kernel traits [longer cobs (27-30 cm), higher number of kernel rows (>18) and higher test-weight (375-400g)]. The seed from the selected plants possessing desirable traits was bulked for further cycles of inter-mating and selection.

Development of normal and specialty corn inbred lines

- Four hundred and seven progenies of different homozygosity levels (72 S_1, 82 S_2, 47 S_3, 33 S_4, 33 S_5, 72 S_6, 21 S_7) and 47 advance generation lines were evaluated and 353 (114 S_2, 70 S_3, 56 S_4, 27 S_5, 46 S_6, 24 S_7) and 16 advance lines possessing earliness (90-100 days), medium plant height (150-175 cm), good vigour, shorter anthesis-silking interval (1-2 days) and tolerance to turcicum leaf blight (disease score <5.0) were retained for further selection and inbreeding.
- Seven advance generation elite inbred lines (V 533 to V 539) possessing early maturity (54-58 days to 50% silking), short stature (140-170 cm), high vigour and resistance to turcicum leaf blight (disease score <5.0) were established and used for hybrid development.
- Selection and inbreeding was continued in 10 S_1 progenies and 21 S_2 progenies of sweet corn, and 17 S_2 progenies and 9 S_3 progenies with medium plant height (150-175 cm), earliness (54-59 days to 50% silking) and tolerance to turcicum leaf blight (disease score <5.0) were retained for further inbreeding, selection and use in hybridization.
- Evaluation of 10 BC_2F_3 progenies each of the crosses between normal corn lines V 412, V 461, V 467 and V 484 and sweet corn donors SA-14-1 and SB-4-1 was carried out. In each cross, 6-8 progenies with early maturity (54-58 days to 50% silking), shorter plant height (165-190 cm), shorter ASI (1-2 days) and tolerance to TLB (disease score <5.0) were retained for further inbreeding, selection and use in hybridization.

Development of new single-cross hybrids

- Forty new normal corn hybrid combinations were generated involving 5 existing elite lines and 23 new promising lines (7 conventional inbreds and 16 DH lines).
- Eighteen new sweet corn hybrid combinations were generated involving 5 existing elite lines and 9 new promising lines.
- Sixteen new biofortified (QPM and Provitamin A) hybrid combinations were also generated using elite VL lines and new promising lines.

Biofortification in maize for high micronutrient and methionine content

- A set of 61 inbred lines involving indigenous, Bajaura lines, MTC DH lines and CIMMYT lines, were evaluated for Fe and Zn content. The target levels were set at 52 µg/g and 33 µg/g for Fe and Zn, respectively, depending on an estimated average requirement (EAR) of 1,460 µg /day for Fe and 1,860 µg /day for Zn by Harvest Plus.
- Sixty-eight DH lines from two source populations *viz.*, MTC 4 (PVD 3-2 x BS 24-2-5) and MTC 8 (PVE 44-11 x BS 24-2-5) were screened for high micronutrient content. A wide range of micronutrient variation was observed in the DH lines for Fe (27.3-45.9 ppm) and Zn (24.3-41.6 ppm) content. A set of 18 DH lines with moderate Fe (>40 ppm) and high zinc (>33 ppm) content were selected.
- During *kharif* 2021, a set of 61 inbred lines for Fe and Zn content were evaluated and maintained. Thirty-two inbred lines were retained with medium plant height (140-195 cm), earliness (52-58 days to 50% silking) and high micronutrient content.
- Thirty new Fe/Zn hybrid combinations were generated using elite VL lines and new promising lines.
- Ten new breeding crosses were generated involving CIMMYT donors with high zinc content and double trait biofortified lines [EC1065432 x VBL1 & EC1065428 x (PVD x PA-12-1)].
- The generation of breeding crosses (CML161 x Lpa2, BAJIM-06-11 x Lpa2, BAJIM-06-15 x VBL1, BS-21-2-3-1 x Lpa2, CS-15-2-1 x Lpa2) was advanced and 5 progenies from each cross were retained for the further generation advancement.
- Backcrosses and three-way crosses of pre-breeding material involving Jala landraces (EC949677-EC949681) and elite inbred lines V400, CQE, MCA, VQL1 and VQL2 were generated for further selection and advancement.

2.3.2. Germplasm Resource: Evaluation and Maintenance

- Thirty-five introductions received from WNC Hyderabad during 2019 were evaluated and 12 introductions with early maturity (53-56 days) and tolerance to TLB (disease score <5.0) were retained for further inbreeding, selection and use in hybridization.
- Four local accessions of Uttarakhand (Kwanu Local, Dhiari Local, Amritpur Local and Jaunsar Local) and 03 from Himachal Pradesh (Chamba Local White, Chamba Local Yellow and Hamirpur Local) were maintained
- Seven CIMMYT donor lines [2 low phytate (Lpa 1, Lpa 2), 2 provitamin A (CIMMYT 4, CIMMYT 13) and 3 haploid inducer lines and 2 liguleless lines from University of Hohenheim (Germany) were maintained.
- Five accessions of Jala landrace from CIMMYT were evaluated and maintained.
- Twenty biofortified (provitamin A, QPM, low phytic acid) lines were evaluated and maintained.

2.3.3. Details of germplasm shared

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

Details of maize inbreds shared with NARS institutes

Institute	Germplasm
Bihar Agricultural University (BAU), Sabour, Bihar	VQL1
Division of Seed Science, ICAR- IARI, Pusa	CM 212, CM145
Indian Institute of Maize Research, Ludhiana (for DUS)	V 335, V 345, V 341, V 346, V 373, CM152, CM212, VQL1
ICAR-NBPGR, New Delhi	VBL 17, VQL 398, VQL 390, V 461

2.3.4. Agronomic investigations

Three new maize genotypes (DH 316, FH 3879 and FQH 160) were evaluated against two checks (VQPM 9 and VMH 45) with two fertilizer levels

(150-60- 22560 and 225-90-90 kg/ha N-P_2O_5-K_2O). The fertilizer level of 225-90-90 kg/ha N-P_2O_5-K_2O provided significantly higher (26.2%) grain yield (7,569 kg/ha) as compared to 150-60-60 kg/ha N-P_2O_5-K_2O (6,000 kg/ha). Among genotypes, FH 3879 produced significantly higher grain yield (7,637 kg/ha) than other genotypes.

Four pre-release sweet corn genotypes (CPS Sweet 2, CPSC-301, CMVL sweet corn 1, Mishti) were evaluated under two planting densities (60 cm × 20 cm and 60 cm × 16 cm) and two fertilizer levels (150-60-60 and 225-90-90 kg/ha N-P_2O_5-K_2O). Two planting densities and fertility levels were found at par for sweet corn green cob yield. Among genotypes, CPSC-301 produced significantly higher green cob yield (29.798 t/ha) than others followed by CP Sweet 2 (green cob yield 26.045 t/ha).

Three pre-release maize genotypes (KMH 18-15, Bio 605 and Vivek Hybrid 45) were evaluated under two planting densities (60 cm × 20 cm and 60 cm × 16 cm) and two fertilizer levels (150-60-60 and 225-90-90 kg/ha N-P_2O_5-K_2O). The fertility level (225-90-90 kg/ha N-P_2O_5-K_2O) improved grain yield of maize by 16.4% over 150-60-60 kg/ha N-P_2O_5-K_2O level. Among genotypes, Bio 605 produced significantly higher grain yield (8.16 t/ha) followed by Vivek Hybrid 45 (7.64 t/ha).

2.3.5. Plant Pathological Investigations

More than 300 maize entries under different coordinated and station trials were evaluated against turcicum leaf blight (*Exserohilum turcicum*) (Table 2.3.1).

Table 2.3.1. Identified resistance sources against turcicum leaf blight

Trial	Highly resistant entries (<3 score on 1-9 scale)
Early entries	AH-4139, SMH-4555, AH-4167, AH-4654, AH-4663, CP 999, CP 111, LMH 2174, and JH 32662.
Medium entries	IM16981, IM 03809, QMH 1701, PHM 114, LMH 221, LMH 4321, LMH 9421, LMH 10921, DH 346, DH 347, DKC 9228, DKC 8221, DKC 9224, JH 17014, JH 17026 and JH 19099.
QPM I-II-III	HQPM 29, IQPMH 2004, HQPM30, LQMH 1920, IQPMH 2012, FQH 160, FQH 165, QQPMH 1725, FQH 186, IQPMH 2101, IQPMH 2102, IQPMH 2103 and IQPMH 2105.
OPV, SC, BC, and PC	MZM 16, DOP-339, KDM -30, L316, ADC-2, ADC-3, DBCH 350, MBC-20-5, IMHSB-20KB- 3, FSCH 144, FSCH 196, LPCH 219, and IMHSB 21KP 2.
Trap nursery	CM 501, BML 7, Surya and IIMR PBT pool

2.4. Trait Mining and Genetic Improvement of Small Millets and Potential Crops in the Context of Climate Change

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). Development of short duration, high yielding and disease resistant varieties of small millets is the main activity of the research

2.4.1. Genetic Stocks Registered

Three genetic stocks of finger millet and two genetic stocks of barnyard millet were registered with National Bureau of Plant Genetic Resources, New Delhi.

Finger millet

Name	INGR No	Unique traits
VL 386	21128	Resistant to foot rot, leaf blast, neck blast, finger blast, high harvest index and high yield
VL 399	21129	Broad resistance to finger and neck blast
VL 384	20146	White grain, blast resistant, medium maturity and high grain yield
Barnyard millet		
VB 19-16	21049	Awnless panicles with green glumes and semi dwarf type
PRB 903	21127	Highly resistant to grain smut

2.4.2. Elite lines under All India Coordinated Small Millets Improvement Programme

Finger millet

In Initial Varietal Trial, 3128 (4,223 kg/ha) and 3114 (4,120 kg/ha) were the top ranking entries. Similarly, in Advanced Varietal Trial (AVT) (early and medium duration), 4057 (3,840 kg/ha) and 4101 (3,654 kg/ha) recorded highest yield followed by 4052 (3,482 kg/ha) and local check VL *Mandua* 324 (3,198 kg/ha).

Barnyard millet

In Barnyard millet Initial and Advanced Varietal Trial (BIAVT), entry 1062 recorded the highest grain yield (3,404 kg/ha) followed by 1051 (3,319 kg/ha) and 1054 (3,023 kg/ha).

2.4.3. Breeding materials/Development of new strains

Finger millet

Yield evaluation of superior bulks in station trial

Twenty five superior bulks identified in F_6 generation of different crosses were evaluated in Initial Station Trial (IST) for yield and yield attributing traits along with four checks GPU 45, GPU 67, PR 202 and VL *Mandua* 376. Entry VR-20-32 (3,604 kg/ha), VR 21-7 (3,304 kg/ha) and VR-21-8 (3,219 kg/ha) were superior to the best check VL *Mandua* 376 (2,805 kg/ha). These bulks were also evaluated for resistance to neck and finger blast disease under natural infestation conditions. Entry VR-20-32 was found to be resistant to neck (mean score 7.6%) and finger blast (mean score 8.7%).

Development of new strains

Forty three new cross combinations were attempted involving high yielding blast resistant released varieties (VL *Mandua* 324, VL *Ragi* 149, VL *Mandua* 315, VL *Mandua* 378, VL *Mandua* 352); early maturing, locally adapted lines (VR 20-35, VR 20-34, VR 20-38, VR 20-36, VR 20-27); white-grain lines (VL *Mandua* 384, VR 13-18, VL *Mandua* 382). In addition, late maturing high yielding lines of African origin (Indaf 7 and Indaf 9) as well as genotypes selected from yield evaluation trials (KMR 316, VL 400 and VL 410) were also included in the crossing programme.The breeding materials were handled following pedigree method. Plant progenies of different segregating generations were subjected to rigorous selection. The infector rows for neck and finger blast were planted in and around the breeding materials.

Yield evaluation of superior bulks in station trial

Twenty-five bulks were evaluated for yield and yield contributing traits in barnyard millet initial station trial along with two national checks (DHBM 93-3 and VL *Madira* 207) and one local check (PRJ 1). Entries IE-548 (3,204 kg/ha), IEc 516 (2,905 kg/ha), VB 21-5 (2,809 kg/ha) were superior to the best check VL *Madira* 207 (2,218.2 kg/ha).

Development of new strains and details of breeding material

Twenty new cross combinations were attempted involving locally adapted genotypes (IEc 778, IEc 510, VB 21-5, IEc 516, VB 21-3, VB 19-16, VB 18-9 and VL 137) and promising line from ICRISAT core collection (IEc 537, IEc 540, IEc 517, IEc 400; IEc 387; IEc 400; IEc 452; IEc 516; IEc 436) (Table 2.4.1).

Table 2.4.1. Details of barnyard millet breeding material

Generation	Number of crosses	Number of progenies	Single Plant selections	Selection criteria
F_1	10	-	-	Early maturity (>100 days), reduced plant height, awnless Japanese type, resistance to grain smut, increased panicle length and width, higher grain yield
F_2	10	-		
F_3	12	45	57	
F_4	7	65	40	
F_5	11	89	47	
F_6	12	53	-	

2.4.4. Agronomy Investigations

Response of pre-release finger millet varieties to different levels of fertilizer under rainfed condition

Pre released finger millet variety (FMV 1162) was evaluated against three checks (VL *Mandua* 376, GPU 67 and PR 202) with four nutrient levels (control, 75, 100 and 125% NPK) under rainfed condition. Grain yield of different finger millet varieties increased with increasing fertilizer levels. The variety FMV 1162 gave highest grain yield (3,333 kg/ha) and recorded yield advantage of ~13% and 28% over the best checks VL *Mandua* 376 and GPU 67, respectively.

2.4.5. Plant Pathological Investigations

Both coordinated and station trials were evaluated for their reaction to finger millet blast and grain smut of barnyard millet. The identified resistant entries were summarized in the Table 2.4.2.

Table 2.4.2. Identified resistant entries

Crop	Nurseries	Total entries evaluated	Disease	Resistant entries
Finger millet	FMIVT	28	Leaf blast	VL-410
			Neck blast	DPLM-2 and DPLM-3
			Finger blast	IIMR-FM-7028, DPLM-2, KOPN-1056, VL-410, CFMV-2, CFMV-1 and VL-376
	FMAVT (NZ & SZ)	13	Leaf blast	-
			Neck blast	VL-400, VL-408, FMV-1194, DPLN-2, CFMV-1 and CFMV-2
			Finger blast	VL-400, VL-408, CFMV-1 and CFMV-2
	National Screening Nursery (NSN-FM)	22	Leaf blast	VR 1146, VR 1148, VHC 4087, VL-384 and VL-410
			Neck blast	VHC 4087, VRBMF 1817, UURM-2015-1, KMR-203, KMR-630, KMR-316, KMR-655, VL-409 and VL-410
			Finger blast	VR 1146, VR 1148, VHC 4087, VRBMF 1817, VRBMF 1819, UURM-2014-2, UURM-2015-1, KMR-203, KMR-340, KMR-630, KMR-655, VL-409 and VL-391
	Station trial	25	Leaf blast	VL 403, VL 405, VL 406, VR 20-12, VR 20-20, VR 20-25, VR 20-1, VR 20-27, VR 20-21, VR 21-1, VR 21-6, VR 21-8 and VL 376
			Neck blast	VR 20-20, PR – 202, and GPU - 67
			Finger blast	VL 403, VL 380, VL 396, VR 20-38, VR 20-12, VR 20-20, VR 20-25, VR 20-1, VR 20-27, VR 20-21, VR 21-1, VR 21-2, VR 21-3, VR 21-4, VL 376, PR – 202 and GPU - 67
Barnyard millet	BIAVT	20	Grain smut	DHBM 93-3, DHBM 4-63, DHBM 47-5-6, VL 284 and TNEF 323
	NSNBM	18	Grain smut	LRB-10, LRB-13, LRB-14, LRB-15, LRB-24, LRB-29, LRB-30, VB-19-12 and VL 257

Sub-project: Genetic Improvement of Quinoa for High Yield, Nutritional Quality and Tolerance to Biotic Stresses

Ten quinoa accessions procured from NBPGR RS, Shimla were evaluated during *rabi* 2020-21. The accessions, namely, EC-507740, EC-507744, EC-507747 and EC-507741 were found promising on the basis of seed yield per plant (>45 g) and maturity duration (<118 days).

Field view of quinoa crop at ICAR-VPKAS, Hawalbagh

2.5. Genetic Improvement of Pulses and Oilseeds for Higher Productivity, Quality, Biotic & Abiotic Stresses for North-Western Himalayan Hills

Pulses and oilseeds are inseparable constituents of rainfed agriculture in marginal lands across the country. These valuable crops traditionally serve as crucial components of 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 106 thousand hectares with 157 thousand tonnes production, whereas the total oilseed production is 74 thousand tonnes from 86 thousand hectares in North-Western Himalayas (DAC 2019-20). 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.

2.5.1. *Rabi* Legumes (Lentil and Field Pea)

2.5.1.1. Elite lines under All India Coordinated Programme

In IVT (Tall), field pea entry VL 72 (2,648 kg/ha), which surpassed the best check Aman (2,132 kg/ha), was promoted to AVT I (NWPZ).

2.5.1.2. Breeding Materials/Development of New Strains

Sixty one new cross combinations were obtained involving high yielding wilt resistant (PL 02, IPL 321, DPL 58, PL 117 and DKL 37), high biomass (LL 1203, LL 699 and LL 1122), and early (ILWLS 118, L 4717 and L 4710) varieties in the crossing program. Thirty-five cross combinations were advanced to F_2 generation and 175 crosses (F_2 to F_6 generation) with 484 progenies were selected and advanced to subsequent generations following pedigree method. Twenty-four 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.

2.5.1.3. Elite Lines under Station Trials

A total of 4 station trials of lentil were conducted. In Initial station trial (large,) entries, *viz.* VLM 2020-102 (1,305kg/ha),VLM 2020-112 (1,247 kg/ha) and VLM 2020-106 (1,131 kg/ha) were found superior to the best check VL *Masoor* 514 (1,015 kg/ha), whereas in Initial station trial (small), entries *viz.* VLM 2020-4 (1,595 kg/ha), VLM 2020-11 (1,595 kg/ha) and VLM 2020-12 (1,537 kg/ha) were found superior to the best check VL *Masoor*148 (1,392 kg/ha). In advance station trial (small), entries *viz.* VLM 2019-12 (2,348 kg/ha) and VLM 2019-7 (1,913 kg/ha) were found superior to the best check VL *Masoor* 148 (1,652 kg/ha), whereas in Advance station trial (large), entries *viz.* VLM 2019-114 (2,049 kg/ha) and VLM 2019-107 (1,920 kg/ha) were found superior to the best check VL *Masoor* 514 (1,721 kg/ha).

2.5.1.4. Elite Lines under International Nurseries

In yield adaptability trial, a total of 36 exotic lines were evaluated in international nurseries LIEN GLO-2020-21 and LIEN SA-2020-21each for their adaptability and yield performance. In LIEN GLO-2020-21, considerable variability was observed in the exotic lines for days to 50% flowering (96-113), maturity days (141-151), plant height (33-51 cm), 100 seed weight (1.78-4.62 g) and grain yield (467-1,915 kg/ha). Exotic lines *viz*., GID 5026 (1,658 kg/ha), GID 4914 (1,728 kg/ha) and GID 4980 (1,915 kg/ha) were found promising based on their yield performance over the best check GID 18960 (1,587 kg/ha). In LIEN SA-2020-21, wide variability was observed for days to 50% flowering (97-112), maturity days (142-151), plant height (36-58 cm), 100-seed weight (2.11-5.56 g) and grain yield (167-1,235 kg/ha). Exotic lines *viz*.GID 5050 (1,511 kg/ha), GID 5019 (1,534 kg/ha) and GID 5113 (1,591 kg/ha) were found promising based on their yield performance over the best check VL *Masoor* 514 (1,034 kg/ha).

2.5.1.5. Plant Pathological Investigations

More than 180 field pea and lentil entries/lines under different coordinated and station trials were screened for Fusarium wilt resistance under natural field conditions. The resistant sources identified are summarized in the Table 2.5.1.

Table 2.5.1. Identified resistant entries

Crop	Trial	Highly resistant entries
Field Pea	State Varietal Trial	PH 601, PH 602, PH 603, PH 604, PH 605, PH 606, PH 607, PH 608, PH 609 and PH 610
	AVT (Tall)	FPT-2, FPT-3, FPT-4 and FPT-5
Lentil	SVT	LH 503
	Advance Station Trial (Small)	VLM 2015-4, VLM 2019-7, VLM 2019-103, and VLM 2019-112
	Advance Station Trial (Large)	VLM 2014-105, VLM 2018-108, VLM 2019-107, VLM 2019-113 and VL-1514
	Initial Station Trial (Small)	VLM 2020-1, VLM 2020-4, VLM 2020-8, VLM 2020-10, VLM 2020-11, VLM 2020-12, VLM 2020-13, VLM 2020-14, VLM 2020-15, VLM 2020-16, VLM 2020-17, VLM 2020-18, VLM 2020-19, VLM 2020-20 and VLM 2020-22
	Initial Station Trial (Large)	VLM 2020-102, VLM 2020-105, VLM 2020-106, VLM 2020-107, VLM 2020-111, VLM 2020-112,VLM 2020-116, VLM 2020-117, VLM 2020-119, VL-507 and VL-514
	AVT (Coordinated)	LSS 20-2, LSS 20-3, LSS 20-7, LSS 20-8, LSS 20-9, LSS 20-15

2.5.1.6. Germplasm Evaluation

Mustard accessions (144) from gene bank of ICAR-VPKAS, Almora along with 3 checks, namely, NRC 101, IRD 6 and Kranti received from the Department of Plant Breeding, GBPUA&T, Pantnagar, were evaluated during *rabi* 2020-2021 in an Augmented Block Design. Yield per plant ranged from 0.33 to 16 gm. The earliest maturing accession KHH 417 (97 days) was considerably earlier than the earliest maturing checks NRC 101 and Kranti, which matured in 139 days. The accessions were grouped into four classes on the basis maturity days, which consisted of 43 (125 to 130 days), 26 (131 to 135 days), 51 (136 to 140 days) and 24 (141 to 152 days) accessions, respectively.

In an another experiment, 24 accessions procured from Gene Bank of NBPGR, New Delhi were evaluated along with three checks, namely, NRC 101, IRD 6 and Kranti. Yield of the accessions ranged from 0.20 to 35 gm per plant. None of the accessions produced higher seed yield than the checks. On the basis of maturity, the accessions formed two groups comprising of 17 (136 to 140 days) and 7 accessions ((141 to 160 days). The check NRC 101 and Kranti matured in 139 days.

2.5.2. *Kharif* Legumes (Soybean/Bhat, Horsegram and Pigeon Pea)

2.5.2.1. Horsegram

Elite lines under station trial

Forty superior bulks were evaluated in Initial Station Trial (IST) for yield and yield components along with two national checks (VL *Gahat* 15 and VL *Gahat* 19). Entries VLG 2020-1 (1,019 kg/ha), VLG 2020-23 (963 kg/ha) and VLG 2020-17 (926 kg/ha) were found superior to the best check VL *Gahat* 15 (889 kg/ha) and resistant to anthracnose (score 1) under natural condition. Among 13 entries evaluated in Advance Station Trial (AST), VLG 2018-1 (706 kg/ha) and VLG 2018-8 (588 kg/ha) were found superior to the best check VL *Gahat* 15 (444 kg/ha).

Breeding materials/Development of new strains

Twelve diverse parents were selected on the basis of high yield (VLG 19, VLG 15, VLG 8 and VLG 10), anthracnose resistance (HPK 2, HPK 4 and VLG 19) and earliness (VLG 19 and AK 42) for hybridization programme. Thirty-one new cross combinations were attempted using these parents. About 155 crosses possessing desirable traits (yield, component traits, anthracnose resistance) were selected in F_2 to F_5 generation. Thirty-seven uniform bulks were selected from F_6 generation for their further evaluation.

Plant pathological investigations

A total of 36 horsegram entries were evaluated for their reaction to anthracnose (*Colletotrichum truncatum*) under natural field conditions. The resistant sources identified are summarized in Table 2.5.2.

Table 2.5.2. Identified resistant entries

Trial	Highly resistant entries
Horsegram SVT	HG-901, HG-903 and HG-905
Horsegram Advance Station Trial	VLG 2016-3, VLG 2016-13, VLG 2018-1, VLG 2019-17, VLG 2019-18, VLG 2019-32, VLG 2019-34, VLG 2019-36, VLG 2019-38, VLG-19 and VLG-15
Horsegram IVT	HG- 3, HG- 7, HG- 8 and HG-13

2.5.2.2. Soybean

Elite lines under All India Coordinated Programme

Soybean entry VL *Soya* 99 (2,363 kg/ha) evaluated in AVT II and based on the mean performance over 3 years of testing in AICRP trials, it exhibited significant yield superiority of 10.32% over the best check VL *Soya* 89 (2,142 kg/ha).

Elite lines under station trials

A total of 3 station trials comprising Initial Station Trial, Advance Station Trial for soybean and Station Trial for *Bhat* were conducted. In Initial Station Trial, entries VS 2020-1 (2,963 kg/ha), VS 2020-3 (2,685 kg/ha) and VS 2020-19 (2,593 kg/ha) were found superior to the best check VL *Soya* 89 (2,407 kg/ha). In Station Trial (Bhat), VS 2020-1 (1,980 kg/ha), VS 2020-3 (1,541 kg/ha) and VS 2020-4 (1,531 kg/ha) were top performing entries and outyielded the best check VL *Bhat* 202 (1,422 kg/ha). In Advance Station Trial of soybean, entries VS 2017-14 (2,321 kg/ha) and VS 2018-6 (2,188 kg/ha) were found superior to best check VL *Soya* 63 (2,025 kg/ha).

Breeding Materials/Development of new strains

In Soybean, 24 diverse parents were selected on the basis of high yield (VLS 47, VLS 63, VLS 59, VLS 77, PS 1556, PS 1092, PK 416 and Pusa 22), frog eye leaf spot resistance (VLS 47, RSC-10-17 and Himso 1685), earliness (JS 95-60 and VLS 73) and determinate plant type in *Bhat* (VLS 65, Birsa Soya 1 and VLB 201) in the hybridization programme. In addition to these, promising local collection (VRPH 1444 and Pauri Local), exotic germplasm (EC 34057) and wild parent (*G. soja*) were also used. Total 28 new cross combinations were attempted. From F_2 to F_5 generation, 96 crosses with about 311 progenies were selected for desirable phenotypic traits like yield and component traits, diseases (frog eye leaf spot and pod blight) and insect-pests (*Chauliops* and defoliators) resistance. Fifty two uniform bulks were selected from F_6 generation for their further evaluation.

Evaluation of AVT-II entries under different row spacing

The highest seed yield (3,019 kg/ha) was obtained in VLS 99, which was 10.0, 11.5 and 45.6 per cent higher than VLS 63, VLS 89 and PS 1556, respectively. Across spacings, VLS 99 produced the highest seed yield of 3,037 kg/ha under 45 cm row spacing.

Plant Pathological Investigations

Major diseases observed at Experimental Farm, Hawalbagh, and in farmers' fields in the Almora district were frog eye leaf spot (FLS), pod blight (Ct), and bacterial pustule (BP). The frog eye leaf spot first appeared in the first week of August and the disease severity increased in September reaching up to 77.77% infection index in susceptible varieties. The bacterial pustule was noticed during August last week, whereas the pod blight was observed in the second week of September with low to moderate intensity. In the soybean trap nursery for disease monitoring, in addition to frog eye leaf spot, pod blight and bacterial pustule, this year virus disease symptoms were noticed in entries JS-335, JS-9305, Punjab 1, Bragg, and NRC-7 with > 50% disease index. Around 500 soybean entries of different coordinated and station trials were evaluated for their reaction to FLS. The identified resistant soybean entries are given in the Table 2.5.3.

Table 2.5.3. Identified resistant sources in soybean and bhat for FLS

Trials	Highly resistant entries
Soybean IVT (N)	Code no. 6, 8, 10, 15,31,35,48, 52, 55 and 65.
Soybean IVT (E)	Code no. 3, 4, 6, 10, 17 and 29
Bhat Station Trial	VB 2019-4 and VB-201
Soybean Initial Station Trial	VS 2020-1
Soybean Advance Station Trial	VS 2016-11, VS 2017-1, VS 2017-14, VS 2018-6 and VS 2019-20
Bhat SVT	BH 604
Soybean maintenance breeding of reference varieties	Davis, DSB-1, DSB-1, DSB-2, Dwlga, Hara soya, Hondee, JS-335, JS-20-29, JS-20-24, JS-20-69, JS-20-98, JS-20-116, JS-71-05, JS-93-05, JS-95-60, JS-97-52, KHSP-2, MACS-57, MACS-58, MACS-124, MACS-1281, MACS-1, MACS-612, MACS-71, MACS-81, MACS-158, MACS-162, PATARN-SOYA, NRC-7, PK 471, PS 1092, PS 1225, PS 1241, PS 1347, PUSA 16, PUSA 20, PUSA 40, PUSA 5, RKS 18, RKS 24, RKS 45, RKS 18, RVS-2001-4 and VL Soya 2

Germplasm Evaluation

Indigenous and exotic soybean germplasm accessions (125 along with 5 checks) were characterized for 8 agro-morphological traits as well as screened for frog eye leafspot (FLS) under hotspot locations. A wide range of variability was observed among accessions for days to 50% flowering (39-59), plant height (41-111 cm), number of nodes/plant (10-30), pod clusters/plant (14-39), number of pods/plant (40-102), days to maturity (96-115), seed yield/plant (4.89-16.54 g) and 100 seed weight (6.02-13.72 g). Hierarchical agglomerative clustering (HAC) divided soybean accessions into 5 clusters. Accession G24 (EC 393222) from Taiwan and G40 (IMP-1) from USA belonging to cluster IV were found promising for multiple yield traits and JS 20-38 from cluster III for earliness. As per the GGE biplot, Average Environment Coordination (AEC) view, accessions G11 (EC 333872), G2 (EC 251506) and G 47 (TNAU-S-55) were the best performing stable genotypes in terms of grain yield per plant across 5 locations. A total 11 accessions exhibited high level of resistance against FLS disease.

2.5.2.3. Pigeon pea

Performance of 30 elite super-early pigeon pea genotypes from ICRISAT Corporate Headquarters, Patancheru, India was assessed to ascertain their suitability for cultivation in NW Himalayan region. Based on the yield performance compared to the check ICPL 88039, 3 super early lines code 22 (806 kg/ha), code 21 (708 kg/ha) and code 24 (697 kg/ha) were selected for further evaluation in multi-location trial.

2.6. Enhancement of Genetic Potency in Important Vegetables Crops for North Western Himalayan Ecosystem

Vegetable cultivation, principally off-season and temperate, is recognized as a practicable and lucrative venture due to niche potential in hills. The total area under vegetable cultivation in Uttarakhand is around 97.41 thousand ha with an average productivity of 10.4 t/ha, which is much lower than national productivity of 18.5 t/ha (NHB 2019-20). Development of HYVs with better nutritional quality and market acceptance with respect to size, shape, colour and resistance to biotic stresses, along with package of practices, is an important area of research for the improvement of vegetable scenario of North- Western Himalayas.

2.6.1. French bean

2.6.1.1. Varietal Improvement

Entry VLFB 1707 (89.01 q/ha) followed by CITHFB-1 (88.04 q/ha) recorded maximum green pod yield comapred to the best check VL Bean 2 (77.8 q/ha) in SVT.

2.6.1.2. Development of new strains

Emphasis was given to develop genotypes with high yield, stringless pod and resistance to rust. Eleven new F_1s were developed using 7 diverse parents. Twenty F_1s and 143 progenies derived from 60 crosses were advanced in F_2 to F_8 generations. Five new bulks were also made based on phenotypic uniformity for evaluation for yield and quality.

2.6.2. Tomato

2.6.2.1. Varietal Improvement

Seven yield evaluation trials were conducted to evaluate 48 entries including suitable checks to identify high yielding genotype in determinate, indeterminate and cherry group. Entries 2019/TODVAR-5 (29.035 t/ha), 2018/TODVAR-3 (28.6.64 t/ha), 2020/TOINDVAR-4 (25.835 t/ha), 2018/TOINDVAR-6 (25.094 t/ha), 2020/TODHYB-1 (28.072 t/ha), 2019/TODHYB-8 (29.939 t/ha) and 2018/TOCVAR-4 (15.061t/ha) recorded maximum fruit yield in AVT-I Det., AVT-II Det., IET Indet., AVT-II Indet., IET Det. Hyb. AVT-I Det. Hyb., and AVT – II Cherry, respectively.

2.6.2.2. Development of new strains (Cherry Tomato)

Emphasis was given to develop high yielding cherry tomato genotypes having desirable horticultural traits, *viz.*, thick pericarp and attractive fruit colour. Fifteen F_1s were made using 8 diverse parents with respect to desirable horticultural traits (red & golden fruit colour, shape, size and high TSS).

2.6.3. Capsicum

2.6.3.1. Varietal Improvement

In AVT-II, entry 2018/CAPVAR-2 (32.367t/ha) recorded maximum fruit yield.

2.6.3.2. Development of new strains

Emphasis was given to develop high yielding hybrids with medium dark green fruits, thick pericarp and other important horticultural traits suitable for protected cultivation and open field, especially under organic conditions. Thirteen progenies derived from 12 crosses were advanced in F_2 to F_3 generations.

2.6.4. Cowpea (Bush-type)

2.6.4.1. Varietal Improvement

AVT I entry 2019/COPVAR-3(10.45 t/ha) recorded maximum green pod yield.

2.6.5. Garden pea

2.6.5.1. Variety Identified

VL *Sabji Matar* 17 (VP 1429): It is an early maturity variety identified and recommended for release in zone I (states of UK and HP and UTs of Jammu & Kashmir and Ladakh) during 39th AICRP (VC) Group Meeting held virtually from 07-09 September, 2021. VP 1429 has high green pod yield (115.5 g/ha), high shelling percentage (>50%) and 8-9 seeds per pod.

2.6.5.2. Varietal Improvement

Nine field yield evaluation trials were conducted to evaluate 81 entries with suitable checks to identify early maturing/medium maturing/edible pod genotypes with higher yield. Entries VP 2005 (11.040 t/ha), VP 1802 (13.075 t/ha), VP 1802 (11.810 t/ha), 2019/PEVAR-6 (12.593 t/ha), 2018/PEDVAR-6 (11.976 t/ha), 2019/PMVAR-7 (11.975 t/ha), 2018/PMVAR-6 (11.218 t/ha), 2018/PEVAR-6 (11.642 t/ha), and 2019/PEMPMR-1 (10.001 t/ha) recorded maximum green pods yield in AST-I, AST-II, SVT, AVT-I (EARLY), AVT-II (EARLY), AVT I (MID), AVT II (MID), AVT-II (EDIBLE) and AVT II (PM), respectively.

2.6.5.3. Development of new strains

Emphasis was given to develop early/medium duration, edible pod genotypes with high green pod yield with avoidance/resistance for powdery mildew. Eleven (edible pod) and 15 (normal pod) new F_1s were made among selected 21 parents to combine different horticultural traits like edible pods (VPsp 906-1 &VPsp 1332), earliness (VLSM 13, VRP 6, VP 1714, VP 1801, VP 1803, Pusa Shree), high green pod yield (VP 1018, VM 11, VM

12, VLSM 15), high shelling percent (VP 1208, VP 1446, VP 1437), attractive pod color and shape as well as disease resistance (2017/PMVAR-1, HFP-715, IFP-13, IFP-14, VP 2020-21). Twenty-three better performing edible pod and 42 normal pod F_1s were advanced to F_2. Besides, selection was practiced in the segregating materials and 262 progenies derived from 39 F_3s, 17 F_4s, 16 F_5s and 4 F_6s were advanced. Six new bulks were made based on phenotypic uniformity for evaluation in ensuing crop season in early and medium maturity group.

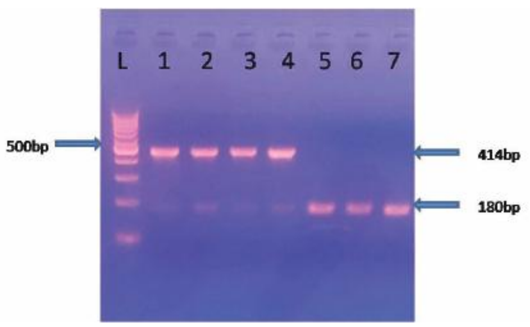
2.6.6. Onion

2.6.6.1. Varietal Improvement

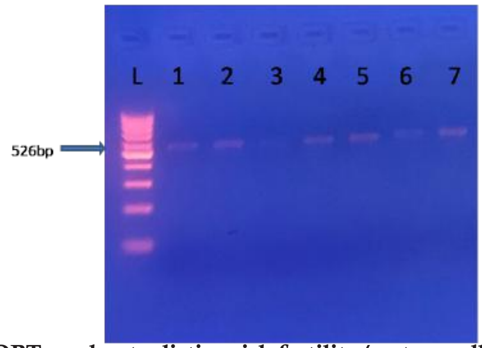
Seven AINRP trials on long day onion were conducted with 46 genotypes to evaluate their yield performance against checks. RVA-20-18 (34.206 t/ha), RVB 20-02 (38.314 t/ha), RVC 20-34 (42.39 t/ha), 20-77 (19.35 t/ha), WVC 20-55 (18.549 t/ha), WVC 20-74 (33.135 t/ha), WTB and RHB 20-45 (30.59 t/ha) recorded maximum bulb yield in IET-Red, AVT I-Red, AVT II-Red, AVT-I White-High TSS, AVT-I White, AVT-II White and AVT-I Red hybrid, respectively. A CMS-based onion hybrid (VLP-68) was nominated to AINRP- Onion & Garlic for IET 2022.

2.6.6.2. Validation and maintenance of CMS lines (VL In. 31-1A & B)

Validation of sterile line (Smsms) and maintainer line (Nmsms) was carried out using PCR-based 5' cob-based marker [which amplified a single 180 bp fragment in maintainer cytoplasm and two fragments (180 and 414bp) in the sterile cytoplasm] and PCR-based marker of OPT (putative oligopeptide transporter) linked to the restorer of fertility (Ms) locus.



OSN marker to distinguish cytoplasm



OPT marker to distinguish fertility/restorer alleles

Lanes 1 to 4 belong to male sterile line (VL In. 31-1A) and Lanes 5 to 7 belong to maintainer line (VL In. 31-1B).

2.6.6.3. Development of new hybrids

Crosses were attempted between male sterile line (VL In. 31-1A) as female and six diverse lines as male for the development of F_1 hybrids. Male sterile line was maintained with the help of its maintainer line VL In. 31-1B.

2.6.7. Garlic

2.6.7.1. Varietal Improvement

Two AINRP trials on long day garlic were conducted with 19 genotypes to evaluate their yield performance against checks. GN 20-17 (27.873 t/ha) in IET and GN 20-60 (27.415 t/ha) in AVT I recorded maximum bulb yield with big clove size.

2.6.7.2. Bulbils as planting material in VL *Lahsun* 2

Ten fertilizer (NPK and S combinations) treatments were applied on the transplanted garlic. Among transplanted garlic seedling treatment, T7 (150-50-150+25; N-P-K+S) resulted in maximum average bulb weight (36.2 g) and bulb yield (17.67 t/ha) and was found statistically at par with treatment $T_1$where, estimated bulb yield was (17.86 t/ha).

VL *Lahsun* 2 bulbils & seedlings

View of field trial
Bulbils as planting material in VL *Lahsun* 2

2.6.8. Seed Multiplication of Released and Pre-released Varieties

A total of 215 kg breeder seed along with 128 kg TL seed through FPSP of pea varieties (VLSM 13 & 15), 700 kg planting material (bulbs) of VL *Lahsun* 2 and 8 kg seeds of VL *Piaz* 3 were produced.

2.6.9. Genetic Resources –Evaluation & Maintenance

Five hundred thirty seven accessions of different vegetable crops were maintained during *rabi* 2020-21 and *kharif* 2021 (Table 2.6.1).

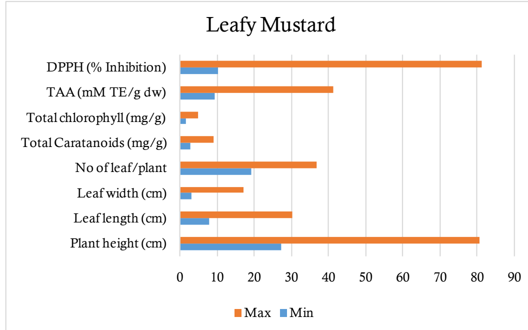
Table 2.6.1. Accessions of different vegetable crops

Crop	No. of Accessions
Garlic	94
Zinger	06
French bean	125
Capsicum	63
Tomato	115
Garden pea	130
Others	04
Total	**537**

2.6.10. Underutilized Vegetables

Leafy Mustard (*B. juncea* var. *rugosa*)

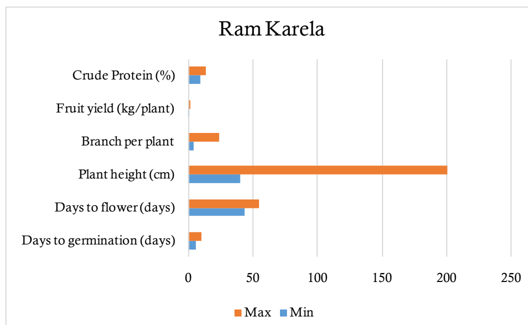
One hundred and eighty six accessions of *Brassica juncea* acquired from different sources (100-NBPGR, Bhowali; 66-NBPGR, Shillong; 1-ICAR-CIAH and 19 local collections) were evaluated. Out of 186 genotypes of *Brassica juncea*, 34 genotypes were identified as *B. juncea* var. *rugosa*. Accessions of leafy mustard (*B. juncea* var. *rugosa*) were assessed for different morphological traits (Table 2.6.2).



Variation in morphological traits of leafy mustard (*Brassica juncea* var. *rugosa*) germplasm

Ram Karela (*Cyclanthera pedata*)

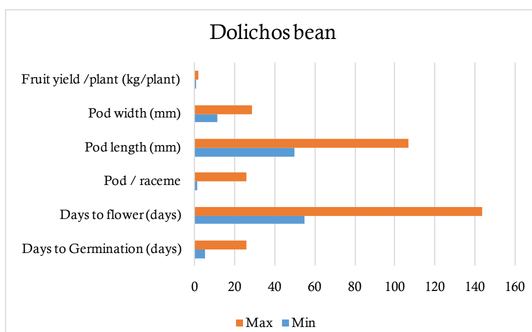
Forty three genotypes of Ram Karela (*C. pedata*) were morphologically characterized (Table 2.6.3). Germination started 7 days after seed sowing and continued up to 10 days after seed sowing while flowering started 45 days (RK-5, RK-13) after sowing and continued up to 55 days (RK-02, RK-03, RK-06), and harvesting was done after 156 days of sowing.



Variation in morphological traits of Ram Karela (*C. pedata*) germplasm

Dolichos bean (*Dolichos purpureus*)

Twenty-six accessions of Dolichos bean (*Dolichos purpureus*) were assessed for different morphological traits (Table 2.6.4). Initial germination was noted at 5 days (DB-2) after seed sowing and continued up to 26 days (DB-05).



Variation in morphological traits of *Dolichos* bean (*D. purpureus*) germplasm

2.6.11. Crop Protection Investigations

Plant Pathological Investigations

Screening of onion and garlic against purple blotch disease

A total of 48 onion and 19 garlic entries were evaluated against purple blotch disease under artificial inoculated conditions. The promising entries are given in Table 2.6.5.

Table 2.6.5. Purple blotch disease screening nurseries

Trial	Name	No. of Entries	Resistant entries
Onion Trial	LDR IET	8	RVA 20-14 (0-3 score)
	LDR AVT I	9	RVB 20-15 (0-2 score)
	LDR AVT II	7	RAVC 20-30 (0-2 score)
	LDR HY AVT I	7	RHB 20-50, RHB 20-51 (0-3 score)
	LDW AVT I	5	WVB 20-55 (0-4 score)
	LDR HY AVT II	5	WVC 20-65 (0-4 score)
	LDHTSS AVT I	7	WTB 20-77 (0-3 score)
Garlic Trial	IET AVT I	7 12	GN 20-02,GN 20-08 (0-2 for PB;1-3 for DM) GN 20-45, GN 20-69 (0-2 for PB; 1-3 for DM)

PB-Purple Blotch; DM-Downy Mildew

Identification of sources of multiple disease resistance in cherry tomato

A total of 29 cherry tomato entries/advance lines were evaluated against various diseases under polyhouse conditions. Early blight disease ranged from 4.0-62.5%; late blight ranged from 3.5-52.5%, whereas powdery mildew ranged from 2.5-55% in different entries. Entry 2016/TOCVAR-2 was promising against early blight (4.0% disease severity), entry 2018/TOCVAR-1 against late blight (3.5%) and entry 2018/TOCVAR-6 was found promising against powdery mildew disease (2.5% disease severity).

Field screening of advance lines and varieties of French bean for major diseases

Advance lines (17) and varieties (04) of French bean were screened against angular leaf spot (*Phaeoisariopsis* sp.), rust (*Uromyces* sp.) and anthracnose (*Colletotrichum* sp.) at High Altitude Testing Sites (HATS), Mukteshwar (2,250 m AMSL). The disease incidence during pod stage was recorded (Table 2.6.6). The advance line VLFB 1827 recorded lowest angular leaf spot (20%). The advance lines VLFB 1819, VLFB 1907 and varieties Pant Anupama, Arka Suvidha showed 0% rust incidence. Four advance lines *viz.*, VLFB 1803, VLFB 1805, VLFB 1806 and VLFB1908 showed 0% anthracnose incidence.

Table 2.6.6. Per cent disease incidence on promising lines and varieties of French bean

Entry No.	Angular Leaf Spot %	Rust %	Anthracnose %
VLFB 1803	60 (50.832)	10 (18.413)	0 (0)
VLFB 1805	30 (32.989)	2 (7.945)	0 (0)
VLFB 1806	50 (44.982)	20 (26.55)	0 (0)
VLFB 1819	60 (50.832)	0 (0)	2 (7.945)
VLFB 1827	20 (26.06)	30 (33.196)	2 (7.945)
VLFB 1907	30 (32.989)	0 (0)	2 (7.945)
VLFB 1908	30 (32.989)	5 (12.874)	0 (0)
Pant Anupama	80 (63.904)	0 (0)	30 (33.196)
Arka Suvidha	60 (50.832)	0 (0)	20 (26.55)
CD@5%	0.83	0.99	1.39
CV	1.15	4.16	6.45

Values in parentheses are angular transformed values

Entomological Investigations

Screening of onion and garlic nurseries for infestation of thrips and mites

A total of 23 IET-LD and 19 AVT lines of onion and 12 IET and 7 AVT lines of garlic were screened for infestation of thrips and mites. The damage score ranged from 1-3, indicating low, medium and high infestation of the pests. Based on screening studies, it was observed that two entries of onion IET-LD red lines recorded low infestation of both thrips and mites with the score of 1. However, in AVT entries of onion, 3 entries out of the 19 recorded low infestation and 16 entries recorded medium infestation with score of 2. In case of garlic, 10 out of the 12 IET entries showed medium infestation and remaining 2 entries recorded high infestation with score of 3. In AVT lines of garlic, 6 entries showed medium infestation and remaining entries recorded high infestation of thrips and mites.

2.7. Germplasm Evaluation in Major Hill Crops for Nutritional and Physiological Parameters through Basic Techniques

ICAR-VPKAS involve basic and applied research in relation to the crop productivity and quality for major hill crops. There is a large pool of promising germplasm of many field crops available in different parts of North-Western hills especially in Uttarakhand state, which can be utilized for nutritional security of the vulnerable population groups of Uttarakhand. 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.

2.7.1. Screening of wheat genotypes for Fe, Zn content

Out of 745 genotypes screened for Fe & Zn content through Dye-binding method, 216 samples were found having high Fe content and 278 samples having high Zn content. Hundred genotypes having both high Fe and high Zn content were selected for further analysis. Sixteen genotypes were found to have high Fe content (>50 ppm) and 25 genotypes were found to have high Zn content (>40 ppm).Out of these, nine samples, namely, A–240, A–463, A–464, VRB-CW1291, HS-562, VL 3020, VHC(BD)5, VHC-6093 and VHC-6403 Amb showed both higher Fe (>50 ppm) and Zn content (>40 ppm).

2.7.2. Biochemical screening of maize genotypes for micronutrient content

A total of 112 maize genotypes (QPM, normal corn, CIMMYT lines and local collections) were analyzed for Ca, Fe, K, Mg, and Zn content (Table 2.7.1). Two genotypes (CM 145 and CM 212) showed high Fe, Zn and Ca content [(CM145; Ca: 4200 ppm, Fe: 65ppm, Zn: 35 ppm), (CM212; Ca: 4050 ppm, Fe: 67.5 ppm, Zn:38 ppm).

Table 2.7.1. Range, mean, standard error for 5 micronutrients

Micronutrient	Range	Mean	SE
Ca (ppm)	1140 - 4200	2,319.13	15.55
Fe (ppm)	12.5 - 70.0	47.04	1.76
K (ppm)	2007 - 5961	4,400.63	11.85
Mg (ppm)	512.5 - 2480	1,177.63	12.41
Zn (ppm)	18.0 - 42.0	27.41	1.03

Ca and Zn showed significant positive correlation ($r=0.54$; $p<0.01$).

2.7.3. Physicochemical characterization of various cherry tomato cultivars

A total of 29 cherry tomato fruits were analyzed for total soluble sugars, pH, lycopene, β-carotene, vitamin C and polyphenols content. Five cherry tomato genotypes (VL CT-1, CITH CH-2-R, CITH CH-6, 2016/TOCVAR-1, 2018/TOCVAR-1) were found promising containing lycopene >6.0 mg/100 g, β- carotene >6.5 mg/100 g and vitamin C ≥86.0 mg/100g FW.

2.7.4. Effect of seed soaking on phytate content in different crops

Three crops (finger millet, wheat and maize) with six genotypes of each crop were taken for study. Soaking (24 h) and soaking (48 h) both resulted in a significant decrease in phytate P content. In both soaking treatments (24 h and 48 h), maximum phytate P reduction (24.84% and 36.83%, respectively) was recorded in finger millet variety VL *Mandua* 380. Phytate P to total P ratio significantly decreased due to soaking (24 h and 48 h). In soaking (24 h), maximum reduction (12.90%) was recorded in VL *Mandua* 378 and VL *Mandua* 379, whereas in 48 hr soaking, maximum reduction (24.67 %) was in VL*Mandua* 378.

2.7.5. Biochemical screening of maize doubled haploid lines for micronutrient content and other quality traits

A set of seventy-two doubled haploid (DH) lines from two source populations [MTC 4 (PVD 3-2 × BS 24-2-5) and MTC 8 (PVE 44-11 × BS 24-2-

5)] were screened for Fe and Zn content and total protein, tryptophan and β- carotene content. Out of 72 samples, 5 DH lines were observed with >40 ppm Fe content, 31 DH lines with high Zn content (>33 ppm) and 19 DH lines with high tryptophan content (>0.65%). Four DH lines (MTC8-DH-86, MTC8-DH-96, MTC8-DH-111 and MTC 8-DH-123) were observed with Zn content >39 ppm. A wide range 2.6-11.67% and 4.92-13.30% was observed for protein and β-carotene content in the DH lines (Table 2.7.2). The results of rapid dye-binding methods for Fe and Zn content were significantly correlated with the biochemical estimation through AAS (Fig. 2.7.1).

Table 2.7.2. Range, mean, standard error and target level for 5 nutritional traits

Micronutrient	Range	Mean	SE	Target level
Protien (%)	8.26-11.60	8.90	0.87	9-11 (%)
Tryptophan (%)	0.44-0.77	0.56	0.23	0.65 (%)
β- carotene (%)	4.92-13.39	8.26	1.06	15 (%)
Fe (ppm)	27.30-45.90	35.65	0.59	60 (ppm)
Zn (ppm)	24.30-41.60	31.75	0.76	33 (ppm)

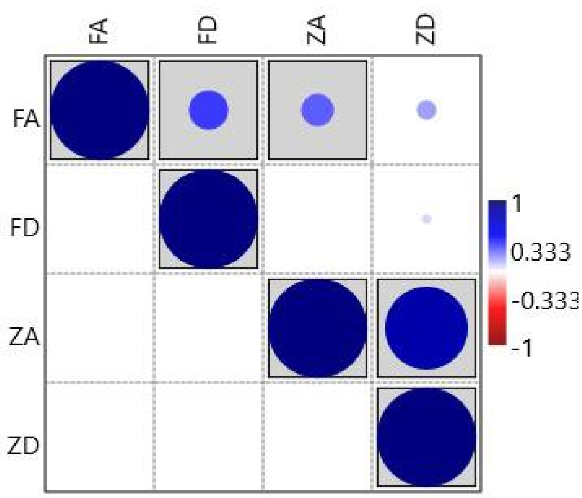


Fig. 2.7.1. Correlation plot between Fe and Zn content results among dye binding and AAS method

2.7.6. Biochemical screening of maize genotypes for micronutrient content

Total 53 maize genotypes (North East collections) were analyzed for Ca, Fe, K, Mg, and Zn content. Out of 53 maize accessions, 19 accessions showed Fe content (>40 ppm), 1010 accessions showed high Zn content (>33 ppm) and 13 accessions showed calcium content (>3000 ppm). In addition to these, 3 accessions were found to have potassium content of >5000 ppm and 4 genotypes showed potassium content of >2000 ppm. Three accessions (MZ 1222, MZ 1224 and MZ 1339) showed Fe content of >50 ppm. Two accessions, MZ 1262 and MZ 1304, showed Zn content of >36 ppm. Two genotypes MZ 1243 and MZ 1262 showed high Fe, Zn and Ca content [(MZ 1243; Ca 4120 ppm, Fe: 46ppm, Zn: 34 ppm), (MZ 1262; Ca: 4050 ppm, Fe: 42 ppm, Zn: 36 ppm)]. The Ca and Zn content showed a significant positive correlation (r=0.67;p<0.01) with each other (Fig. 2.7.2).

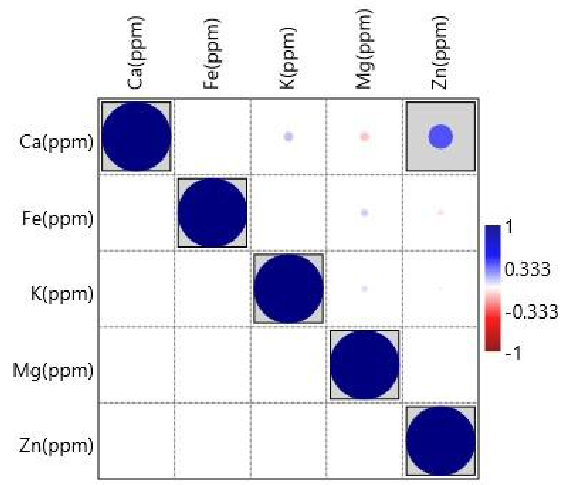
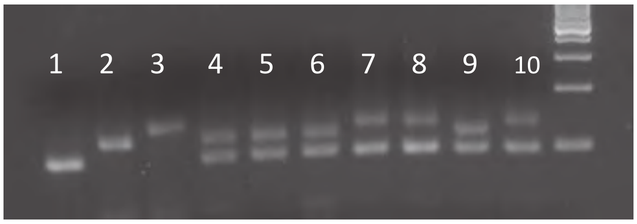


Fig. 2.7.2. Correlation plot among concentration of 5 nutritional quality traits

Sub-Project: Identification and utilization of important genes/alleles/ markers in hill crops

Identification of cold tolerance QTLs in Rice

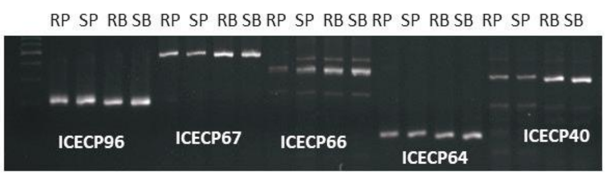
After two years of trial at High Altitude Testing Site at Muktewar, two rice germplasm IRCTN91-82 and Hua110 were found to be cold tolerant. In order to identify cold tolerance QTL in these genotypes, crosses were made between cold sensitive cultivar VL *Dhan* 85 and cold tolerant accessions IRCTN91-82 and Hua110 for development of a mapping population. In *kharif* 2021, F_1 seeds were sown for generation advancement and the hybridity of F_1s was confirmed with polymorphic SSR markers.



Confirmation of F_1 hybrids with polymorphic SSR markers. 1. VLD 85, 2. IRCTN91-82, 3. Hua110. Lane 4-10: F_1 progenies

Identification of Blast tolerance genes/QTLs in Finger millet

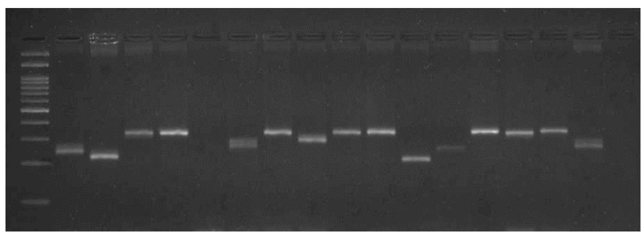
A recombinant inbred line (RIL) population segregating for neck blast disease resistance was developed by crossing resistant genotype GPU48 with susceptible genotype VR708. The population was screened in uniform blast nursery and 10 most susceptible and 10 most tolerant lines were identified. Bulked Segregant Analysis (BSA) was deployed to identify marker/s linked with Blast resistance gene. Resistant and susceptible bulk was prepared by pooling equimolar DNA of 10 most resistant and 10 most susceptible genotypes. One hundred and eighty SSR markers were used to genotype the resistant and susceptible bulks along with resistant genotype GPU48 and susceptible genotype VR708. However, no informative marker was identified despite genotyping with adequate number of SSR markers.



Representative gel picture of BSA. RP-Resistant Parent, SP-Susceptible parent, RB-resistant Bulk, SB-Susceptible bulk

Development of genomic resource in Amaranth: Identification of novel long non-coding RNA

In the study, publicly available amaranth transcriptome was mined to identify lncRNA in amaranth genome. SRR5817790, SRR5817792, SRR5817794 sequence reads were retrieved from NCBI database and assembled using HISAT2 assembler which identified 28024 transcripts. After filtering through various programmes (CPC calculator, rfam search, transdecoder, blastx, CD search), 3013 long non-coding RNAs were identified. Minimum lncRNA length was 200 and maximum length was 7551bp with average length of 848bp. Trans-acting targets of these lncRNA were also identified by program LncTar. Out of 3013 lncRNAs, 282 were found to have trans-acting target. In order to see if computationally identified lncRNA are expressing, pooled cDNA from leaf and root of grain amaranth variety VL *Chua* 44 (*Amaranthus hypochondriacus*) was used to amplify 20 lncRNA amplicons. Though out of 20, only 6 lncRNA were amplified, it nevertheless confirmed their expression in leaf/root tissue.



Expression of lncRNA in amaranth tissue. Lane 1: 1kb Ladder, Lane 2-8: amplification of lncRNA from amaranth cDNA

Molecular screening of wheat genotypes for yellow rust resistance

In this study, molecular markers were used to identify the distribution of 5 Yr genes (Yr5, Yr10, Yr15, Yr7, Yr26) in 274 wheat germplasm accessions. Based on the size of amplicons and donor genotype, presence of rust resistance genes was estimated. It was found that Yr15 was least abundant in the germplasm collection.

2.8. Seed Production Programme

The institute produces four types of seed viz., Nucleus Seed, Breeder Seed, Truthfully Labelled Seed and Hybrid Seed of elite varieties and hybrids to cater to its clientele. Besides the seed production of field crops, the institute produces seeds of vegetable crops. Production of breeder seeds of important hill varieties is the mandate of the institute.

Resource-poor hilly areas face a significant challenge; non-availability of the quality seed (improved varieties), an important component to increase crop production and productivity. The institute produces four seed types, viz. Nucleus Seed, Breeder Seed, Truthfully Labelled (TL) seed and hybrid seeds of elite hybrids to cater to the quality seed requirements of its mandate area North-Western hills and additionally of the North Eastern hill states as well as to meet the seed indent placed by DAC, Govt of India.

During the period, 161.38 q breeder seed of 46 released varieties/inbreds of 17 crops were produced. A total of 131.21 q breeder seed was supplied to different seed producing agencies for further multiplication. Around 13.13 q nucleus seed of 49 released varieties of 17 crops were also produced following standard methods of maintaining genetic purity. In addition to this, 6.55 q Truthfully Labeled seed of 20 varieties of 13 crops were produced. Including the carry-over stock of TL seed; a total of around 4.02 q TL seed was supplied to different stakeholders. Under farmer participatory seed production programme, 260.50 q TL seed of wheat (VL *Gehun* 829, VL *Gehun* 907, VL *Gehun* 953, VL *Gehun* 967, VL *Gehun* 2014), 32.90 q seed of rice (VL *Dhan* 68, VL *Dhan* 85, VL *Dhan* 86), 13.70 q TL seed of garden pea (VL *Sabji Matar* 13, VL *Sabji Matar* 15), 10.43 q TL seed of soybean (VL *Soya* 89, VL *Soya* 201), 1.67q TL seed of finger millet (VL *Mandua* 379) was produced and out of it, a total of 263.22 q TL seed was supplied.

Seed production during *kharif* 2020 and supply in *kharif* 2021

Crop	Variety	Breeder Seed		TL Seed		Nucleaus Seed	
		Pro. (q)	Supp. (q)	Pro. (q)	Supp. (q)	Pro. (q)	Supp. (q)
Paddy	VL *Dhan* 157	1.30	1.30	0.00	0.00	0.40	-
	VL *Dhan* 158	5.30	2.24	0.00	0.00	0.10	-
	VL *Dhan* 85	0.60	0.60	0.00	0.00	0.10	-
	VL *Dhan* 68	10.50	11.71	0.15	0.00	0.10	-
	VL *Dhan* 86	0.00	0.32	0.05	0.00	0.10	-
Maize	*Vivek Sankul Makka* 35	3.50	3.70	0.12	0.05	0.20	-
	VL Amber Popcorn	2.00	0.77	0.05	0.03	0.10	-
	VQL 1	1.00	0.04	0.00	0.00	0.10	-
	VLMH 57	0.00	0.00	1.85	0.69	0.00	-
	VMH 53	0.00	0.00	0.00	0.21	0.00	-
	CMVLSC 1	0.00	0.00	1.25	0.88	0.00	-
	CMVLBC 2	0.00	0.00	0.00	0.84	0.00	-
	VLQPMH 59	0.00	0.00	0.00	0.46	0.00	-
	VLS 16	0.20	0.00	0.00	0.00	0.05	-
	V 405	0.20	0.00	0.00	0.00	0.05	-
	V 373	0.30	0.00	0.00	0.00	0.10	-
	V 390	0.20	0.00	0.00	0.00	0.08	-
	VQL 373	0.55	0.08	0.00	0.00	0.08	-
	V 407	0.80	0.00	0.00	0.00	0.10	-
	V 409	0.20	0.00	0.00	0.00	0.08	-
	V 412	0.45	0.00	0.00	0.00	0.08	-
	V 433	0.15	0.00	0.00	0.00	0.05	-

Crop	Variety	Breeder Seed		TL Seed		Nucleaus Seed	
		Pro. (q)	Supp. (q)	Pro. (q)	Supp. (q)	Pro. (q)	Supp. (q)
Finger Millet	VL *Mandua* 347	0.45	0.45	0.00	0.00	0.02	-
	VL *Mandua* 352	4.10	3.85	0.00	0.00	0.02	-
	VL *Mandua* 376	1.50	1.40	0.00	0.00	0.02	-
	VL *Mandua* 379	2.80	2.72	0.00	0.02	0.02	-
	VL *Mandua* 380	2.20	1.92	0.00	0.00	0.02	-
	VL *Mandua* 382	0.00	0.00	0.00	0.00	0.02	0.03
Barnyard Millet	VL *Madira* 207	1.20	1.23	0.05	0.02	0.02	-
Soybean	VL Soya 63	0.00	0.12	0.00	0.00	0.00	-
	VL Soya 65	4.50	4.29	0.05	0.00	0.80	-
	VL Soya 89	9.50	7.44	0.05	0.00	0.50	-
Horsegram	VL *Gahat* 19	2.00	0.43	0.20	0.00	0.15	-
Pigeonpea	VL *Arhar* 1	0.45	0.28	0.00	0.00	0.15	-
Buckwheat	VL *Ugal* 7	0.35	0.29	0.00	0.00	0.05	-
Amaranth	VL *Chua* 44	0.70	0.10	0.02	0.00	0.01	-
French bean	VL Bean 2	0.15	0.05	0.00	0.03	0.05	-
Okra	*Vivek Bhindi* 2	0.00	0.00	0.40	0.05	0.00	-
	Total	**57.15**	**45.33**	**4.24**	**3.27**	**3.72**	**0.03**

***Carryover stock**

Seed production during *Rabi* 2020-21 and supply in *Rabi* 2021-22

Crop	Variety	Breeder Seed		TL Seed		Nucleus Seed
		Prod. (q)	Supply (q)	Prod. (q)	Supply (q)	Prod. (q)
Wheat	VL *Gehun* 829	4.00	0.45	0.00	0.00	1.00
	VL *Gehun* 907	7.00	6.81	0.00	0.00	1.50
	VL *Gehun* 892	0.00	7.14	0.00	0.00	0.00
	VL *Gehun* 953	29.00	29.00	0.00	0.00	1.50
	VL *Gehun* 967	35.00	24.15	0.00	0.00	2.00
	VL *Gehun* 3004	8.00	5.00	1.00	0.00	1.00
	VL *Gehun* 2014	6.00	6.00	0.00	0.00	1.00
Barley	VL *Jau* 118	3.50	1.50	0.10	0.36	0.20
Field pea	VL *Matar* 42	0.40	0.00	0.00	0.00	0.05
Garden pea	*Vivek Matar* 10	0.00	0.03	0.00	0.00	0.00
	VL *Sabji Matar* 15	0.10	0.06	0.00	0.00	0.10
	VL *Sabji Matar* 12	0.00	0.24	0.00	0.00	0.00
	VL *Sabji Matar* 13	2.70	1.00	0.68	0.00	0.10

Crop	Variety	Breeder Seed		TL Seed		Nucleus Seed
		Prod.	Supply	Prod.	Supply	Prod.
		(q)	(q)	(q)	(q)	(q)
Lentil	VL *Masoor* 126	0.30	0.20	0.00	0.00	0.10
	VL *Masoor* 133	1.00	2.10	0.00	0.06	0.10
	VL *Masoor* 129	0.80	0.00	0.01	0.06	0.10
	VL *Masoor* 148	1.00	0.10	0.00	0.00	0.10
	VL *Masoor* 507	0.30	0.07	0.05	0.02	0.05
Onion	VL *Piaz* 3	0.13	0.03	0.00	0.00	0.01
Garlic	VL *Lahsun* 2	5.00	2.00	0.00	0.00	0.50
Radish	Dunagiri Local	0.00	0.00	0.12	0.10	0.00
Lahi	Hathikaan	0.00	0.00	0.35	0.15	0.00
	Total	**104.23**	**85.88**	**2.31**	**0.75**	**9.41**

Farmer Participatory Seed Production (q)			
Crop	**Variety**	**Production *kharif* 2020**	**Supply *kharif* 2021**
Paddy	VL *Dhan* 68	11.00	10.70
	VL *Dhan* 85	7.15	1.00
	VL *Dhan* 86	14.75	5.50
Finger Millet	VL *Mandua* 379	1.67	1.67
Soybean	VL Soya 89	3.49	3.00
	VL Soya 201	6.94	3.09
	Total	**45.00**	**24.96**

Farmer Participatory Seed Production (q)			
Crop	**Variety**	**Production *Rabi* 2020-21**	**Supply *Rabi* 2021-22**
Wheat	VL *Gehun* 829	7.50	8.50
	VL *Gehun* 907	21.00	17.33
	VL *Gehun* 953	72.00	65.73
	VL *Gehun* 2014	18.00	9.05
	VL *Gehun* 967	142.00	125.96
Garden pea	VL *Sabji Matar* 13	8.90	7.00
	VL *Sabji Matar* 15	4.80	4.69
	Total	**274.20**	**238.26**

3. Natural Resource Management for Sustainable Productivity

Research Projects

- Crop Management for Higher Soil Quality and Sustainability in Indian Himalayas *[Drs. P.K. Mishra, Manoj Parihar, R.P. Meena (on study leave), Mahipal Chaudhary (upto February 10, 2021) & Priyanka Khati]*
- Enhancing Productivity and Profitability of Major Hill Crops through Efficient Resource Utilization *[Drs. Sher Singh (upto October 28, 2021), J.K. Bisht, P.K. Mishra, B.M. Pandey & V.S. Meena (on deputation)]*
- Design and Development of Pre and Post-Harvest Mechanization Technologies for Hill Agriculture *[Drs. Shyam Nath, Sher Singh ((upto October 28, 2021), Kushagra Joshi, R.P. Yadav (upto August 12, 2021), Jitendra Kumar, J.K. Bisht & Er. Hitesh Bijarniya]*
- Agro-forestry and Fodder Production Management with Emphasis on Utilization of Marginal Lands in Hills *[Drs. J.K. Bisht, R.P. Yadav (upto August 12, 2021), P.K. Mishra, B.M. Pandey, V.S. Meena (on deputation), Er. Shyam Nath, Jitendra Kumar & Manoj Parihar]*
    - **Sub-project:** Fodder Production Management with Emphasis in Utilization of Marginal Lands *[Dr R P Yadav (PI) (upto August 12, 2021)]*
- Water Harvesting and Effective Utilization of Water for Enhancing Crop Productivity and Input Use Efficiency & Integrated Development of Water Resources and Management for Optimizing Production and Use Efficiency *[Drs. S.C. Panday, Manoj Parihar, Mahipal Chaudhary (upto February 10, 2021), R. P. Yadav (upto August 12, 2021), Shyam Nath, Jitendra Kumar, Priyanka Khati, R. P. Meena (on study leave), Utkarsh Kumar (on study leave), Ashish Kumar Singh, Tilak Mondal]*
    - **Sub-project:** Development of sensor network based automation system for improving water productivity *[Dr Jitendra Kumar (PI)]*
- Evaluation of Multifaceted Microbial Inoculants for Improving Soil Health and Yield of Crops in Hilly Areas *[Drs. P.K. Mishra (PI), Priyanka Khati, Manoj Parihar, B.M. Pandey and Tilak Mondal]*
    - **Sub-project:** Assessment of Native Arbuscular Mycorrhizal Fungi for the Sustainable Production of Hill Crops *[Dr Manoj Parihar (PI)]*
    - **Sub-project:** Development of nano bioformulation to alleviate drought stress in hill crops – *[Dr Priyanka Khati (PI)]*

3. Natural Resource Management for Sustainnable 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 in Indian Himalayas

Level of nutrient to harvest economic optimum yield with different nutrient sources

The five years' experiment revealed that the economic optimum wheat equivalent grain yield of 10,688 and 10,787 kg/ha through farmyard manure (FYM) and vermicompost (VC) were produced with application of 50.1 and 48.6 kg P/ha per season, which were 30 and 31% higher than the recommended NPK, respectively for rainfed soybean-wheat cropping system. The net return from economic optimum yield through FYM and VC were 97,514 and 93,795 Rs/ha, which were 6 and 2% higher than NPK, respectively. The level of P required from FYM and VC to achieve the same yield as recommended NPK were 15.3 and 14.9 kg P/ha, respectively. But this yield under FYM and VC will provide 9.6 and 8.6% less net return compared to NPK, respectively (Fig. 3.1.1).

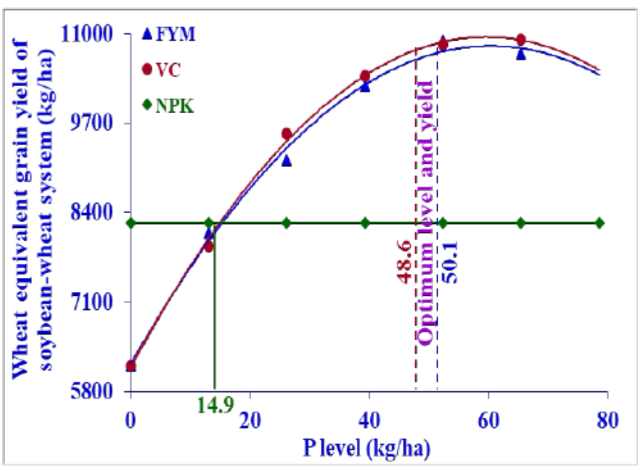


Fig. 3.1.1. Response of wheat equivalent grain yield of rainfed soybean-wheat cropping system to P application through farmyard manure and vermi-compost

Different carbon pools in land uses and cropping system

Forest land (FL) use system has the highest Walkley-Black Carbon (WBC), total carbon (TC), total nitrogen (TN), carbon and nitrogen (C and N)-storage and carbon management index (CMI) values, while barren land (BL) use system having least. Land use system (LUS) had minimum effect on non-labile carbon (NLC), lability of carbon (LC), lability index (LI) and carbon pool index (CPI) of the ecosystem. Moreover, TC and TN were increased in the grass and forest land compared to the barren and cultivated land and TC concentration was highly correlated with TN (R^2=0.88, $p<0.01$) and soil N-sequestration (R^2= 0.93, $p<0.01$). The labiality of carbon (LC) varied among land use system and different soil depths. It significantly varied among soil depth from 0.09–0.18, 0.10–0.26 and 0.09–0.34 at the 0–15, 15–30 and 30–45 cm depth, respectively ($p<0.05$). In case of lability index (LI), the similar trend was noticed under different land use system and soil depth (0–45 cm). At the depth of 15–30 cm, the CPI was significantly greater under forest land than grass land.

Evaluation of PGP bacterial consortia on growth, nutrient uptake and yield of lentil

Eight PGP bacterial consortia along with uninoculated control were used for seed inoculation of lentil (VL *Masoor* 126) to study their response on growth, nutrient uptake and yield of lentil under field conditions. Bacterization of lentil seeds with PGPR bacterial consortium C1, C7 and C6 significantly enhanced grain yield by 18.2, 16.3 & 15.1%, respectively over uninoculated control (1,077 kg/ha) (Fig. 3.1.2.). Inoculation with PGP bacterial consortium enhanced per cent P content in lentil grain (2.9 to 35.0%), over uninoculated control (1.03%) (Fig. 3.1.3.).

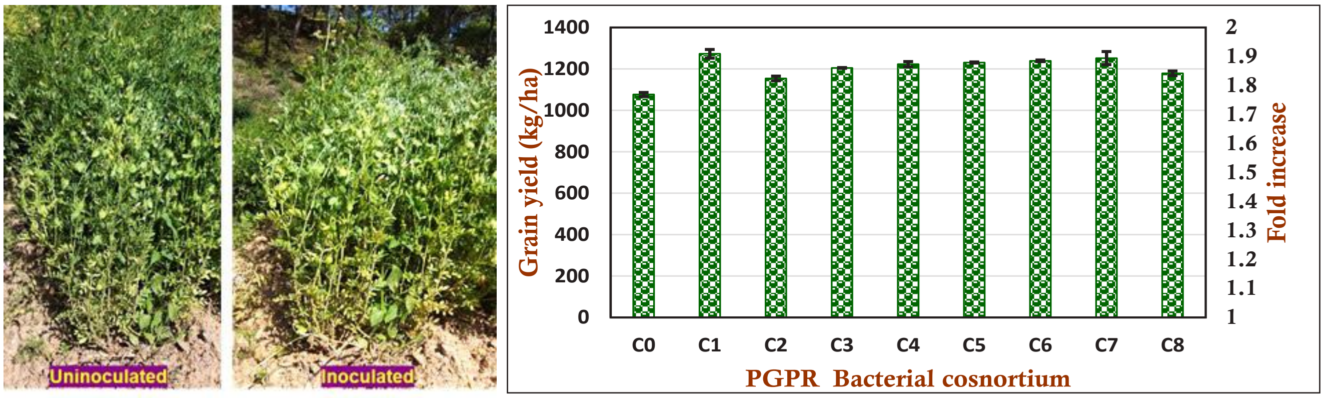


Fig. 3.1.2. Effect of PGP bacterial consortium on yield of lentil (VL *Masoor* 126)

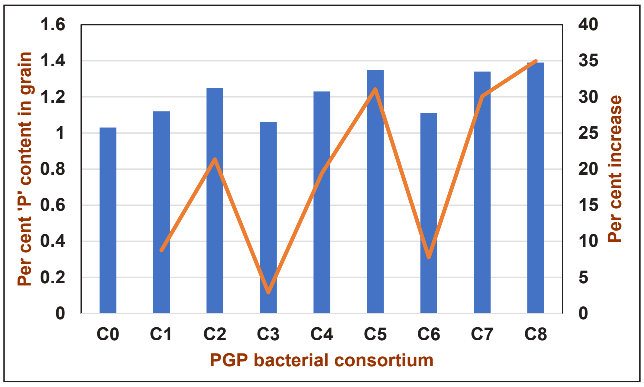


Fig. 3.1.3. Effect of PGP bacterial consortium on P uptake in lentil (VL *Masoor* 126)

Evaluation of psychrotolerant 'P' solubilizing Pseudomonas strains on nutrient uptake and yield of lentil

Effect of two cold tolerant PSB bacterial strains (*Pseudomonas* sp. RT5RP6(2) & *Pseudomonas fragi* CS11RH1) were evaluated on yield of lentil varieties (VL *Masoor* 126, VL *Masoor* 507 & VL *Masoor* 514) for three consecutive years under field conditions. Bacterization with cold tolerant PSB *Pseudomonas* sp. RT5RP6(2) enhanced lentil varieties grain yield by 22.9, 13.7 & 5.6%, respectively over the uninoculated control (839, 776 & 796 kg/ha, respectively) (Fig. 3.1.4.). *Pseudomonas fragi* CS11RH1 and *Pseudomonas* sp. RT5RP6(2) enhanced lentil varieties grain per cent 'P' content in the range of (13.9 to 46.7) and (30.9 to 51.4), respectively over uninoculated control (0.981 to 1.393 per cent 'P' content) (Fig. 3.1.5).

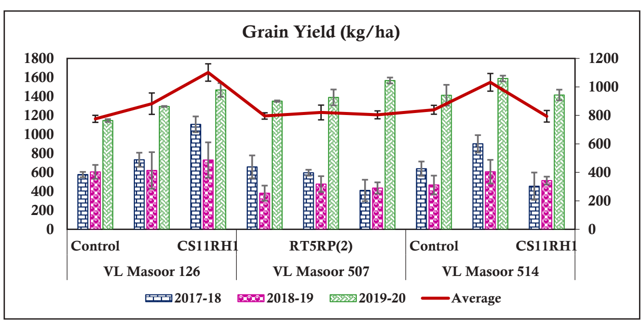


Fig. 3.1.4. Effect of psychrotolerant 'P' solubilizing bacterial strains on yield of lentil varieties (average of three years)

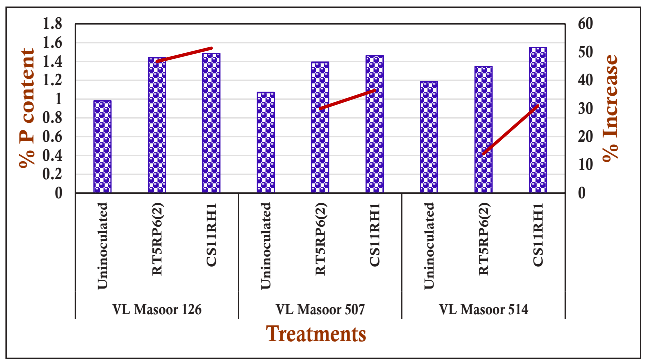
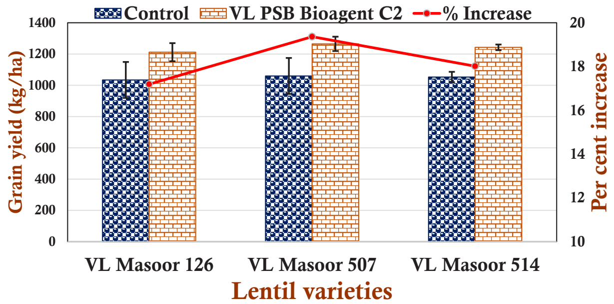


Fig. 3.1.5. Effect of psychrotolerant 'P' solubilizing bacterial strains on 'P' uptake of lentil varieties (average of three years)

Field demonstration of cold tolerant 'P' solubilizing bacterial consortium C2 on yield of different varieties of lentil

'P' solubilizing consortium [C2{*Pseudomonas* sp. (PB2RP1 (2), NS12RH2 (1), CS11RP1)} was evaluated under large field during 2020-21. It significantly enhanced lentil varieties (VL *Masoor* 507, VL *Masoor* 514 & VL *Masoor* 126) grain yield by 19.4, 18.0 & 17.2%, respectively compared to uninoculated control (1,060, 1,053 and 1,034 kg/ha, respectively). Inoculation with consortium C2 enhanced per cent P content in lentil grain by 28.3, 20.6 & 18.2%, respectively in VL *Masoor* 126, VL *Masoor* 507 & VL *Masoor* 514 over uninoculated control (0.99, 1.12 & 1.13%, respectively) (Fig. 3.1.6).



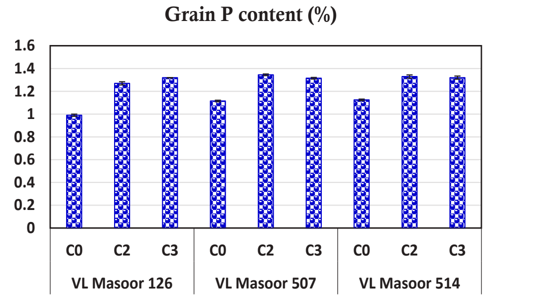


Fig. 3.1.6: Effect of cold tolerant 'P' solubilizing VL PSB *Consortium* C2 on yield and 'P' content in grain of different lentil varieties under large field condition

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

Effect of kharif sown crops using different methods on the productivity, profitability and sustainability of rainfed rabi crops

Among *kharif* season crops the Fingermillet Equivalent Yield (FMEY), fingermillet (3,035 kg/ha) and soybean (3,052 kg/ha) crops were at par and both were significantly higher than rice (881 kg/ha). Among sowing methods, the line sowing/ transplanting + mulch gave highest FMEY (2,455 kg/ha) followed by line sowing (2,314 kg/ha). After *kharif* season crops, the wheat equivalent yield (WEY) was highest after soybean crop (2,259 kg/ha) followed by rice (2,225 kg/ha). Among sowing methods, the line sowing + mulch gave highest WEY (2,368 kg/ha) followed by line sowing (2,209 kg/ha).

Response of soybean varieties to different phosphorus levels

The response of soybean varieites (VL *Soya* 47 and VL *Soya* 89) to phospours levels (0, 55, 80 & 105 kg P_2O_5/ha) showed that soybean grain yield increased with increasing levels of phosphorus upto 105 kg P_2O_5/ha (2,330 kg/ha), however, the increment was significant upto 80 kg P_2O_5/ha (2,250 kg/ha). Soybean variety VL *Soya* 89 (2,150 kg/ha) gave higher yield than VL *Soya* 47 (2,090 kg/ha).

Effect of PGP bacteria/consortia on grain yield of finger millet

PGP bacteria (*Azotobacter* sp./*Pseudomonas* sp.), (*Azotocbacter+Pseudomonas*) and consortia were evaluated on finger millet (VL *Mandua* 379) under three sets of nutrient {I set received RDF and RDF (75%RDF+25%N by FYM) + bacteria/ consortium; II set received 75% RDF and 75RDF+ bacteria/consortium, whereas in third set 75% RDF (25%N by FYM)} were applied. Treatment of finger millet (VL *Mandua* 379) seed with PGP bacteria/consortia T13 (75% RDF; 25% N by FYM+*Azotobacter)* recorded highest grain yield (1,599 kg/ha) followed by T15 (75% RDF; 25% N by FYM+*Azotobacter+Pesudomonas*) (1,528 kg/ha) over un-inoculated control (T12) (1,310 kg/ha) with 75% RDF (25% N by FYM). Maximum harvest index (HI) was recorded by T10 (38.8) followed by T13 (36. 6) (Fig. 3.2.1).

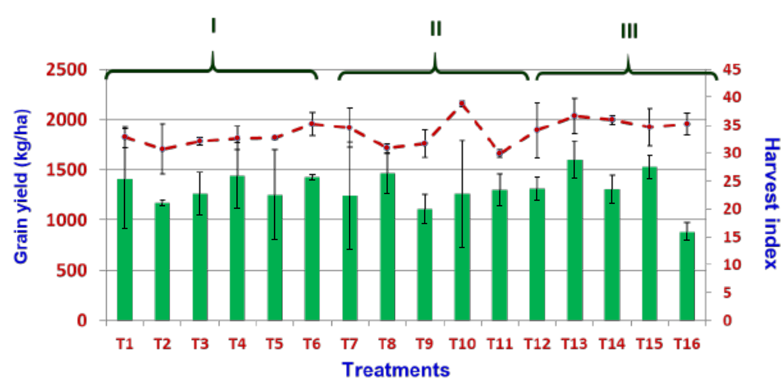


Fig. 3.2.1. Effect of PGP bacteria/consortia on grain yield of finger millet

Effect of plant growth promoting Pseudomonads on growth, nutrient uptake and yield of finger millet

Three years' performance of eight PGP pseudomonad strains revealed that *Pseudomonas* sp. NARs9 significantly enhanced grain yield by 1.24 fold followed by *Pseudomonas putida* PBRs5 (1.22 fold) and *Pseudomonas* sp. PGERs17 (1.22 fold) over un-inoculated control (1,338 kg/ha) (Figure 3.2.2).

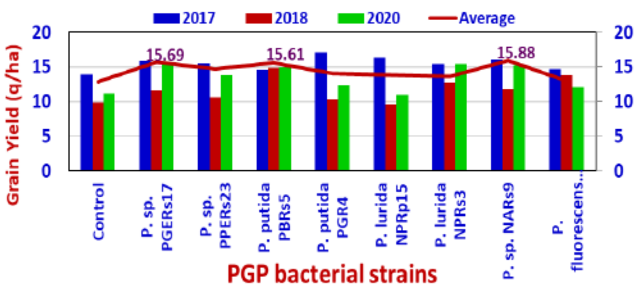


Fig. 3.2.2. Effect of PGP Pseudomonad on yield of finger millet

Effect of plant growth promoting bacterial consortia on yield of finger millet

Four years' performance of bacterial consortium revealed that consortium C5 recorded highest finger millet (VL *Mandua* 347) grain yield 1,419 kg/ha (11.31%↑) followed by C4 1,380 (8.23%↑) compared to un-inoculated control (1,275 kg/ha) (Fig. 3.2.3).

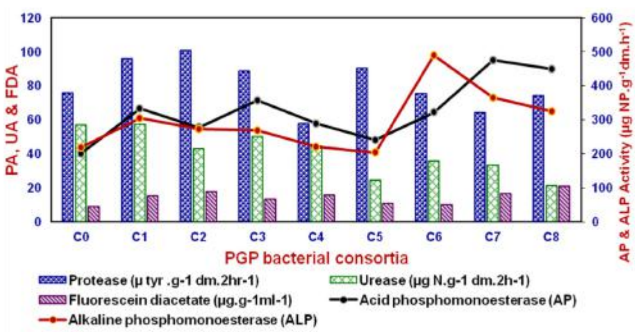


Fig. 3.2.3. Effect of PGP bacterial consortium on yield of finger millet

Evaluation of buckwheat sowing dates for its suitability for contingency planning

Buckwheat variety VL *Ugal* 7 was evaluated for 20 dates of sowing (March 10 to September 20) for its suitability for contingency planning. The highest grain yield was obtained when sown on July 30 (741 kg/ha) followed by June 30 (520 kg/ha).

Effect of split application of varying nitrogen levels in finger millet-wheat cropping system under rainfed conditions

Finger millet variety VL *Mandua* 379 was evaluated to four different nitrogen levels viz., 50%, 100%, 150% and 200% RDN {20 kg, 40 kg (recommended dose), 60 kg and 80 kg N/ha)} with three different split application of urea (2 equal split at basal and 35-40 DAS; 3 equal split and three different split (1/4+3/8+3/8) at basal, 30 DAS and 60 DAS) under rainfed conditions. Among various nitrogen levels, 80 kg N per ha recorded the maximum grain yield (2,350 kg/ha) which was at par with 60 kg N/ha (2,307 kg/ha). The highest grain yield was recorded with three different split (2,224 kg/ha) followed by three equal split (2,106 kg/ha).

Response of finger millet varieties to different dates of sowing under rainfed conditions to screen suitable variety for contingent crop planning

Six finger millet varieties, *viz.*, VL *Mandua* 347, VL *Mandua* 352, VL *Mandua* 376, VL *Mandua* 378, VL *Mandua* 379, and VL *Mandua* 380 were evaluated for 4 dates of sowing (June 25, July 5, 15 and 25) under rainfed condition (for contingent crop planning in case of late onset of monsoon). Sowing on June 25 gave significantly higher grain yield (3,288 kg/ha) followed by July 5 (2,983 kg/ha) and July 25 (2,587 kg/ha). The highest yield was recorded with VL *Mandua* 378 when sown on July 5 (4,102 kg/ha) followed by VL *Mandua* 379 (3,706 kg/ha) whereas, VL *Mandua* 376 performed better (3,668 kg/ha) when sown on 25 June. VL *Mandua* 352 (2,902 kg/ha) and VL *Mandua* 347 (1,120 kg/ha) were found most suitable variety for 15 and 25 July sown condition, respectively.

Response of different nutrient sources on seed yield of Buckwheat

Buckwheat variety VL *Ugal* 7 was evaluated for eight different combinations of nutrient sources (N:P:K though urea+SSP+MoP; calcium nitrate+SSP+MoP; urea+DAP+MoP; calcium nitrate+DAP+MoP; urea+NPK; calcium nitrate+NPK; 20 kg P/ha through FYM; and 10 kg P/ha through FYM. The significantly higher grain yield of buckwheat was recorded with N:P:K through urea+SSP+MoP (1,400 kg/ha) and calcium nitrate+SSP+MoP (1,366 kg/ha). However, the lowest yield was obtained with urea+DAP+MoP (1,072 kg/ha) and calcium nitrate+DAP+MoP (1,025 kg/ha).

Sub-Project: Identification of micro watershed (natural spring) using remote sensing & GIS technique and its runoff estimation for potential water harvesting

To identify the micro watershed (natural spring) using watershed

Fifteen water harvesting sites were identified in the catchment to trap surface runoff water. Both agronomical (napier) and mechanical (trench) measures were applied for efficient harvest the runoff. The average daily discharge during July, August and September 2020 was 6,670, 7,451 and 8,639 lit./day, respectively. The result showed that there has been 140% increase in discharge during July month, 39% increase in August while decrease of 3.72 % in discharge was found in the month of September.

3.3. Design and Development of Pre and Post-Harvest Mechanization Technologies for Hill Agriculture

Development of manual operated VL Multi-crop Sowing Device

Manual operated VL multi-crop sowing device was developed for crops like finger millet, barnyard millet, foxtail millet, wheat, rice, maize, pea, soybean, lentil, pigeon pea and some vegetables seed. Seed rate of crops were obtained with different hole size and peripheral distance. The drum consistes of 15 cm diameter pipe with 1 meter length, it has discharge holes which can be opened or blocked as per required crop spacing.These holes can be opened and closed as per sowing requirements. Dimension of the device is 130x125x40 cm and total weight of the device is 12 kg. Depth of the seed placement

Fig. 3.31. Prototype of Manual Operated VL Multi-crop Sowing Device

is adjustable in nature. Adjustable seed covering is also provided to cover seed simultaneously with sowing. The seed metering PVC pipe rotate with help of ground wheel (Fig. 3.3.1).

Development of VL Manual Weeder

VL manual weeder was refined and tested for pea weeding. The weeder consists of 12 series of piercing pegs in circle. Each series of pegs consist of two pegs jointed with 15x2 cm MS flat, fabricated in zig zag position. A shovel type furrow is provided at the rear to dig and cut weeds. Dimension of weeder is 130x40x25 cm. Weight of weeder is 10 kg. Working efficiency of weeder in pea weeding which was in the range from 75-80 per cent. Angle of handle is adjustable for fitting to the different height of operators (Fig. 3.3.2).

Fig. 3.3.2. Prototype of VL Manual Weeder

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

Evaluation of grasses

Bajra Napier hybrid: Out of sixteen entries in varietal trial of bajra napier hybrid, entry VTBN-2019-9 gave significantly higher green fodder (18,526 kg/ha) and dry fodder (4,381 kg/ha).

Evaluation of cultivated fodder

Oat: In initial varietal trial on oat, out of nine entries, entry IVTO MC-8 produced significantly higher green fodder (24,097 kg/ha) and entry IVTO MC-1 gave significantly higher dry matter (5,090 kg/ha).

Berseem: Out of six entries in advance varietal trial, AVTB-1-6 produced significantly higher green fodder (7,125 kg/ha) and dry fodder (1,240 kg/ha).

Maize: Out of seventeen entries of initial varietal trial of maize, significantly higher green forage (34,000) and dry fodder (9,600 kg/ha) was obtained from entry IVTM-8.

Investigation on fodder trees

In case of *kachnar* field terrace plantation, the highest green forage (5.96 kg/tree) was recorded from lopping of tree twice in a year followed by pollarding at 2m height leaving main shoot intact (LMSI), whereas, in case of wayside plantation of *kachnar*, lopping leaves and tender twigs twice in a year produced highest green forage (8.83 kg/tree).

Agroforestry

Agri-horti system

Fruit-based

Sweetcorn (CMVL sweetcorn 1) and buckwheat (VL *Ugal* 7) and pea (VL *Matar* 12) were evaluated during *kharif* and *rabi* seasons. The maximum sweetcorn cob yield (11.80 t/ha) and buckwheat grain yield (0.78 t/ha) were obtained under control (sole cropping) followed by under lemon, plum, apricot and pear trees. The maximum green pod yield (11.12 t/ha) of pea (VL *Matar* 12) was recorded under open followed by with plum (*Prunus domestica*), pear (*Pyrus communis*), lemon (*Citrus limon*) and apricot (*Prunus armeniaca*).

Peach-based

In peach-based agrihorti system, four cropping systems were evaluated namely, okra-wheat, okra-barley, finger millet-wheat and finger millet-barley. Grain yield reduced significantly by 21.67% under peach than without peach (open). In case of cropping system, significantly higher grain yield was recorded from okra-wheat system (4,031 kg/ha) which was 20.86-31.03% higher than other systems (Fig. 3.4.1).

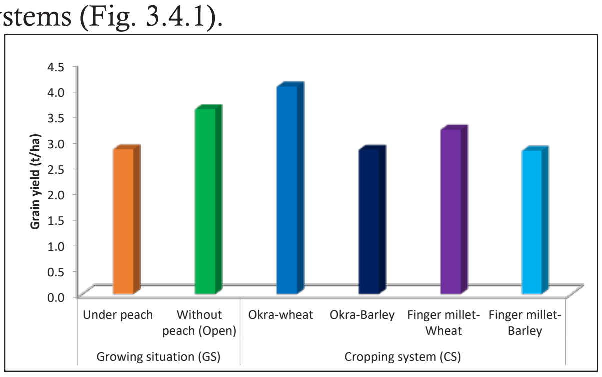


Fig. 3.4.1. Performance of different crops in peach-based agri-horti system

Soil microbial activities under peach based agro-horti system

Soil microbial activities study of wheat-barley crop field soil under peach based agro-horti system was performed in different soil depth. The soil microbial activities were observed significantly higher in barley crop than wheat crop under peach trees and the value drastically decrease with soil depth under both conditions. The result showed the maximum microbial activities such as dehydrogenase (59.3 µg TPF/g dw soil/hr), acid phosphatase (512.8 mg PNP/g dw soil/hr), microbial biomass carbon content (624.6 µg/g) and soil respiration process (46.4 µg CO_2-C/g) in soil sample from barley field under peach trees at 0-15 cm soil depth (Fig.3.4.2).

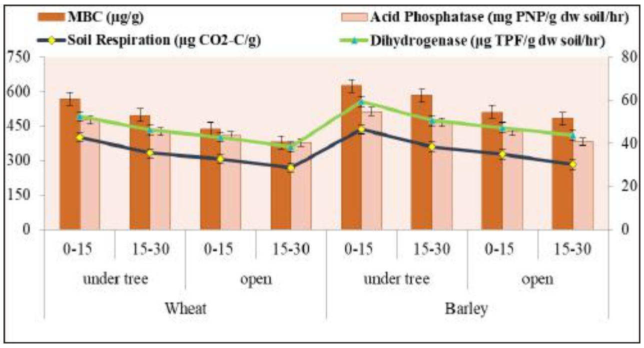


Fig. 3.4.2. Soil microbial activities in wheat-barley crop soil under peach based agro-horti system

Silvi-horti system

Oak-based

Two cultivars of turmeric *i.e.*, *Pant Pithab* and *Swarna* were evaluated under oak with different cutting management options. Highest green fodder (2.62 kg/tree), wood yield (2.24 kg/tree) and biomass C stock (1119.7 Mg/ha) was recorded in pollarding at 3 m height. The maximum turmeric yield was recorded with pollarding at 3m (88.09 q/ha) and least in sole turmeric cropping (61.13 q/ha). However, under oak 31.17% higher turmeric

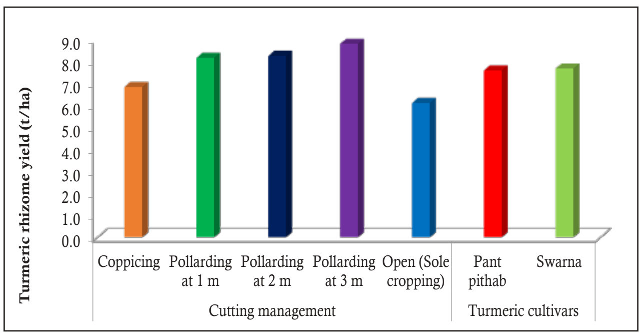


Fig. 3.4.3. Effect of oak cutting management on yield of turmeric cultivars

rhizome yield was obtained. *Swarna* yielded 1.61% higher than *Pant Pithab* (Fig. 3.4.3).

Silvipasture System

Fodder trees *Quercus leucotrichophora, Grewia optiva, Morus alba, Bauhinia retusa* and *Melia azedarach* along with four cutting management *viz*., coppicing, pollarding at 1m height, pollarding at 2m height and pollarding at 3m height with *Setaria kazungula* under these trees were tested under silvi-pastoral system. The highest green fodder leaves (2,895 kg/ha) was yielded by *Morus alba*, however, in case of cutting management pollarding at 3m height produced the highest green fodder leaves (2,920 kg/ha).

Fodder tree-based on sloping land

Turmeric cultivar (RCT 1) was evaluated under different fodder trees namely, *Quercus glauca*, *Alnus nepalensis, Melia azedarach* and *Bauhinia retusa* and in open (sole turmeric) on sloping land. Under tree, significantly higher (22.73%) turmeric rhizome yield (8.13 t/ha) was recorded than in open (6.62 t/ha). Among trees, maximum turmeric yield (9.12 t/ha) was recorded under *Quercus glauca*. The highest green fodder yield (892 kg/ha), fuel wood yield (7.45 t/ha) and biomass C (15.57 t/ha) was recorded from *Q. glauca*.

Fodder tree-based on flatland

Turmeric cultivar (RCT1) was evaluated under different fodder trees viz., *Quercus leucotrichophora, Celtis australis, Bauhinia retusa, Grewia optiva* and in open (sole turmeric). Significantly higher turmeric rhizome was obtained under *Quercus leucotrichophora* (13.6 t/ha) followed by under *Celtis australis*. Significantly higher yield under trees was 12.47 t/ha than in open 9.35 t/ha. The *Celtis australis* tree yielded highest green fodder (27.63 kg/tree) and fuelwood (19.97 kg/tree)

Evaluation of different *Cactus* spp. during winter season

Out of 24 cacti planting materials, seven namely, *Palma ruchira, Palma grande, Palma redone, IPA-90/115, Maxico* vegetable, *Jalpa* and locally available cactus (Prickly pear cactus) were found promising. Among these, moisture content ranged from 89.8 to 95.6%, 4.4 to 8.2% dry matter, 14.2 to 18.4% crude protein, 0.7 to 2.1% crude fat, 14.4 to 21.6 % crude ash and 4.38 to 7.37% crude fiber. *Palma ruchira* showed the highest nutritional value followed by *Palma grande* (Prickly pear cactus).

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

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

The higher wheat yield (2,793 kg/ha) was recorded under zero tillage in comparsion to conventional tillage (2,537 kg/ha). The average highest wheat yield (2,854 kg/ha) was recorded under FYM mulch followed by walnut mulch (2,655kg/ha). The water use efficiency and water productivity followed the same trend.

The higher soybean yield (2,657 kg/ha) was recorded under conventional tillage in comparsion to zero tillage (2,364 kg/ha). The avergage highest soybean yield (2,690 kg/ha) was recorded under FYM mulch followed by *Artimisia* mulch (2,617kg/ha).

Influence of tillage and different mulching practices on soil microbial process in wheat-soybean crop rotation

Soil respiration process and microbial biomass content of soybean harvested soil samples under different tillage and mulching treatments showed that zero tillage practices provided the maximum soil microbial activities (Fig. 3.5.1). Soil microbial activities declined with increasing soil depth. Mulching with FYM showed the highest soil respiration (36.7 µg CO_2-C/g for zero tillage & 33.6 µg CO_2-C/g under conventional practices) and MBC (554.8 µg/g for zero tillage & 515.6 µg/g under conventional tillage) content in both tillage practices.

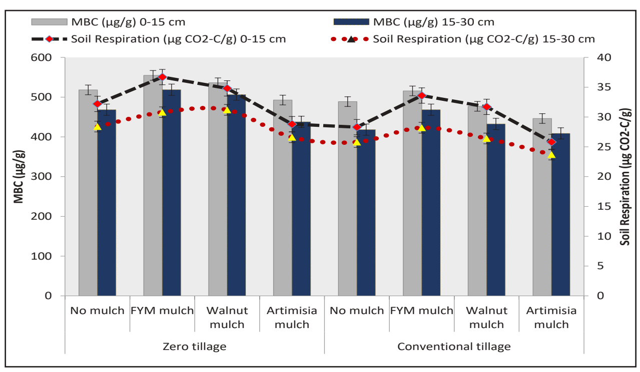


Fig. 3.5.1. Soil respiration and microbial biomass carbon content under different tillage and mulching practices in soybean crop soil

3.6. Integrated development of water resources and management for optimizing production and use efficiency

Grain quality of wheat (VL 804) and soybean (VL Soya 63) as affected by long term exposure of chemical fertilizer and manure in soybean-wheat cropping system under irrigated condition

Long term exposure of fertilizer and manure significantly influenced the grain quality parameters *viz.* crude protein, crude ash, crude fat and crude fiber content of both crops. It was observed that crude protein content varied from 10.4-12.9% for wheat and 36.3-42.6% for soybean, crude fat varied from 1.21-2.85% (wheat) and 19.5-24% (soybean), crude fiber 2.38-3.98% (wheat) and 9.2-13.5% (soybean) and crude ash content 3.3-4.2% (wheat) and 4.0-5.1% (soybean).

Artificial recharging techniques for hill springs

It was observed that the mean annual discharge of the spring was higher (18.7, 68.4, 72.5, 64.6, 141.9, 155.8, 136.1, 181.2, 129.1, 126.6, 120.0, 156.3, 146.5, 147.8, 112.8 and 186.3 per cent during 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020 and 2021, respectively) in comparison to annual discharge recorded during 2000 (Fig. 3.6.1).

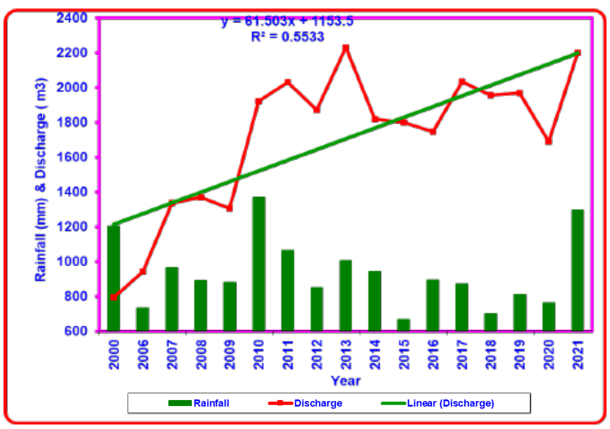


Fig 3.6.1. Annual rainfall and discharge in different years from spring before and after treatments

3.7. Evaluation of Multifaceted Microbial Inoculants for Improving Soil Health and Yield of Crops in Hilly Areas

Field demonstration of 'P' solubilizing bacterial consortium C4 on nutrient uptake and yield of finger millet varieties

PGP bacterial consortium C4 {*Pseudomonas* sp. (CS11RH1, CS11RP1, CS11RH4)} was evaluated at larger area and it significantly enhanced grain yield of finger millet varieties VL *Mandua* 380, VL *Mandua* 379 and VL *Mandua* 376 by 23.7, 13.4 and 11.3%, respectively as compared to uninoculated control (Fig. 3.7.1).

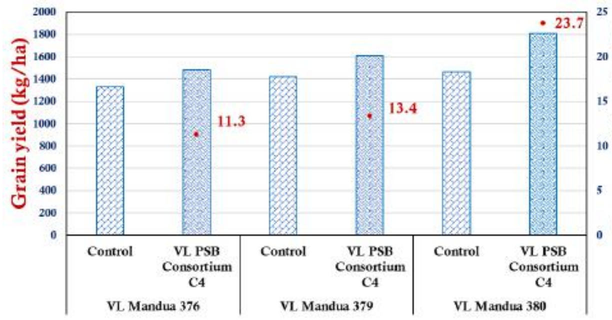


Fig. 3.7.1. Evaluation of 'P' solubilizing bacterial consortium C4 on grain yield of finger millet varieties

Subproject I: Assessment of Native Arbuscular Mycorrhizal Fungi for the Sustainable Production of Hill Crops

Assessment of rhizospheric samples collected from diverse plant habitats for soil physico-chemical properties and mycorrhizal status

The mycorrhizal spore density was significantly ($p < 0.05$) and positively correlated with organic carbon (r =0.65), dehydrogenase (r=0.69), acid phosphatase (r=0.56), urease enzyme (r=0.68) and root colonization percentage (r=0.71) whereas negatively with soil potassium (r = -0.50), phosphorus and alkaline phosphatase enzyme (r=-0.60) activities. Similarly, mycorrhizal root colonization was

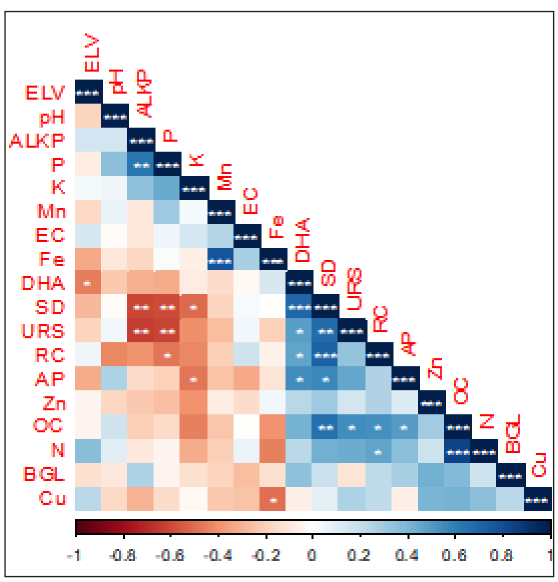


Fig.3.7.2. Correlation matrix between different soil variables and mycorrhizal properties Interactions among the variables are indicated as * *p* <0.001, ** *p* <0.01, and * *p* <0.05**

positively correlated with organic carbon (r=0.53), available nitrogen and dehydrogenase (r=0.46) enzymes, whereas negatively with soil phosphorus (r= -0.48) at the significance level of 0.05 (Fig. 3.7.2).

Subproject II: Development of Nano-Bioformulation to alleviate drought stress in hill crops

Isolation and characterization of drought tolerant plant growth promoting bacteria from finger millet rhizosphere (natural drought tolerant)

Roots of drought tolerant (source of this information?) finger millet cultivar (Specify) were collected from Experimental farm, Hawalbag. Six isolates were able to grow on chrome azurol-nutrient agar medium. The siderophore production was also confirmed and quantified in sodium succinate medium. Siderophore production was highest in isolate A4 (71.9 mg/l) followed by A3 (63.5 mg/l) (Fig. 3.7.3).

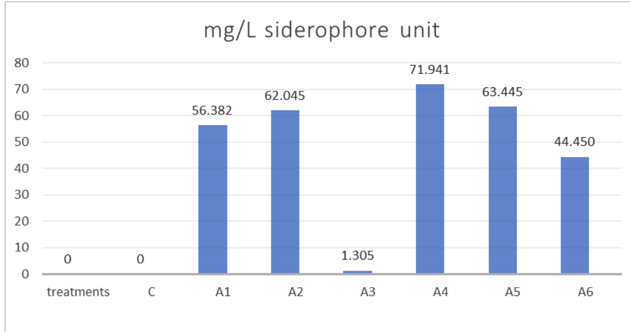


Fig. 3.7.3. Siderophore production by different isolates in sodium succinate medium

4. Integrated Pest Management

Research Projects

- Race Distribution Pattern, Diversity and Eco-Friendly Management of Economically Important Diseases of Hill Crops [*Mr. Chandan Maharana (upto 16.10.2021), Drs. Gaurav Verma (w.e.f. 26.10.2021), Jeevan, B. and K. K. Mishra]*
- A High Value Medicinal Fungus (*Cordyceps militaris*): Characterization & Commercial Exploitation *[Dr. K. K. Mishra, Mr. Chandan Maharana (upto 16.10.2021), Drs. Ashish Kumar Singh, Ramesh Singh Pal and Gaurav Verma (w.e.f. 26.10.2021)]*
- Exploring Potential Bio-inoculants and Host Resistance for Management of Blast Disease *[(Dr. Jeevan B, Mr. Chandan Maharana (upto 16.10.2021), Drs. Priyanka Khati and Gaurav Verma (w.e.f. 26.10.2021)]*
- Crop Pollination through *Apis* and Non-*Apis* Bee Pollinators *[(Mr. Amit Umesh Paschapur)]*
- Management of Insect Pests of Hill Crops through Integrated Approach *[(Mr. Amit Paschapur, Dr. Ashish Kumar Singh, Mr. Chandan Maharana (upto 16.10.2021) and Dr. Gaurav Verma (w.e.f. 26.10.2021)]*
- Comprehensive Assessment of Diversity of Agriculturally Important Nematode and their Management under Hill Agriculture *[(Dr. Ashish Kumar Singh and Mr. Amit Umesh Paschapur)]*

4. Integrated Management of Diseases and Pests of Hill Crops

Crop protection measures play a vital role in reducing crop yield losses due to diseases and insect pests. Integrated methods of management are environmentally safe and important in the hill ecosystem. Thus, emphasis has been given to the adoption 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 & surveillance of diseases and insect-pests

In wheat and barley, yellow rust severity was low to medium (10S to 40S) at the Experimental farm, Hawalbagh, however, at the farmer's field it was low (<10S). In most of the experimental lines at Hawalbagh, low severity of powdery mildew was observed (1-3 score on a 0-9 scale). In garden pea, very low severity of wilt (2%); low-moderate severity of purple blotch (10-20%) and stemphylium blight (30-50%) in onion and garlic were noticed during the March-April months. The infestation of shoot fly, aphid and thrips was observed in wheat and barley at a very low severity (<10%), while infestation of thrips in onion and garlic was observed with moderate severity (15%). In crucifers and garden pea, very high severity of aphid infestation (>35%) was recorded in both open field and polyhouse conditions.

In maize, a very high infestation of fall army worm was recorded with per cent damage of 60-80% in the vegetative stage and 20-30% damage in the reproductive stage. In millets, the infestation of shoot fly and aphids was observed with moderate severity (10-20%), whereas, damage of grass hoppers and ear head caterpillars was recorded with high severity (20-30%). In case of soybean, the damage of *Chauliops choprai* and aphids was very mild with 10-15% damage, while, the damage of *Platypria* spp. was observed with very high severity (30-40%) in vegetative stage of the crop. In paddy, the leaf roller damage was noticed with moderate severity (10-20%) and grasshopper damage was recorded with low severity (5-10%). Moreover, the damage of aphids was recorded in both vegetative and reproductive stages in *Toria* and Capsicum with low to medium severity (5-15%). In 2021, the damage of *Tuta absoluta* and russet mite in tomatoes increased rapidly as compared to previous years and the severity of up to 40% was recorded under polyhouse conditions at experimental farm, Hawalbagh and at farmers' fields in Almora and Bageshwar districts. Additionally, this year the damage of polyphagous black cut worm (*Agrotis segetum*) was also observed in the initial crop growth stages. However, the per cent of pest damage varied from 5 to 40% in soybean and maize respectively.

4.2. Race distribution Pattern, diversity and eco-friendly management of economically important diseases of hill crops

4.2.1 Efficacy and characterization of *Trichoderma* isolates from Northwestern Himalayas

The antagonistic potential of two *Trichoderma* isolates namely Tr-28 and Tr-202 were assessed against *Fusarium oxysporum* f. sp. *lentis* through the dual culture technique. Both the isolates showed inhibition against the pathogen. However, the *Trichoderma* isolate Tr-202 showed significantly higher inhibition (72.2%) in comparison to the isolate Tr-28 (65.5%) (Fig. 4.1). These isolates were identified using both morphological and molecular characteristics. Furthermore, a phylogenetic analysis based on the ITS region was performed, and the maximum parsimony analysis of the ITS gene confirmed, both the isolates as *T. harzianum* (Fig. 4.2).

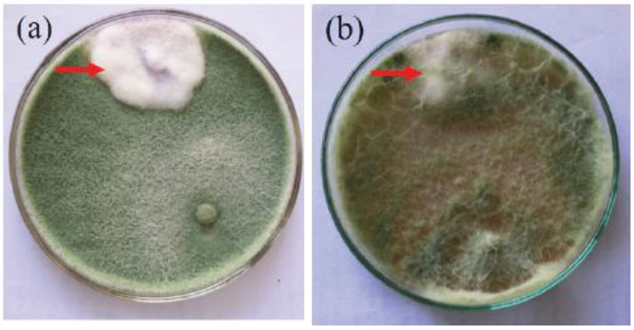


Fig. 4.1. Mycoparasitic action of *Trichoderma* isolates on *Fusarium oxysporum* f. sp. *lentis*; (a) Tr-28 and (b) Tr-202

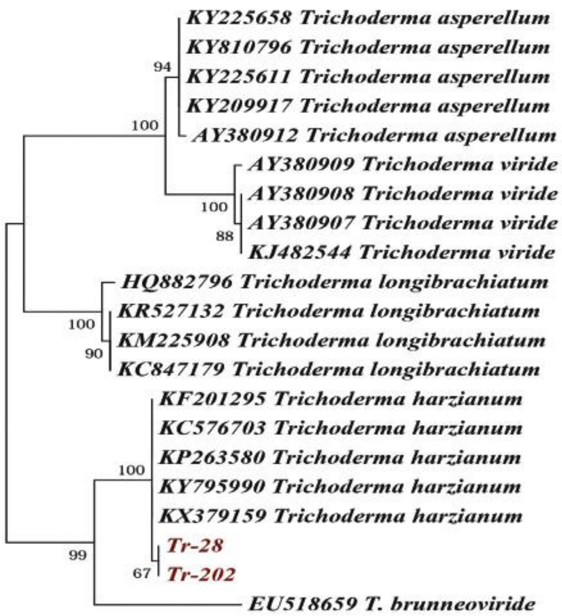


Fig. 4.2. Phylogenetic tree of *Trichoderma* isolates from Northwestern Himalayas based on sequences of the ITS region.

4.3. A high value medicinal fungus (*Cordyceps militaris*): Characterization & commercial exploitation

4.3.1 Evaluation of media, pH and temperature on radial growth of *Cordyceps militaris* isolate

A total of five media namely, Sabouraud Dextrose Yeast Agar (SDYA), Potato Dextrose Agar (PDA), Czapek Dox Agar (CDA), Oat Meal Agar (OMA) and Malt Extract Agar (MEA) were tested for radial growth of *Cordyceps militaris* isolate. The maximum and minimum growth was recorded on SDAY (44.93 mm) and CDA (32.60 mm) media on the 12th day, respectively. The radial growth of the fungus was evaluated from a pH range of 2-10 at an interval of 2. The maximum (44.93 mm) and minimum (28.30 mm) growth were obtained at pH 6 and pH 10, respectively on the 10th day. There was a decline in growth below pH 5 and above pH 7, while, the pH ranges from 5 to7 were found to be the best for the growth of *C. militaris*. The fungal growth was further evaluated from a temperature range of 5-25^{0}C at an interval of 5^{0}C. The maximum (44.87 mm) and minimum (35.67 mm) growth were recorded at 20^{0}C and 5^{0}C, respectively. There was a significant decline in growth below 15^{0}C.

4.4. Exploring potential bio-inoculants and host resistance for management of blast disease

4.4.1 Characterization of endophytic bacterial isolates for plant growth-promoting (PGP) activities

A total of 63 endophytic bacteria were characterized for plant growth-promoting (PGP) activities. Based on the test results, five isolates (JE54, JE49, JE42, JE41 and JE44) were recorded to have good zinc solubilization potential, two isolates namely JE44 and JE23 found positive for siderophore production, 11 isolates (JE25, JE54, JE15, JE10, JE43, JE38, JE29, JE44, JE539, JE32 and JE4) were positive for IAA production, three isolates (JE9, JE1 and JE33) were found positive for P solubilization and 9 isolates (JE39, JE32, JE4, JE15, JE38, JE26, JE53, JE58 and JE13) were positive for HCN production (Fig. 4.3).

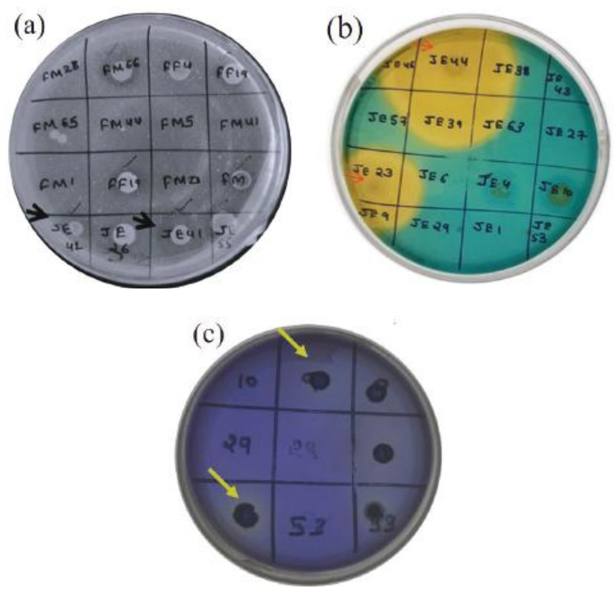


Fig.4.3. Qualitative assay of endophytic bacteria for PGP traits; (a) Zn solubilization (b) Siderophore production (c) P solubilization

4.5. Crop pollination through *Apis* and non-*Apis* bee pollinators

4.5.1 Pollination efficiency and yield advantage studies in Brinjal/Eggplant (*Solanum melongena* L.) by artificial introduction of bees

In this study, we analyzed the diversity of insect pollinators in brinjal. A total of 28 insect species belonging to two orders were observed to visit the flowers. The floral biology studies showed that at

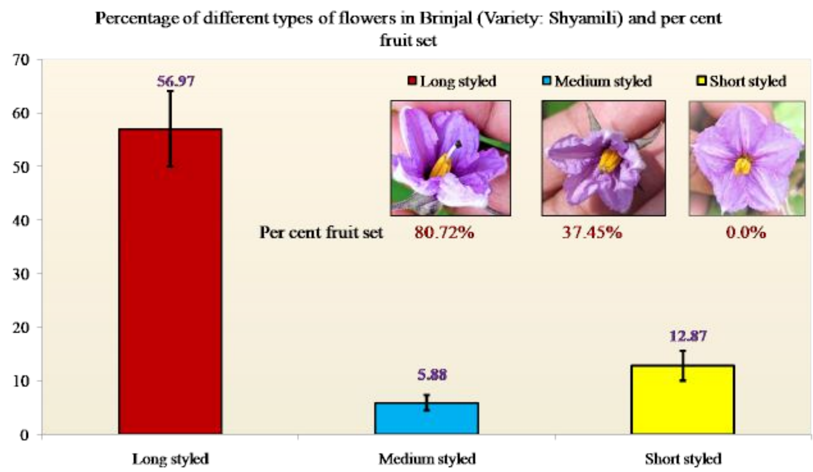


Fig 4.4. Proportion of different flowers classified based on length of style

9.30 AM highest stigma receptivity of 86% and pollen germination of 89.50% was recorded. The per cent of flowers belonging to different classes was analyzed and observed for the presence of long, short and medium styled flowers at 56.97%, 12.87% and 5.88%, respectively (Fig 4.4). Among these, 80.72% and 37.45% of the long-styled and medium styled flowers set into fruits, while, the short-styled flowers set no fruits. The pollination efficiency studies showed that *Bombus haemorrhodalis* spent the most time on a single flower (33.83 - 34.33 seconds) whereas, *Apis mellifera* visited the maximum number of flowers in one minute (6.16 - 6.67), however, *Apis indica* showed intermediate activity. The pollination of brinjal by both *A. indica* + *A mellifera* showed synergism and lead to a 54.97% fruit set (Fig 4.5). It was also evident in yield advantage studies with an increase in yield of 44.36 - 49.98%, followed by *A. indica* (37.28-38.66%) and *A. mellifera* (23.93 - 24.41%). The number of bee colonies required for optimum fruit set for one hectare of brinjal was estimated as 2.60 and 1.62 colonies of *A. indica* and *A. Mellifera*, respectively. The time parameter analysis showed that *B. haemorrhodalis* pollinated plants were harvested at the shortest time of 79.2 days, while, closed control plots took 83.7 days for final harvesting.

4.5.2. Pollination efficiency and yield advantage studies in Onion (*Allium cepa* L.) by artificial introduction of bees in the Indian Himalayas

The pollination behaviour and pollination efficiency studies of *Apis cerana indica* showed that both the pollen and nectar foragers visited the flowers during

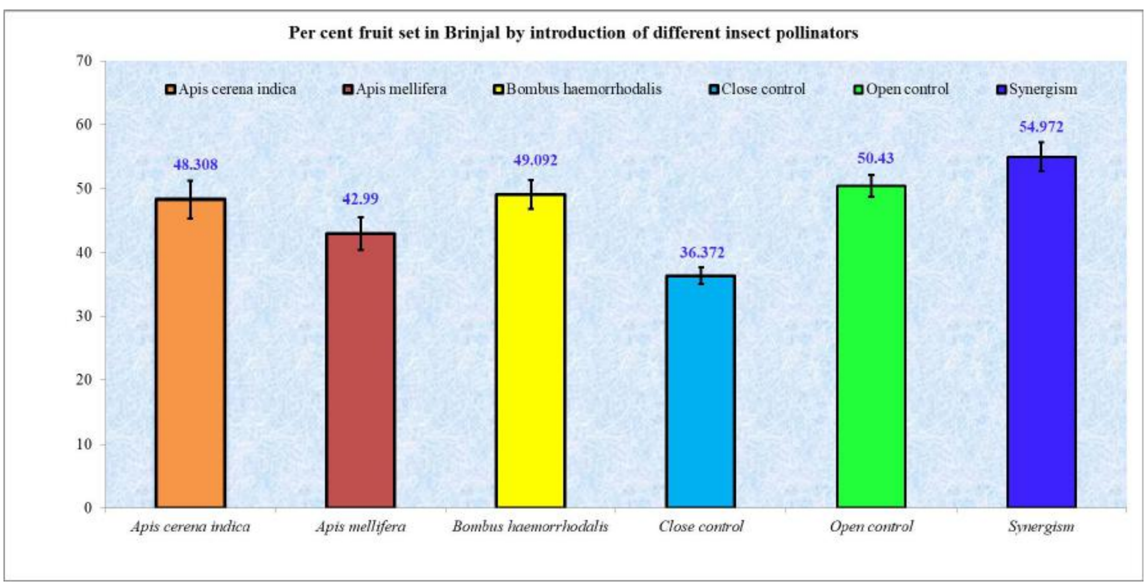


Fig 4.5. Per cent fruit set in different treatments of brinjal

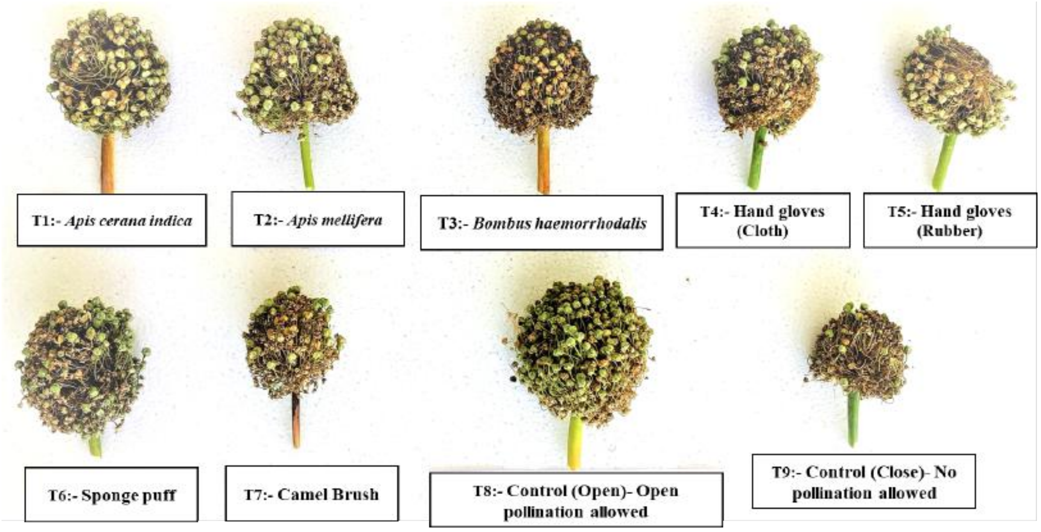


Fig. 4.6. Assessment of per cent seed set with respect to total number of flowers per umbel under different pollination conditions

the entire day and nectar feeders spent most time per flower than the pollen feeders. Artificial pollination through various cross pollination techniques like hand, brush and controlled entomophily using honeybees were studied in onion. The quantitative yield data (Fig 4.6) showed that open control (724±7.00) recorded highest number of seeds per umbel, followed by *A. c. indica* (394±6.35) and *Apis mellifera* (307±9.02). While, per cent seed set per umbel was highest in open control (85.99%), followed by *A. c. indica* (46.79%) and *A. mellifera* (36.46%). The yield advantage studies over the close control showed that, open control plots had the highest yield advantage of 1423.50%, followed by *A. c. indica* (345.16%) and *A. mellifera* (238.71%). Among the artificial pollination methods, hand gloves (rubber) and hand gloves (cloth) were the least effective treatments with per cent yield advantage of 9.68% and 22.58%, respectively. The optimum pollination studies showed that 12.60 colonies of *A. c. indica* were required for efficiently pollinating one hectare of onion.

4.5.3 Hornet Pests of honey bees in the Indian Himalayas and a low-cost trapping device for their eco-friendly management

Honey bees suffer from a cosmic array of biotic and abiotic stress during their life cycle. The insect pests like wax moths and Dermestid beetles contribute immensely for the damage of bee colonies and reduction in honey yield in tropical regions of India. While, the bee colonies in temperate regions of Indian Himalayas, face an entirely different set of hitches that include predation of forager bees by three hornet species (*Vespa mandarinia*, *Vespa velutina nigrithorax* and *Vespa tropica*). The attacks on bee colonies by these hornet species compel the bees to desert the colony and swarm away to a new habitat thus, causing severe economic losses to bee keepers. Considering the severe setbacks enforced by hornets, a low-cost hornet trap was designed. The bait ingredients and its trapping efficiency against targeted hornet species were given in Table 4.1. It was observed that green coloured bottles

Table 4.1. List of ingredients required to design one low cost hornet trap

Ingredient	Quantity per trap	Proportion to be added	Cost per trap (Rs.)
Green plastic bottle	1	-	
Apple cedar vinegar/ wine	25 ml	1	12
Orange juice	50 ml	2	5
Water	50 ml	2	-
Detergent powder	1 gram	-	1
Rotten banana	1-2 pieces	-	-
Market honey	1 table spoon	-	2
		Grand total	**20**

≅≅indicates the approximate cost

Table 4.2. Comparison between benefit-cost ratios of trap vs. the traditional method

Materials and labour	Cost in the traditional method (Rs)	Cost for installation of the trap (Rs)
Cost of ingredients	Nil	20 per trap
Cost of labour	267 per day	Approx Rs. 267 for designing 10 traps
Cost of labour per month	8000 per month	10 traps per apiary X changed 4 times a month= 800 Rs
Total cost per month	8,000 per month	1067 per month
Total cost for 3 months during peak infestation	24,000	3,201
Total honey produced per apiary (average)*	87.5 kg X 450**= 39,375	= 39,375
B:C ratio	**1.64:1**	**12.30:1**

*an average apiary in the Indian Himalayas consists of 25 beehives with an average honey yield of 3.5 kg per hive per year, established in an area of 200 m^2. So, 10 traps are sufficient to cover an area of 200 m^2

**average cost of honey in the Indian Himalayas is 450 Rs/ Kg

attracted 34 hornets of three species in a period of 10 days, while, transparent bottles attracted only seven hornets at bait proportions of 1:2:2 (Apple cedar Vinegar: orange juice: water). Moreover, to reduce the attraction of honey bees into the trap, supplementary ingredients like rotten fruits and market honey were used, which enhanced the trapping efficiency of hornets. The benefit cost ratio of 12.30:1 was recorded after installation of trap, which was significantly superior over traditional method (1.64:1) of manual swatting of hornets in apiary (Table 4.2, Fig 4.6 & 4.7).

Fig 4.6. Procedure for designing of a low-cost hornet trap

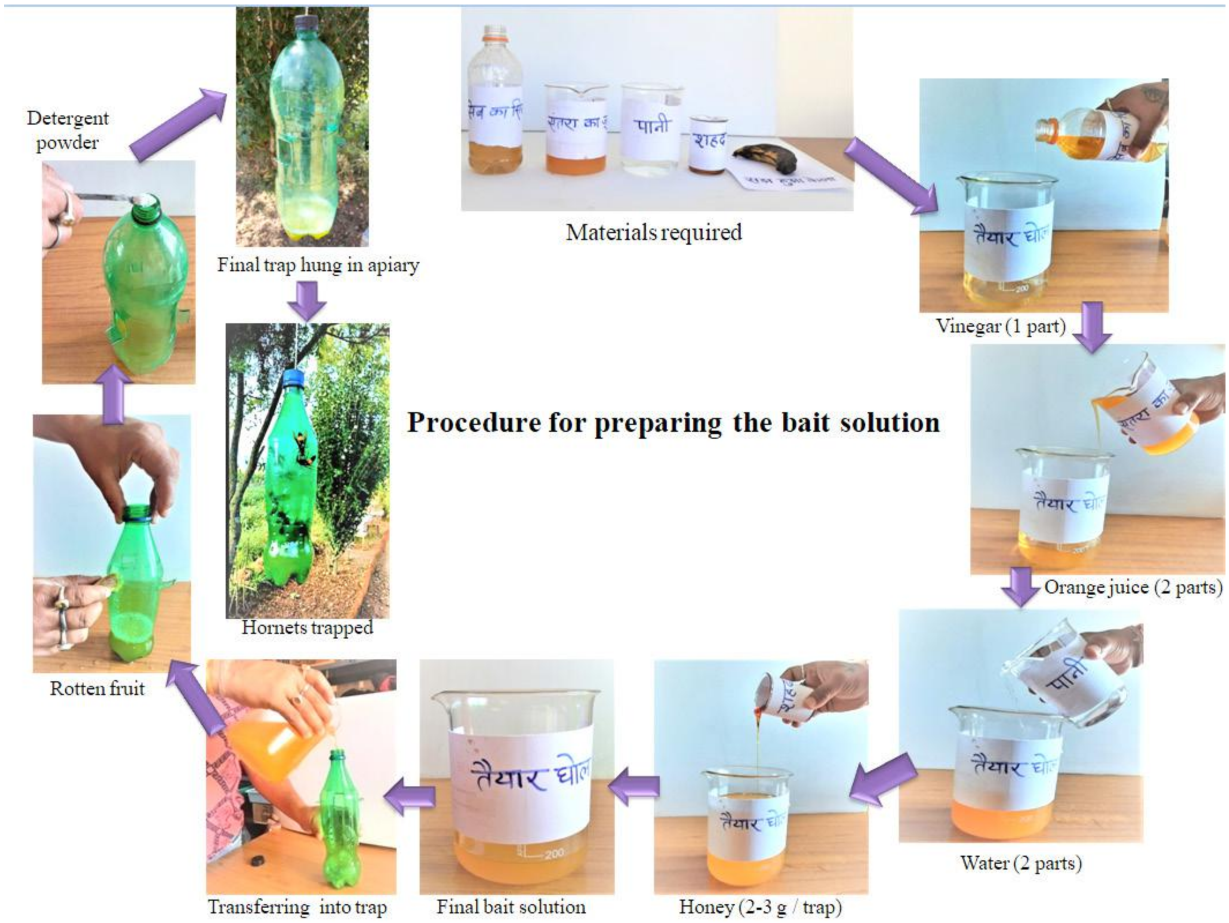


Fig 4.7. Procedure for preparation of bait solution for trapping hornets

4.6. Management of insect pests of hill crops through integrated approach

4.6.1 Deciphering the mode of action of native entomopathogenic fungi *Alternaria alternata* VLH1

4.6.1.1 Ascertaining chitinase activity of the crude protein extracts

A study was conducted to quantify the Chitinase enzyme activity in the protein extract. The results showed a progressive increase in the enzymatic activity over a period of time (Fig. 4.8). Four days after inoculation, the maximum protein concentration of 117.78 U/mL was obtained, which was followed by 104.72 U/mL and 91.83 U/mL after 3rd and 5th days, respectively.

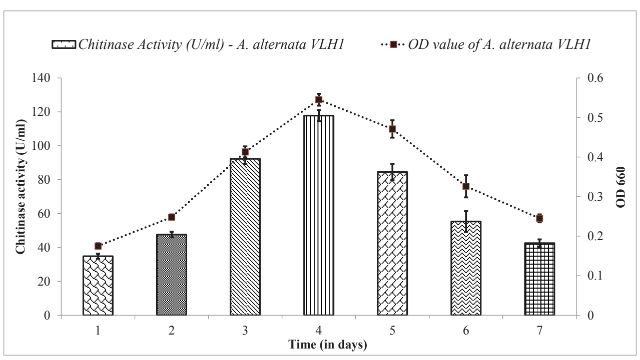


Fig. 4.8. Kinetics of chitinase production by protein extracts of *A. alternata* strain VLH1

4.6.1.2 Characterization of chitinolytic activity of protein extract through protein electrophoresis

The protein extract was electrophoresed and the band thus obtained on the PAGE gel was compared with the standard molecular weight marker (Fig. 4.9). The band revealed the presence of an enzyme of the size ranging between 75-90 kDa. Further studies to confirm the chitinolytic activity of the band, colloidal chitin 0.2% was used as substrate and the superimposition of PAGE gel formed a clear chitin degradation zone on the 2% agarose gel, thus, confirming the chitinolytic activity of the protein fraction isolated from *A. alternata* strain VLH1.

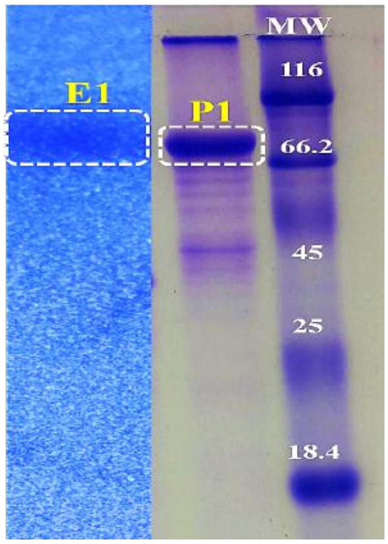


Fig. 4.9. Characterization of chitinolytic activity of protein extract of *A. alternata* VLH1 (Lane 1. (E1) chitinolytic activity on 2% agarose gel with 0.2% colloidal chitin as substrate, Lane 2. Chitinase enzyme band isolated from crude protein extracts of *A. alternata* VLH1, Lane 3. Molecular weight marker)

4.6.1.3 Effect of protein extracts on nutritional physiology of *Helicoverpa armigera*

The analysis of the effect of protein extracts on the nutritional physiology of third instar larvae of *H. armigera* showed that there was a significant decline in the food utilization efficiency of larvae (Table 4.3). The RGR value reduced from 7.09 to 2.18 mg/mg/day 96 HAT (F=32.65, p<0.001), RCR value declined from 18.56 to 3.81 mg/mg/day 96 HAT (F=136.96, p<0.001), per cent ECI decreased from 9.47 to 3.19 after 96 hrs (F=41.94, p<0.001), per cent ECD reduced from 8.02 to 1.96 after 96 hrs (F=39.79, p<0.001) and AD declined from 99.65 to 96.70% after 96 hrs (F=6.72, p<0.001) in control and 40 ppm concentration of protein, respectively. The decline in the food utilization efficiency of larvae was dose-dependent and the highest dose of protein extract (40ppm) led to abnormal pupal moulting and the formation of deformed adults. At the highest protein concentration, the relative growth rate (RGR), relative consumption rate (RCR), the efficiency of conversion of ingested food (ECI), the efficiency of conversion of digested food (ECD) and approximate digestibility (AD) declined 3.25, 4.87, 2.96, 4.09 and 1.03 times, respectively over control. Moreover, all the nutritional indices showed a significant reduction at 1% level of significance.

The possible reason for causing growth deformity and mortality in insects by *A. alternata* VLH1 might be the degradation of the chitin layer present in the gut of insects and associated toxicities caused by other insecticidal protein fractions. Also, the degradation of the chitinolytic cuticular layer during appressoria formation and fungal penetration might have given the entomopathogenic capacity to *A. alternata* VLH1.

4.6.2 First report of maize fall armyworm, *Spodoptera frugiperda* (J E Smith) and its rapid spread in Uttarakhand Himalayas, India

4.6.2.1 Survey and collection of fall armyworm

Fall Armyworm, *Spodoptera frugiperda* (J E Smith), a notorious pest of maize, was reported for the first time in the hills of Uttarakhand, Himalayas during

Table 4.3. Effect of chitinolytic protein extracts of *Alternaria alternata* strain VLH1 on nutritional physiology of third instar larvae of *Helicoverpa armigera* (96 hours after treatment)

Concentration of protein (in ppm)	RGR (mg/mg/day)	RCR (mg/mg/day)	ECI (%)	ECD (%)	AD (%)
Control	7.09±0.14^{e}	18.56±0.76^{e}	9.47±0.75^{d}	8.02±0.54^{d}	99.65±0.16^{c}
5ppm	5.12±0.43^{d}	10.83±0.44^{d}	6.01±1.16^{c}	3.39±0.33^{c}	97.27±0.70^{b}
10ppm	4.81±0.35^{c}	8.31±0.38^{c}	4.90±0.339^{b}	3.23±0.21^{c}	97.21±0.50^{b}
20ppm	3.45±0.45^{b}	5.25±0.50^{b}	4.41±0.01^{b}	2.45±0.43^{b}	97.04±0.40^{ab}
40ppm	2.18±0.12^{a}	3.81±0.23^{a}	3.19±0.26^{a}	1.96±0.21^{a}	96.70±0.19^{a}
SE (m)	0.32	0.498	0.516	0.384	0.456
F	32.65**	136.96**	41.94**	39.79**	6.72**

RGR- Relative growth rate, RCR- Relative consumption rate, ECI- Efficiency of conservation of ingested food, ECD- Efficiency of conservation of digested food, AD- Approximate digestibility

**Tukey's-B test conducted at 1% level of significance (mean ±SD values are presented in the table)

Table 4.4. Survey and estimation of fall armyworm per cent pest infestation in various districts of Uttarakhand

Sl. No.	Location	District	Longitude	Lattitude	Altitude (in m)	Variety	Pest infestation
Low hills (<800m)							
1	Dhanpau	Dehradun	30.52699	77.84697	550	VMH 45, local cultivar	High
2	Kwanu	Dehradun	30.24486	78.10361	576	VMH 45, local cultivar	High
3	Bailpadao	Nainital	29.30859	79.20518	341	CMVLSC1, V373 and V390 (male and female parent of VMH 45 respectively)	Very high
4	Haldwani	Nainital	29.182746	79.442936	351	VMH45, VMH53 and DKC 9108	Very high
Mid hills (800-1800m)							
5	Chhana Golu	Almora	29.71552	79.45756	1281	Local Cultivar	High
6	Chaukhutiya	Almora	29.88497	79.35032	936	Local Cultivar	Very high
7	Hawalbagh	Almora	29.63296	79.63042	1218	Diverse maize material	Very high
8	Kafligair	Bageshwar	29.75560	79.73749	1332	Local Cultivar, sweet corn lines VSL4 and VSL16 and normal corn lines V433, V412, VQL373	Very high
9	Lakhani	Bageshwar	29.88118	79.66010	1343	Local Cultivar	Very high
10	Ranichauri (Gaja)	Tehri Garhwal	30.30755	78.42076	1750	Different maize hybrids	High
11	Majhera	Nainital	29.50821	79.47564	897	Different maize hybrids	Low
12	Khyarsi Tehri	Tehri Garhwal	30.51582	78.08656	1755	Local Cultivar	High
High hills (>1800m)							
13	Liti	Bageshwar	30.00989	80.03053	2144	VMH 45/CMVL 55/ VMH57	Medium
14	Shama	Bageshwar	29.97642	80.04802	2174	VMH 45/ FQH 106	Medium
Low- 10-20%, Medium- 20-30%, High- 30-40%, Very high- >40%							

kharif, 2020 and within a span of two months the pest traversed a long-distance and spread from foot hills (300 m) to high mountains (2174 m) of the Himalayas, where maize cultivation is being practised. The pest incidence varied from 15% in the Nainital district (Majhera) to 60% in Almora, Bageshwar and Dehradun districts. An extensive survey was conducted to collect the FAW samples from five districts of Uttarakhand namely, Almora, Bageshwar, Dehradun, Nainital and Tehri Garhwal. The details of locations surveyed and the severity of pest infestation in each district are given in Table 4.4.

4.6.2.2 Identification of insect pest

The identification of FAW was carried out by both molecular and morphological characterization methods.

Morphological characterization

The male and female moths of FAW can be easily differentiated by sexual dimorphism in their forewing colouration and variegation, wherein, the females have greyish-brown wings with no peculiar markings, while the forewings of males have a typical straw-brown marking at the mid-region of the wing and a dull whitish patch at the anal margin of the wing.

Molecular characterization

The PCR reaction was set up to amplify the mitochondrial cytochrome oxidase I (mtCOI) gene by using Universal COI primer (JM 76 (GAGCTGAATTAGG(G/A)ACTCCAGG) and JM 77 (ATCACCTCC(A/T)CCTGCAGG ATC). The PCR-amplicon was purified and the sequencing was outsourced to Biologia Research India Pvt. Ltd., a Delhi-based private company. The obtained sequence was compared to the mtCOI sequences in the NCBI GenBank database by BLASTN analysis. The generated sequences of the partial mitochondrial COI region were deposited in NCBI GenBank (https://www.ncbi.nlm.nih.gov/WebSub/?tool=gen bank).

Based on morphological characteristics the pest was identified as *Spodoptera* species. Further sequencing and phylogenetic analysis of mtCOI gene confirmed the pest as *Spodoptera frugiperda* strain miryang (Fig 4.10). Moreover, from the phylogenetic tree, it can be seen that our specimen (*Spodoptera frugiperda* voucher specimen Hawalbagh (UK) maize MW357423) had a close identity with *Spodoptera frugiperda* isolate TNAU Maize (MH779591.1) recording 97% node value after bootstrapping. Although the CO1 sequence of FAW sample collected from Hawalbagh, Uttarakhand (29.63296, 79.63042, 1218m) showed close identity with Indian populations of *S. frugiperda* (Tamil Nadu and Chamarajnagar), but, it was distantly related to other *Spodoptera frugiperda* populations of Karnataka, Maharashtra, Andhra Pradesh and Madhya Pradesh.

4.6.3 Food poison bait technique for management of polyphagous cutworm (*Agrotis segetum*)

A simple technique of utilization of food poison bait for the management of polyphagous cutworm

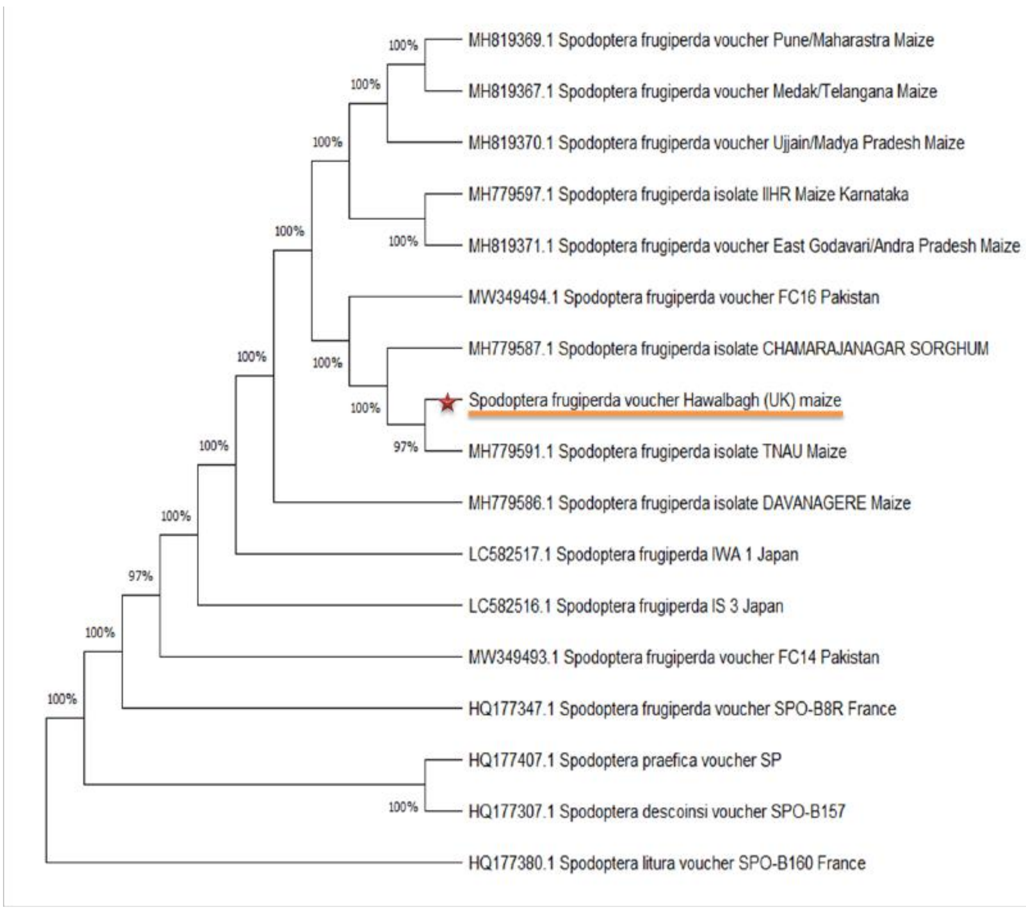


Fig. 4.10. Phylogenetic analysis of *Spodoptera frugiperda* voucher specimen Hawalbagh (UK) maize along with 12 closely associated *Spodoptera frugiperda* species sequences (*Spodoptera litura* voucher SPO-B160 is taken as outgroup).

S. frugiperda **voucher FC16 raises the question of the possible migration of FAW populations into the Himalayan region from both southern parts of India and eastern parts of Pakistan.**

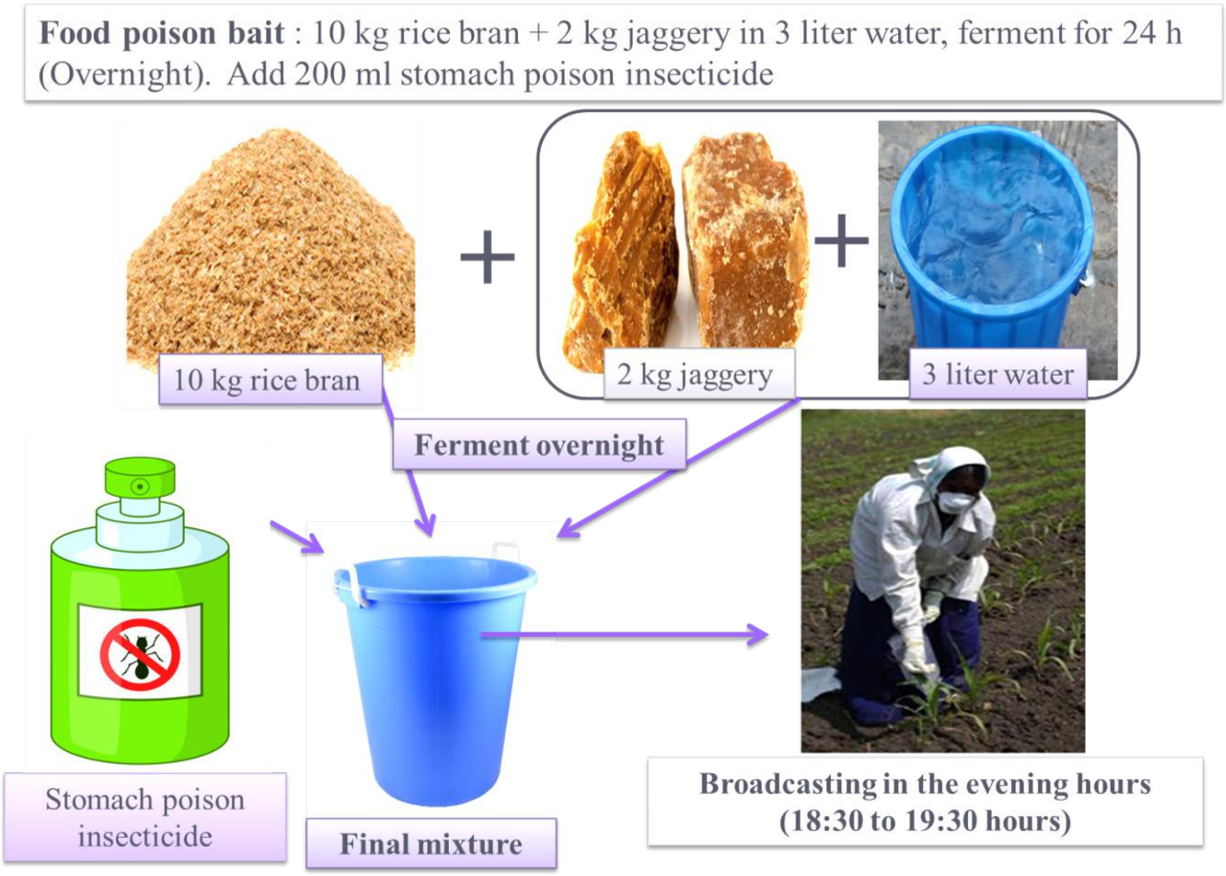


Fig. 4.11. Materials required and procedure followed for preparation of food poison bait for management of polyphagous cut worm, ***Agrotis segetum***

was devised. The materials for the preparation of the bait included 10 kg of rice bran, 2 kg of jaggery, 3 lit. of water and a stomach poison insecticide (200 ml). The prescribed amount of jaggery was dissolved thoroughly in water and sprinkled finely on the rice bran and placed in a container. All the ingredients were mixed properly and allowed to ferment overnight in a large container. On the next day, just before use, 200 ml of stomach poison insecticide (Monocrotophos/ Chlorpyriphos/ Quinolphos/ Thiodecarb) was mixed into the fermented bait mixture (Fig 4.11). The poison bait mixture was broadcasted into the fields in the evening hours between 18.30 to 19.30 hours when the cutworms are actively feeding and cutting the crops. Through this technique, the damage of cutworm was reduced to a tune of 65% in Rajma at Niti and Mana village clusters of Uttarakhand, India. Further, this technique is also recommended to farmers of Bageshwar district, where a severe outbreak of cutworm was noticed in *Rabi*, 2021.

4.7. Comprehensive assessment of diversity of agriculturally important nematode and their management under hill agriculture

4.7.1 Characterization of Necromenic Nematode *Pristionchus pacificus* and associated bacteria isolated from rhizospheric soil of apple orchard

4.7.1.1 Soil sample collection and baiting

Field soil samples (200 g each) were collected from different locations in Almora and Nainital districts. The site was positive for *Pristionchus* and was located in a 20-year apple orchard at Darima, (79^{0}38’2.321” E, 29^{0}27’49.583” N, 1781 m AMSL)

4.7.1.2 Morphology, molecular identification and phylogenetic analysis

Morphological characterization of isolated nematode showed the typical features of the Diplogastridae family and conspecific to

Pristionchus pacificus. In order to assure the morphological based identification of *P. pacificus*, the molecular characterization technique taken under investigation. BLAST search of DNA sequence displayed significant similarity of 99.32% identity with *P. pacificus* (KY914570.1) with 100% query cover and 0.0 E-value. The Blast of D2-D3 sequenced displayed 92.79% identity with 98% query cover and 0.0 E-value to *Pristionchus pacificus* (KY914570.1). The identified isolate is designated as *P. pacificus* VLPP01 (Vivekananda Lab *Pristionchus pacificus* 01). Molecular phylogeny based on rDNA cistron 18S SSU was estimated using a combination Maximum likelihood (ML) statistical method (Fig. 4.12 & 4.13). Maximum likelihood analysis placed the isolate of *P. pacificus* independently with a single branch at the bottom of clade 1. 28 LSU sequence searches in BLASTn showed the highest similarity to *P. pacificus* (KY914570.1) with 96.86%. Twenty-eight LSU gene-based phylogeny supported the identity and indicated the isolated nematode belongs to *Pristionchus* genera and has an independent origin but shares a common ancestor with other known isolates. Evolutionary descent of different *Pristionchus* spp. indicated the isolated nematode is related to other isolates of *P. pacificus.* The obtained sequence of forward and reverse rDNA cistrons were deposited at the NCBI GenBank database under accession codes MZ506757 (874 bp), MZ506758 (874 bp), MZ853186 (667 bp) and MZ853185 (667 bp).

4.1.7.3 Test of reproduction potential of *Pristionchus pacificus* on different insect hosts

P. pacificus were inoculated on *Corcyra*, *Holotrichia* and *Spodoptera* which demonstrated the reproduction potential of these three hosts. Emergence periods from different insect hosts and post mortality (days) were evaluated using different insect hosts. *P. pacificus* took the lowest duration in completion of life cycle and emergence on *Corcyra* larvae, however, insect host *Holotrichia* required the highest duration from mortality to the emergence of nematodes (Fig.4.14). The emergence of nematodes from the larval body of *Corcyra*, *Spodoptera* and *Holotrichia* started from the 6^{th,} 7th and 9th days and continued to the 15th, 16th, and 29th days, respectively. The frequency of *P. pacificus* emerged from different insect host were found significantly higher for *Holotrichia* followed by *Spodoptera* and *Corcyra* larvae (Fig. 4.15).

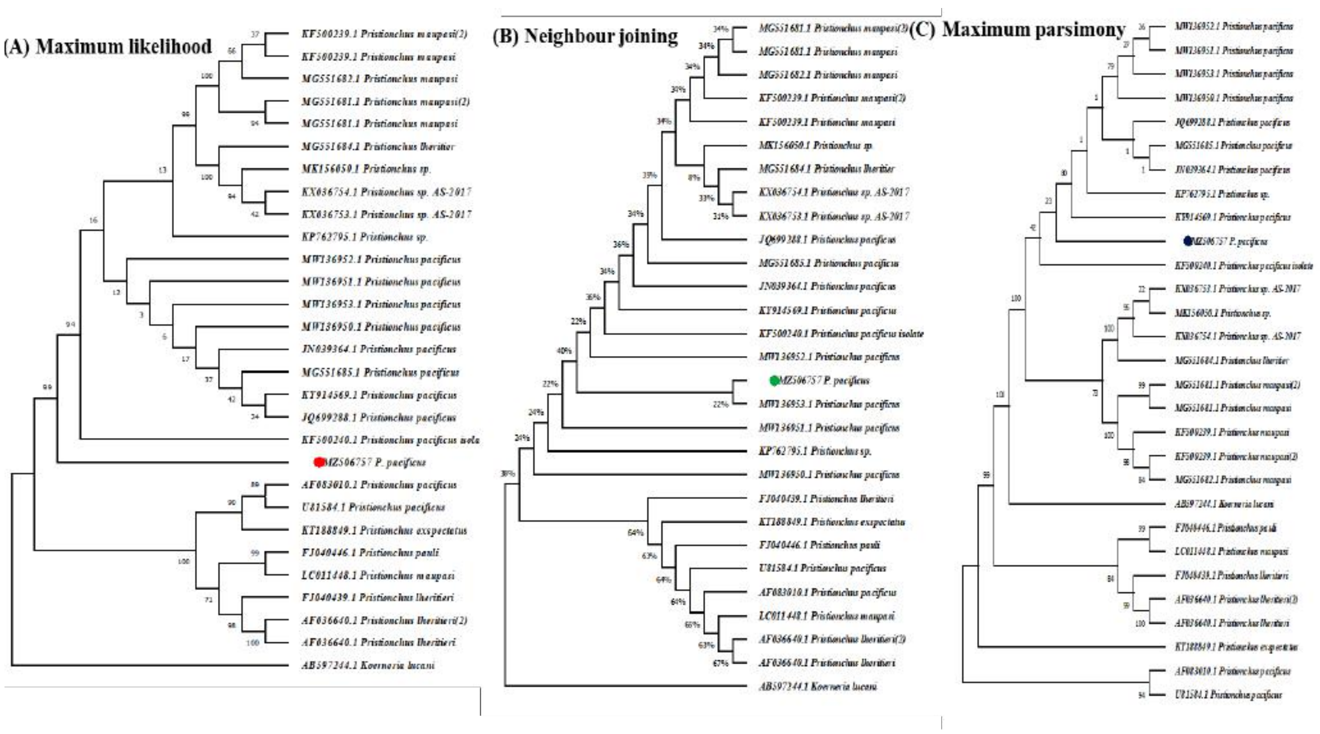


Fig. 4.12. Phylogenetic tree based on 18S SSU gene sequence indicating the position of *P. pacificus* isolates in comparison to similar isolates based phylogenetic relationship. AB597244.1 (*Koerneria lucani*) were chosen as outgroup and bootstrap value 2000 (A) Maximum Likelihood (B) Neighbour Joining (C) Maximum Parsimony

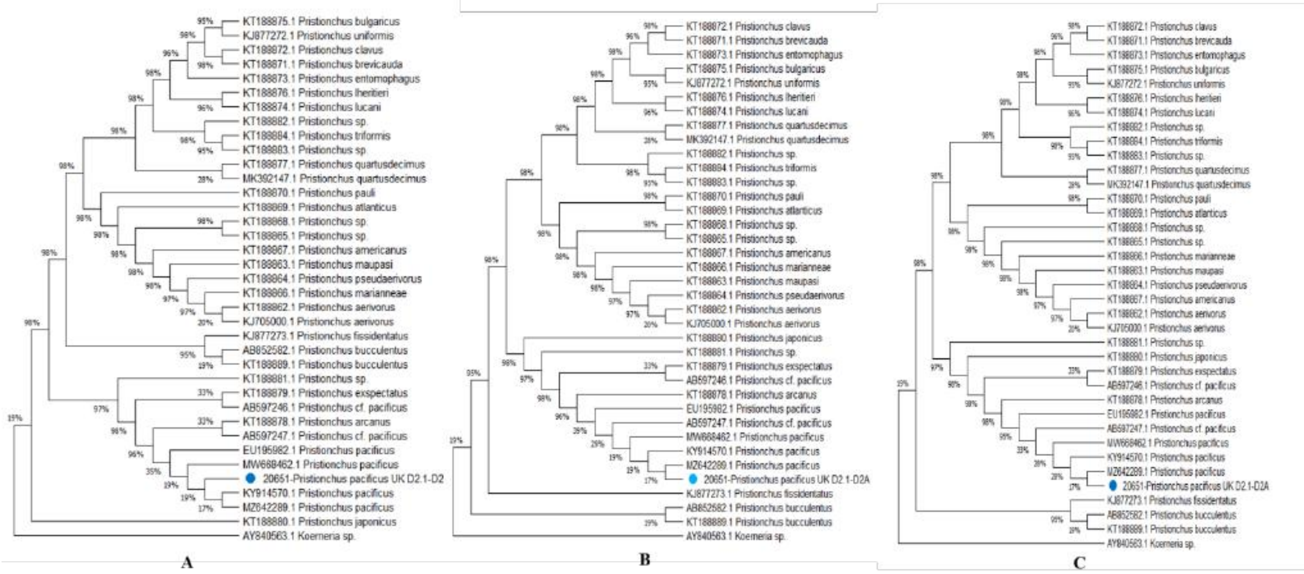


Fig. 4.13. Phylogenetic tree based on D2-D3 region LSU of the 28S rRNA gene sequence indicating the position of *P. pacificus* isolates in comparison to similar isolates based phylogenetic relationship. AB597244.1 (*Koerneria lucani*) was chosen as the outgroup. (A) Maximum likelihood (B) Neighbour joining (C) Maximum parsimony.

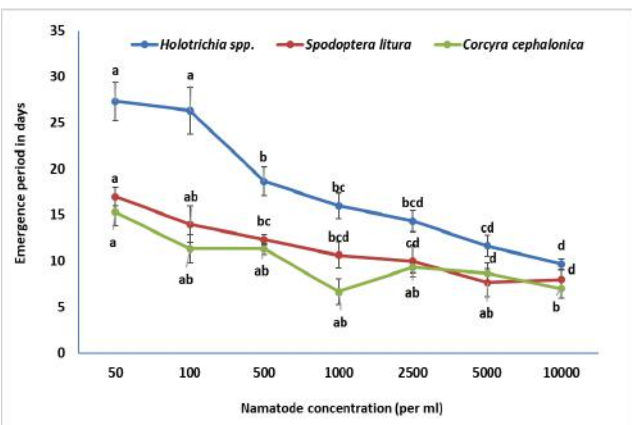


Fig 4.14. Emergence period of *P. pacificus*

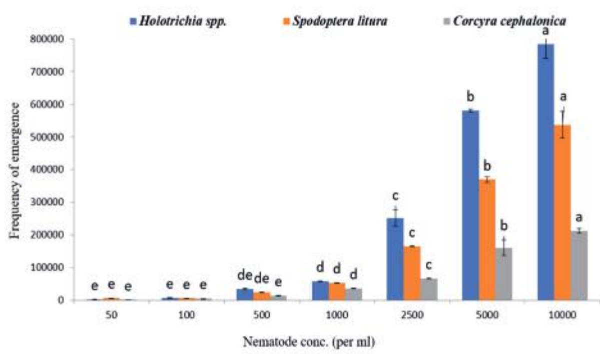
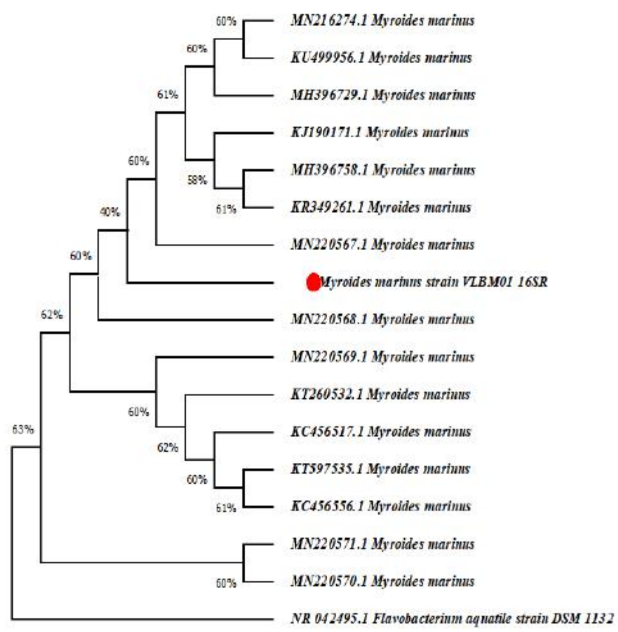


Fig 4.15. Frequency of *P. pacificus*

4.1.7.4 Isolation, identification and phylogenetic analysis of associated bacteria

The molecular diagnostics of associated bacteria based on the 16S rRNA gene displayed the highest homology with *Myroides marinus* strain GN-5 MN220571.1 (98.28%) belonging to the family Flavobacteriaceae. Forward and reverse sequences *Myroides marinus* strain VLBM01 submitted to GenBank with accession ID OK402026 and OK405021. Maximum likelihood-based phylogenetic tree of the *Myroides marinus* strains was depicted in Fig. 4.16. The isolated strain showed close similarity to *Myroides marinus* strains.



Fig, 4.16. Phylogenetic tree of *Myroides marinus* strain VLBM01 based on 16S rRNA gene indicating the position of *Myroides marinus* strain VLBM01 with other similar strains. *NR_042495.1 Flavobacterium aquatile strain DSM 1132* was taken as an outgroup. Bootstrap value 2000 replicates

4.7.2 Indigenous entomopathogenic nematode (*Heterorhabditids indica* VLEPN01) to combat insect pests

4.7.2.1 Survey and collection of soil samples

Soil samples were collected from different locations of Experimental farm, Hawalbagh and Almora district. Soil samples were baited with *Corcyra cephalonica* and observed regularly for their mortality. From dead insects, EPNs were extracted using the white trap method.

4.7.2.2 Morphological, morphometrical and molecular characterization

Based on morphological and morphometrical studies, *Heterorhabditids* sp. VLEPN01 showed a resemblance with *Heterorhabditids indica.* Further identity was confirmed with molecular characterization using 28S (D2-D3 region), ITS and COXI gene sequences. The sequence of this native EPN isolate revealed 99.87% similarity with *H. indica* isolate from Mizoram, North-eastern India (MF618314). The phylogenetic study indicated the relatedness of *Heterorhabditids indica* with other species of the same group (Fig 4.17).

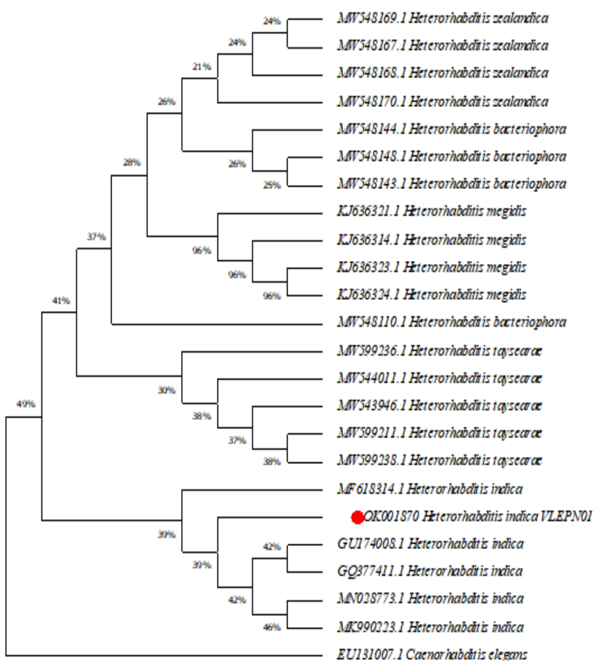
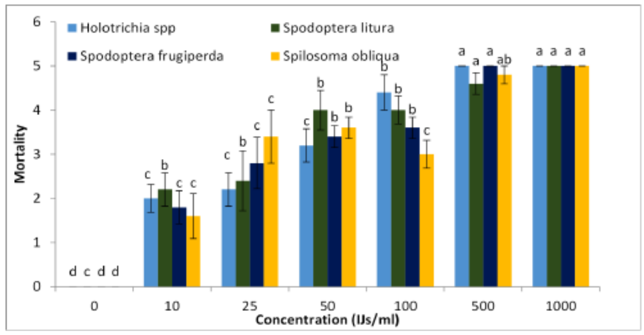


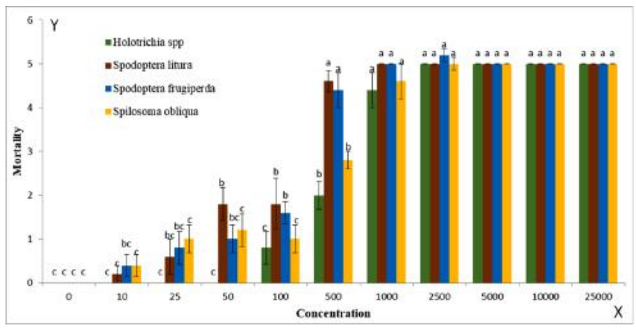
Fig. 4.17. Maximum likelihood phylogenetic tree based on 18S SSU gene sequence in MEGA V. 10 program

4.7.2.3 Bioassay

Furthermore, the efficacy of EPNs was evaluated against major insect pests of the North-western Himalayan region. The results showed that *H. indica* VLEPN01capable to cause 100% mortality in early instars of fall armyworm (*Spodoptera frugiperda*), white grub (*Holotrichia* spp.) and tobacco caterpillar (*Spodoptera litura)* under laboratory condition (Fig. 4.18). Hence, *H. indica* VLEPN01can be used for the management of insect pests.



(a)



(b)

Fig. 4.18 Bioassay for the larvicidal activity of EPNs performed by spraying larval suspension (a) and oral feeding (b)

4.7.3. Morphological and molecular characterization of rice root-knot nematode, *Meloidogyne graminicola*

The population of *M. graminicola* from the rice grown areas of the Almora district were characterized *via* morphology (based on J2, J3, J4 and adult) and molecular analysis using internal transcribed spacer (ITS) rDNA genes. Optimized PCR amplification process of *M. graminicola* DNA using ITS primers F 5'-TTGATTACGTCCCTGCCCTTT-3' and R 5'-TTTCACTCGCCGTTACTAAGG-3' under thermocycler programme. Furthermore morphological, molecular and phylogenetic studies confirmed the species as *M. graminicola*. The ITS sequence has been successfully deposited in the GenBank (NCBI) under the respective accession codes *Meloidogyne graminicola* (SUB7390067) (Fig. 4.19).

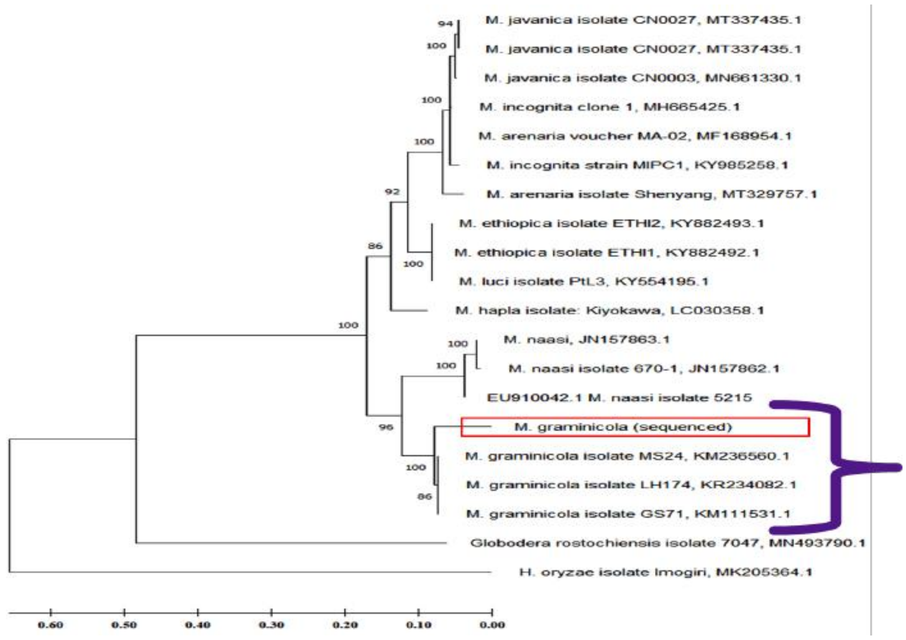


Fig. 4.19. Phylogenetic analysis of *M. graminicola* based on internal transcribed spacer (ITS) rDNA sequences.

4.7.4 Occurrence of root-knot nematode in vegetable crops

The distribution and characterization of root-knot nematodes collected from different vegetable crops (Okra, chilli, tomato, coriander, cucurbits and tomato) were investigated. The surveys were conducted in Bagheshwar, Almora and Nainital districts. The affected plant and roots were collected from vegetable growing areas. The adult female, egg masses, and juveniles were isolated from infected roots showing knots. These stages were characterized morphologically based on perennial pattern and molecularly using ITS-rDNA markers. The obtained results confirmed the identity of the isolated nematode as *M. incognita*. The obtained sequence was subjected to a phylogenetic study which indicated the relationship with other known *M. incognita* groups (Fig 4.20).

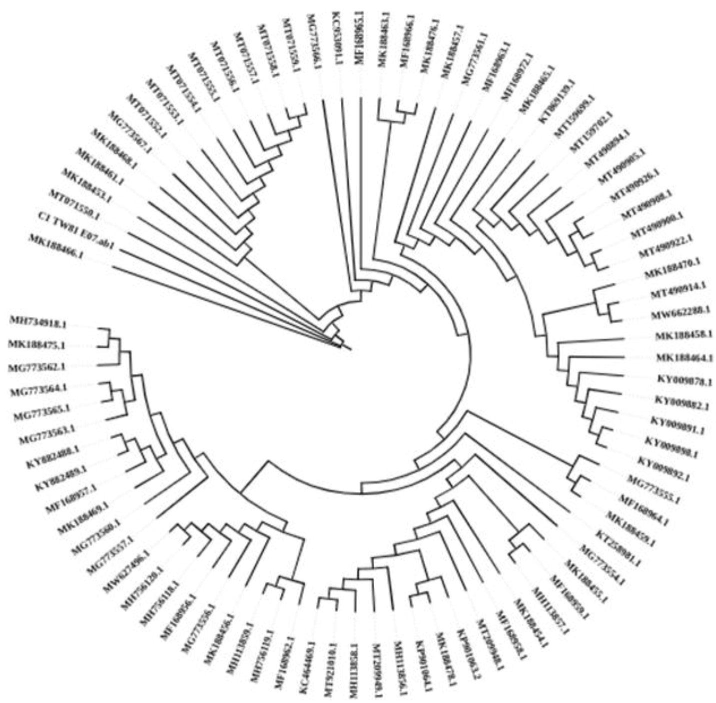


Fig. 4.20 Phylogenetic analysis of *M. incognita* based on rDNA ITS region

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

Research Projects

- Technological Interventions for Mitigating Drudgery and Improving Nutritional Status of Hill Farm Women *[Drs. Kushagra Joshi and Renu Jethi]*
- Impact Assessment of Improved Agricultural Technology in Hill Agriculture *[Drs. Renu Jethi, Kushagra Joshi & BM Pandey (Associated)]*

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

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

5.1 Technological interventions for mitigating drudgery and improving nutritional status of hill farm women

5.1.1 Strategy for promoting good occupational health of women farmers

A quasi-experimental study on promoting good occupational health including ergonomic health, safety and nutrition was taken for three consecutive years. Homestead nutrition gardening kits coupled with seasonal calendar for sowing and harvesting of vegetables as an educational tool was provided to women farmers of two villages *i.e.* Kotyura of Takula block and Daal of Hawalbag block. Kotyura farm women also received IEC (Information-Education-Communication) strategy on good ergonomic and nutrition practices as full intervertion. The women of Patiya village were kept as a control group. Demonstrations of improved tools and work simplification techniques were provided to women along with knowledge of good nutritional practices and work simplification techniques. Through a WhatsApp group, the information to farm women under a series "*Swasth Kisan, Unnat Kisan*" was provided in a timely manner on good nutrition, balanced diets, good posture during work, safe lifting techniques, seasonal calendar of vegetables, layout of home garden etc. Regular messages through WhatsApp and trainings through women farm school were provided to increase women farmers' engagement and facilitate behavior change.

5.1.2 Effectiveness of strategy on KAP (Knowledge, Attitude and Practise) levels of farm women

Tracking the same households over a period of three years, three rounds of survey data in analysis were used, which were collected before the intervention, one year after the intervention, and a follow-up after the intervention. In a repeated-measures analysis of variance, the effects of interest were between-subject effects such as Group and within-subject effects such as Time (Table 5.1.1).

Table 5.1.1 Mean KAP (Knowledge, attitude, practice) scores for intervention group and control group during pre, post and follow up test

Measures	Groups	Mean	SD
Pre test Scores	Control (Patiya)	6.38	1.628
	Partial (Daal)	6.19	0.981
	Full (Kotyura)	6.44	1.548
	Total	6.33	1.389
Post test Scores	Control (Patiya)	6.63	1.408
	Partial (Daal)	6.94	1.289
	Full (Kotyura)	8.75	1.125
	Total	7.44	1.570
Follow up Scores	Control (Patiya)	6.50	1.155
	Partial (Daal)	6.56	0.814
	Full (Kotyura)	8.06	1.806
	Total	7.04	1.487

A repeated-measures ANOVA (Table 5.1.2) determined that mean KAP scores differed significantly across three time points ($F (2,90) = 15.154$, $p = .000$). It is evident that a statistical difference exists in mean scores over time.

Table 5.1.2 Difference in KAP (Knowledge, attitude, practice) scores of women on good nutrition and ergonomic practices across time (Pre, Post and Follow up)-ANOVA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Time	30.042	2	15.021	15.154	.000*

A post-hoc pairwise comparison using the Bonferroni correction showed an increased KAP score between the control and full intervention group and partial and full intervention group statistically significant (Table 5.1.3). Therefore, it can be concluded that the mean KAP (knowledge, attitude and practice) scores were highest for the full intervention group. No significant difference was

Table 5.1.3 Pairwise comparison of KAP scores of women on good nutrition and ergonomic practices across groups

Group (I)	Group (J)	Mean Difference (I-J)	p-value
Control (Daal)	Partial (Patiya)	-.063	1.000
	Full (Kotyura)	-1.250*	.005
Partial (Patiya)	Control (Daal)	.063	1.000
	Full (Kotyura)	-1.187*	.009
Full (Kotyura)	Control (Daal)	1.250*	.005
	Partial (Patiya)	1.187*	.009

* Significant at 95% confidence level

observed between KAP scores of women of partial intervention (nutrition garden only) and the control group.

5.1.3 Effectiveness of strategy on dietary diversity of farm women

The mean scores of dietary diversity of farm women across the groups *i.e.* during pre-test, post-test and follow-up in control, full intervention and partial intervention group are depicted in Table 5.1.4.

Table 5.1.4 Mean dietary diversity Scores (DDS) for intervention group and control group during pre-post and follow up

Measures	Group	Mean	SD
Pre-test	Control (Patiya)	3.56	1.153
	Partial (Daal)	3.88	1.025
	Full (Kotyura)	3.69	1.014
	Total	3.71	1.051
Post Test	Control (Patiya)	5.00	1.155
	Partial (Daal)	5.50	1.366
	Full (Kotyura)	6.13	1.025
	Total	5.54	1.254
Follow up	Control (Patiya)	4.75	1.065
	Partial (Daal)	5.44	.892
	Full (Kotyura)	6.00	1.317
	Total	5.40	1.198

A repeated-measures ANOVA (Table 5.1.5) determined that mean dietary diversity scores differed significantly across three time points {F (2, 90) = 55.35, p = .000}

Table 5.1.5 Difference in DDS scores of women across time (Pre, Post and Follow up)-ANOVA

Source		Type III Sum of Squares	df	Mean Square	F	p-value
Time	Sphericity Assumed	99.681	2	49.84	55.350	.000*

The pre-test and post test scores (after a year and half) and pre-test (baseline) and post-test (follow up) for dietary diversity scores significantly varied. However, no significant difference was observed for scores between the post-test and follow-up. (Table 5.1.6).

Table 5.1.6 Comparisons between the mean DDS for Control, Partial and Full intervention groups over time

Measure: DDS (Dietary Diversity Scores) of women			
(I) Time	(J)	Mean Difference (I-J)	p-value
Pre test	Post Test	-1.833*	.000
	Follow up	-1.687*	.000
Post test	Pre test	1.833*	.000
	Follow up	.146	1.000
Follow up	Pre test	1.687*	.000
	Post test	-.146	1.000

* Significant at 95% confidence level

The post-hoc analysis (Table 5.1.7) showed that there was a significant increase in dietary diversity scores across groups because of womens' participation in the intervention. Difference was observed significant between dietary diversity scores of control group and full intervention group only indicating that nutrition gardening coupled with IEC (reinforcing messages) only was able to bring the changes. A short, targeted educational programme supplemented with nutrition gardening is effective for improving dietary diversity among rural households.

Table 5.1.7 Comparisons between the mean DDS (dietary diversity scores) for Control, Partial and Full intervention groups

(I) Group (J) Group		Mean Difference (I-J)	p-value
Control	Partial	-.50	.264
	Full	-.83*	.017
Partial intervention	Control	.50	.264
	Full	-.33	.753
Full intervention	Control	.83*	.017
	Partial	.33	.753

* Significant at 95% confidence level

5.1.4 Feasibility testing of three row paddy transplanter with farm women for its adoption

Demonstration of three row paddy transplanter was done in Binta village and data from 41 women farmers was collected on their perception towards the introduced transplanter as a measure of willingness to adopt the technology. The responses of farmers were recorded in a five-point likert scale and the perceived feasibility index (PFI) was calculated as below:

$$PFI = \frac{Score\ acheived}{Score\ acheivable} \times 100$$

Attributewise, highest score was recorded for Compatibility (22.56), Relative advantage (22.2), Triability (22.2) and lower scores for Complexity (19.15) and Observability (16.22) (Fig 5.1.1).

5.1.5 Factors determining perception of farmers towards the paddy transplanter

Personal variables including age, education, farming experience, farming characteristics like farm land size, active labour force, yield; and institutional characteristics like receiving agricultural information, membership in farmers' group were selected as factors determining farmers' perception

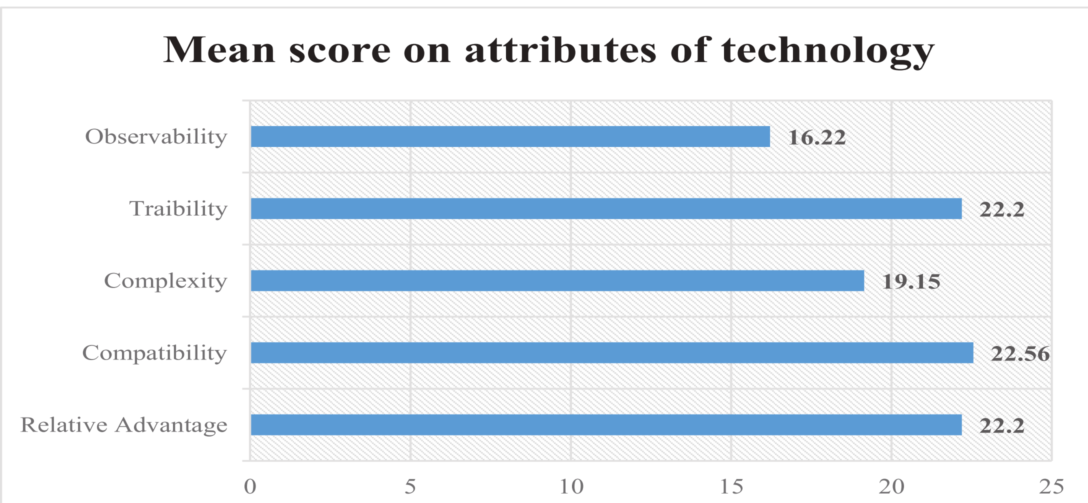


Fig 5.1.1 Farmer's mean score on attributes of technology *i.e.* paddy transplanter

Demonstration of paddy transplanter to farmers/farm women

Table 5.1.8 Relationship between socio-personal profile of farmers with perception towards the transplanter

	Unstandardized Coefficients		Standardized Coefficients	t-value	p-value	95.0% Confidence Interval for B		Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
(Constant)	95.698	9.474		10.102	.000	76.401	114.995		
Age*	-.855	.218	-.772	-3.924	.000	-1.298	-.411	.117	8.543
Yield	-.024	.103	-.017	-.235	.816	-.235	.186	.864	1.157
Land size*	.370	.138	.205	2.684	.011	.089	.651	.773	1.294
Education	1.562	1.318	.137	1.185	.245	-1.123	4.247	.337	2.971
Farm experience	.148	.222	.113	.665	.511	-.305	.600	.158	6.342
Family Help *	-1.390	.661	.302	2.102	.043	.043	2.736	.219	4.558
Extension contact	1.292	2.055	.065	.629	.534	-2.894	5.479	.426	2.350
Group Membership*	9.233	3.296	.463	2.801	.009	2.520	15.947	.166	6.042

R^2 (adjusted)= 0.819, p value=0.00

towards the paddy transplanter. The regression analyses for identifying the factors detrimental to farmer's perception towards the transplanter was introduced (Table 5.1.8). It showed positive and significant relationship between landholding size, group membership and negatively significant relationship was found between the perception towards the transplanter and number of family members to help in transplanting activity.

5.2 Impact assessment of improved agricultural technology in hill agriculture

Participatory on-farm evaluation and demonstration of improved agricultural technology (improved variety and line sowing with recommended plant spacing) was done and its effect on productivity, farmers' preferences for crop variety traits and for line sowing was studied.

Crop	Area selected for demonstrations	Treatments
Finger Millet (VL *Mandua* 376, VL *Mandua* 379 and VL *Mandua* 380 / Local farmers variety)	Two villages in high hills	• T_I = Improved variety + line sowing • T_{II} = Improved variety + farmers' practice (Broadcasting) • T_{III} = Farmers' variety + farmers' practice (Broadcasting)
Finger Millet (VL *Mandua* 376 and VL *Mandua* 379 / Local farmers variety)	One village in low hills	


Demonstration of Improved Finger Millet Varieties at Farmer's Field

5.2.1 Farmers' evaluation criteria and preference ranking (Finger Millet)

VL *Mandua* 376, VL *Mandua* 379 and VL *Mandua* 380 were demonstrated in 2 ha area in high hills during *kharif* 2020 with 40 farmers. An equal number of farmers performed line sowing and broadcasting as a method of sowing. Qualitative and quantitative data were collected employing checklist and Focused Group Discussion (FGD). Tally method was used in which the first, second, third, fourth, fifth and sixth ranking has weighted values of six, five, four, three, two and one, respectively and a weighted ranking matrix table was constructed. Scores provided by farmers were multiplied with the respective weights.

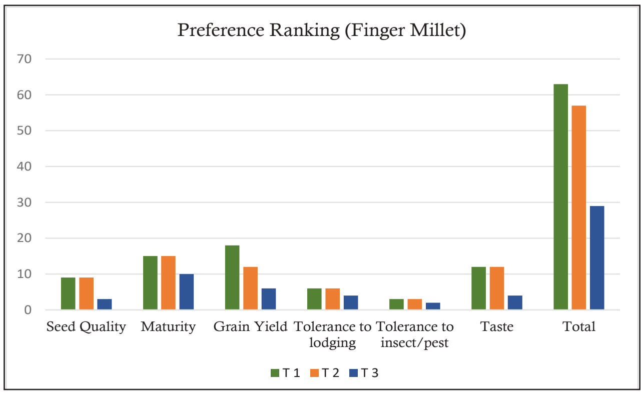


Fig 5.2.1 Farmer's evaluation criteria and preference ranking (Finger Millet)

Based on the overall preference criteria, treatment I (improved variety along with line sowing was preferred by farmers with total score of 63 followed by treatment II with score 57 (Fig 5.2.1). Treatment II with score 78 was preferred when criteria of farmers' convenience were also considered followed by treatment I with score 70 (Fig 5.2.2).

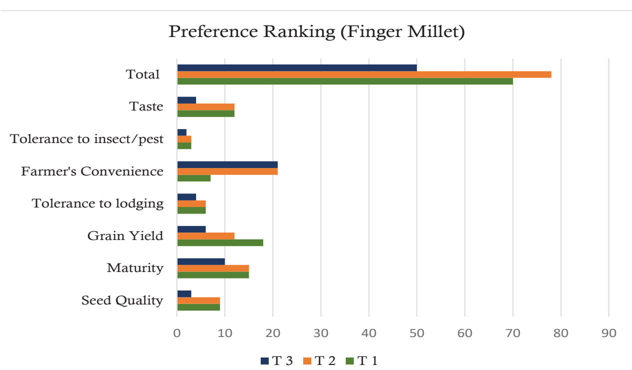


Fig 5.2.2 Farmer's evaluation criteria and preference ranking with farmer's convenience

5.2.2 Yield Gap analysis

Yield analysis of VL *mandua* 376 showed that the variety gap was 750 $kgha^{-1}$ and the technology gap was 243 $kgha^{-1}$. Yield analysis of VL *Mandua* 379 showed that the variety gap was 733 $kgha^{-1}$ and the technology gap was 187 $kgha^{-1}$. Demonstration yields of VL *Mandua* 376 under T I and T II were 2,043 $kgha^{-1}$ and 1,800 $kgha^{-1}$ which was 94.6 % and 71.4 % higher than farmers' practice (T III), respectively. Demonstration yields of VL *Mandua* 379 under T I and T II was 1,970 $kgha^{-1}$ and 1,783 $kgha^{-1}$ which was 87.6 and 69.8 % higher than farmers' practice (T III), respectively.

5.2.3 Analysis of factors constraining farmers' adoption of improved sowing method in finger millet

An effort was made to identify important factors constraining farmers' adoption of improved sowing method (Line sowing) in finger millet through focused group discussions. On the basis of FGD, six important constraints were identified. Individual level survey was then conducted to rank these constraints.

$$Rank\ Based\ Quotient = \frac{\Sigma fi\ (n + 1 - i)}{N \times n} \times 100$$

Where, fi = frequency of farmers for i^{th} rank of the constraints,

N = Number of farmers,

n = Number of constraints identified,

i = concerned ranks

Traditional practice of mixed cropping in finger millet (RBQ 89.3) was the most important factor that constraints the adoption of line sowing

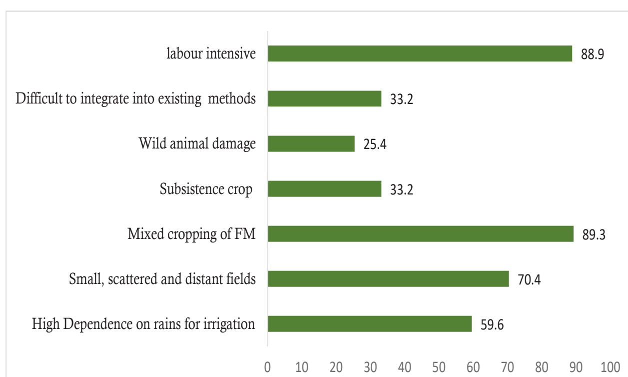


Fig 5.2.3 Constraint analysis of factors constraining farmer's adoption of improved sowing method in finger millet

in finger millet crop. It was followed by the factors like line sowing, regarded as labour intensive (RBQ 88.9), small, scattered and distant finger millet fields (RBQ 70.4), dependence on rains for irrigation (RBQ 59.6), subsistence crop with less remunerative prices and difficult to integrate with existing land preparation methods (RBQ 33.2), and crop damage by wild animals (RBQ 25.4) (Fig. 5.2.3)

5.2.4 Farmers' evaluation criteria and preference ranking (Wheat)

A study was conducted to assess the preference of farmers for improved wheat varieties introduced and demonstrated. Seeds of improved wheat varieties VL *Gehun* 907, VL *Gehun* 953, VL *Gehun* 967 and VL *Gehun* 2014 were demonstrated in farmer's field. A total of 30 farmers were selected for the purpose of assessing farmers' preference for wheat varieties in village Lakhani of district Bageshwar.

Crop	Area selected for demonstrations	Treatments
Wheat (VL *Gehun* 907, VL *Gehun* 953, VL *Gehun* 967 and VL *Gehun* 2014)	Mid Hills	• T_I = Improved variety + line sowing • T_{II} = Improved variety + farmers' practice (Broadcasting) • T_{III} = Farmers' Variety + farmers' practice (Broadcasting)
Wheat (VL *Gehun* 892, VL *Gehun* 3004 and VL *Gehun* 953)	High Hills	

Seventeen major traits were presented for assessing the farmers' preferences. The weighted score for each identified trait was worked out based on the scoring given by farmers through focused group discussions. Weighted score for each identified trait was worked out using the rating given by the selected ten farmers on a scale of 1-10 based on their perceived significance of those quality parameters. The preference of the farmers was measured by using the Wheat Preference Index (WPI). To calculate WPI, the farmers were asked to score the wheat varieties for various traits using 1-5 scale.

$$WPI = \frac{\sum_{k=1}^{m}\sum_{j=1}^{6}\sum_{i=1}^{n} W ijXijk}{\sum_{k=1}^{m}}$$

Where WPI = Wheat Preference Index,

Wij = weight of the j[th] characteristic of the i[th] wheat variety,

Xijk = farmers' preference score assigned towards j[th] characteristics of i[th] wheat variety by k[th] farmer,

i = wheat variety ranging from 1 to n,

j = characteristics of wheat variety ranging from 1 to 6,

k = number of respondent farmers ranging from 1 to m.

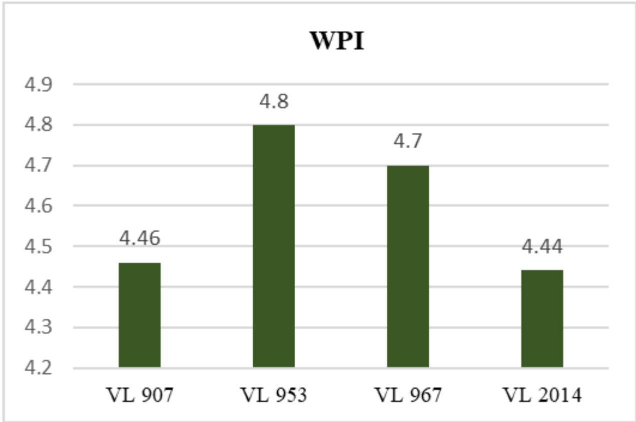


Fig 5.2.4 (a) Wheat Preference Index for Improved Varieties in mid hills

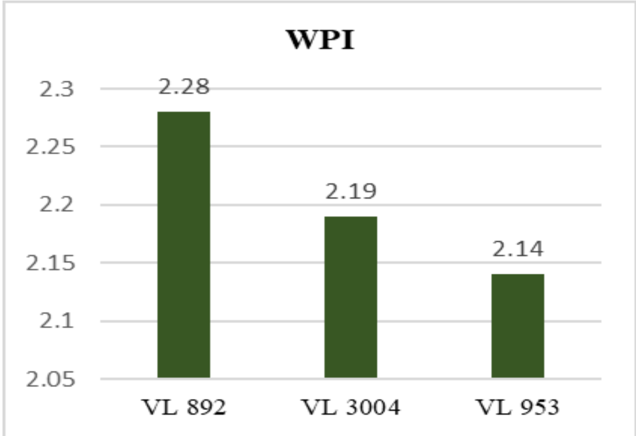


Fig 5.2.4 (b) Wheat Preference Index for Improved Varieties in high hills

The individual weightage of the selected traits showed that yield had the highest weightage (0.091) followed by timely maturity (0.085) and drought resistance (0.082). The Wheat Preference Index (WPI) for VL *Gehun* 907, VL *Gehun* 953, VL *Gehun* 967 and VL *Gehun* 2014 was found to be 4.46, 4.80, 4.7, 4.44, respectively {(Fig. 5.2.4 (a)}. The WPI of variety VL *Gehun* 953 (4.80) ranked first and was followed by VL *Gehun* 967 (4.79). Farmers preferred VL *Gehun* 953 and VL *Gehun* 967 mainly for its yield and timely maturity.

Improved late wheat varieties of VL *Gehun* 892 and VL *Gehun* 3004 were demonstrated in high hills of Berinaag block of Pithoragarh district during *rabi* 2020-21. The WPI for VL *Gehun* 892, VL *Gehun* 3004 and VL *Gehun* 953 was found to be 2.28, 2.19 and 2.14, respectively {(Fig. 5.2.4 (b)}.

5.2.5 Economic analysis of different method of sowing in wheat crop

The profitability analysis exhibited that treatment I (improved variety with line sowing) was more profitable with benefit-cost ratio of 2.49 followed by treatment II (improved variety with broadcasting) and treatment III (local variety with broadcasting) with B:C ratio 2.21 and 1.85, respectively (Table 5.2.1).

Table 5.2.1 Economic analysis of sowing methods in wheat crop

	Improved variety (Line sowing)	Improved variety (Broadcasting)	Local variety (Broadcasting)
Cost of Production	22975	20500	18150
Gross Return	57275	45425	33575
B:C Ratio	2.49	2.21	1.85

6. Other Research Projects

6.1 ICAR-NASF Funded Project

- Utilization and Refinement of Haploid/Doubled haploid Induction Systems in Rice, Wheat and Maize using In-Vitro and Molecular Strategies *[Drs. R.K. Khulbe & A. Pattanayak]*

6.2 Consortium Research Platform (CRP) Projects

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

6.3. UN Environment - GEF Project

- Mainstreaming Agricultural Biodiversity Conservation and Utilization in Agricultural Sector to Ensure Ecosystem Services and Reduce Vulnerability *[Drs. A. Bhartiya, Kushagra Joshi & Jitendra Kumar]*

6.4. PVP & DUS Test Through ICAR-SAU System

- DUS/GOT trials in kidney bean *[Dr. Anuradha Bhartiya]*

6.5. DBT Funded Project

- Integrated Genomic Strategy for accelerating domestication of Ricebean (*Vigna umbellata*) under genetic enhancement of minor pulse *[Dr. D C Joshi]*
- Collection and Characterization of Indigenous Shiitake (*Lentinula edodes)* and DNA Barcoding of Oyster *(Pleurotus* spp.*)* Mushroom Germplasm for Commercial Exploitation *[Dr K. K. Mishra]*
- Popularization of Biofortified Maize Hybrids in Himalayan States with Special Reference to the North Eastern Region for Nutritional Security [*Drs. R.K. Khulbe & Devender Sharma*]

6.6. AICRP/ Network Projects

- Use of Plastics in Agriculture Particularly in Protected Cultivation, Water Harvesting and Packaging (AICRP on PEASEM) *[Drs. Jitendra Kumar, Sher Singh (upto 28.10.2021), Shyam Nath and Er. Utkarsh Kumar (on study leave)]*
- Post Harvest Technology for Value Addition and Marketing of Agricultural Produce (AICRP on PHET) *[Drs. Shyam Nath (PI), Dr. Sher Singh (upto 28.10.2021), Dr. Kushagra Joshi, Er. Jitendra Kumar & Dr. J.K. Bisht (Associated Scientist)]*
- All India Network Project on Soil Arthropod Pests *[Mr. Amit Umesh Paschapur]*
- Monitoring Pesticide Residues at National Level (under AINP on Pesticide Residue Analysis) *[Mr. Amit Umesh Paschapur]*

- All India Coordinated Research Project on Mushroom *[Dr. K. K. Mishra]*
- Network Programme on Organic Farming (NPOF) *[Drs. Amit Kumar (PI, w.e.f. 10.02.2021), P.K. Mishra, K.K. Mishra, Amit Umesh Paschapur, Manoj Parihar & Priyanka Khati]*
- 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 (on deputation)]*

6.7. NICRA Project under Competitive Grants Component (CGS)

- Design & Development of Protective Structures for High Values Crops to Reduce Damage from Hail and Frost *[Dr. Sher Singh (PI, upto 28.10.2021)]*

6.8. National Mission on Himalayan Studies (NMHS) Project

- Characterization of Kidney Bean (Rajmash) Rhizosphere Microbiome from Higher Altitude of Indian Central Himalaya *[Dr. Pankaj K. Mishra]*

6.9. ICSSR Funded Project

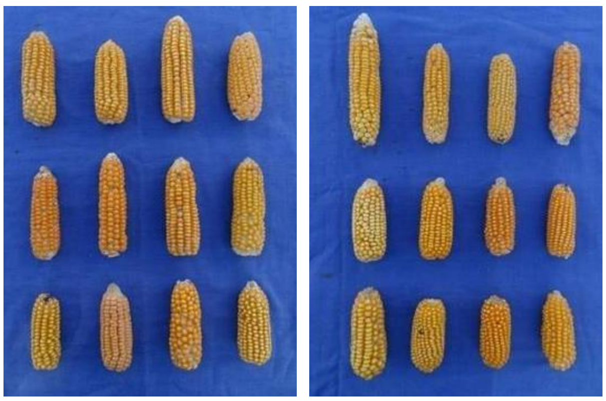
- Gender Dynamics in Agriculture Information Usage in Hills of North-Western and North-Eastern Himalayan region of India *[Dr. Kushagra Joshi]*

6.1. ICAR-NASF Funded Project

6.1.1 Utilization and Refinement of Haploid/ Doubled haploid Induction Systems in Rice, Wheat and Maize using *in vitro* and Molecular Strategies

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

During *kharif* 2021, 263 DH lines (High Tryptophan, High Provit A, and High Tryptophan + High Provit A) were raised and about 33 DH lines with good agronomic attributes were identified. These DH lines will be evaluated for tryptophan and Provit A content for use in the hybrid development programme for the development of biofortified maize hybrids.



Ears of promising high tryptophan+high provitaminA DH lines derived from MQA x PVQPM9I (left) and MQB x PVQPM9I (right)

Three new source populations for the production of triple-trait DH lines (High Tryptophan + High ProvitA + Low phytate) have been generated during *kharif* 2021 for DH generation during *kharif* 2022.

Up-scaling of maize DH programme

More than 900 doubled haploid lines of normal corn, sweet corn, and biofortified maize (QPM/high Provitamin A/low phytate) generated during *kharif* 2020 were raised during *kharif* 2021 for evaluation and identification of promising DH lines. Selfed seed was harvested from about 600 diploidized haploid plants obtained from induction crosses generated during *kharif* 2019 which are expected to yield 500-550 new DH lines during *kharif* 2022. Six new induction crosses involving normal corn, sweet corn, and biofortified inbreds have been generated during *kharif* 2021 for production of new DH lines during *kharif* 2022.

6.1.2 Development/identification of Genetic Resources

Prolific DH lines with maintainer gene(s) for developing male sterile baby corn hybrids

Prolificacy and male sterility are desirable traits in baby corn as it considerably reduces seed production and crop cultivation cost, besides improving the quality of the baby corn harvest. Development of male sterile baby corn hybrids involves the generation of A-line (male sterile line to serve as the female parent in F_1s), B-line (fertile version of A-line for maintenance of A-line) pair(s), followed by developing hybrid combinations between the A-line and other promising lines carrying maintainer gene(s) as the male parent (C-line). Identification of promising lines with maintainer gene(s) and the development of A-B pairs is a time and resource-intensive exercise.

Another potential approach for swifter redistribution of maintainer gene (s) in diverse genetic backgrounds is the doubled haploid (DH) technology, and the lines so derived can be used for developing A-B pairs or used directly as C-lines. Following this approach, DH lines were derived from a popular baby corn hybrid, CMVL Baby Corn 2, which is heterozygous

Fig. 6.1.1. Prolific DH lines with maintainer gene(s): VMH27DH 35, VMH27DH 63, VMH27DH 140 and VMH27DH 153

Table 6.1.1. Key characteristics of prolific DH lines with maintainer gene(s)

Characters	VMH27DH 35	VMH27DH 63	VMH27DH 140	VMH27DH 153	Parents of VMH 27	
					V 335	V 345
Days to 50% pollen shed	58	58	61	60	56	58
Days to 50% silking	57	57	62	58	55	59
Plant height (cm)	150	145	140	150	145	160
Ear height (cm)	80	80	75	75	85	75
No. of baby corns per plant	1.75	2.00	2.25	2.00	2.25	1.25
Days to 75% brown husk	93	91	95	94	92	95
Cob length (cm)	13.5	14.8	11.6	12.3	14.5	15.4
Cob girth (cm)	11.2	13.6	9.5	10.0	10.5	12.5
Grains/row	28	33	26	24	32	35
1000 grain weight (g)	185	185	170	175	185	215

for the fertility restorer alleles (Rf/rf). The generated DH lines were evaluated for prolificacy and other important agronomic traits (Fig. 6.1.1 and Table 6.1.1) and promising lines were crossed with a male sterile line (V 335 ms). On the basis of the phenotype of the F1s, the DH lines were classified as (i) fertility restorers (ii) sterility maintainers, and (iii) segregating/unstable.

6.2. Consortium Research Platform (CRP) Projects

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

Development and validation of breeder-friendly markers linked to lpa2 gene

For developing *lpa2* gene based marker, *lpa2* gene was amplified from low phytate donor *lpa2* and two inbred line VQL373 and V407. The amplicons were sequenced using the ABI3130xl sanger sequencer. The three sequences were aligned using the Clustal Omega program. A comparison of the sequences revealed that *lpa2* genotype carries a substitution (A to G) in the coding region of the gene which caused the elimination of HindIII restriction site from the *lpa2* mutant. A pair of primers was designed to amplify the region carrying the HindIII restriction site. After amplification, the amplicon was digested with the HindIII restriction enzyme. It was found to produce polymorphic bands between *lpa2*, VQL373, and V407. The marker was also validated in the segregating population.

Expression analysis of lpa2 gene in different stages of kernel development

The expression of *lpa*2 gene (inositol phosphate kinase) was analyzed during three developmental stages of maize kernel (Blister stage, Dough stage and Physiological maturity stage). Maize cobs were collected in three different stages and frozen in liquid nitrogen immediately. RNA was extracted using a modified trizol method and cDNA was prepared using a Superscript III kit (Invitrogen). cDNA was diluted to 50ng/ul and RT-PCR was performed. Phytate content was also analysed during these developmental stages. It was found that phytic acid content was higher in the dough stage than in the blister stage and physiological maturity stage. Expression values also revealed that enhanced *lpa2* gene (phytic acid biosynthetic gene) expression leads to higher phytic acid content.

Development of new hybrids with low phytate using newly developed inbreds

Twenty-nine low phytate lines were evaluated and maintained during *kharif* 2021 for agronomic traits and phytate content. Fifteen new experimental

Matures cobs of promising low phytate hybrids FLPH 45 and FLPH 49 hybrids were developed using these lines for evaluation during *Kharif* 2022. Eighteen low phytate hybrids were evaluated in station trial during *Kharif* 2021 and two promising low phytate hybrids [FLPH 45 (2.33 mg/g) and FLPH 49 (2.29 mg/g)] were identified for further evaluation and advancement.

6.2.2. ICAR-CRP on Molecular Breeding in Maize

Inrogression of genes governing high tryptophan (QPM), provitamin A, low phytic acid and high amylopectin into elite cultivars using MABB approach

High lysine and tryptophan

Vivek Maize Hybrid 45 (V 373 x V390), a high yielding and 'stay green' single-cross hybrid released and notified in 2013 for J&K, HP and UK, was selected for conversion. CML 173, a high tryptophan CIMMYT line, was used as a donor for introgression of *opaque2* allele and genic SSR marker phi057 was used for selection of the favourable allele. The reconstituted hybrid (FQH 165) was evaluated in State Varietal Trials (SVT) conducted in *Kharif* 2019 and *Kharif* 2020. On the basis of yield parity [FQH 165 (4,342 kg/ha), VMH 45 (4,167 kg/ha)] and higher tryptophan content [FQH 165 (0.70%), VMH 45 (0.55%)] was identified for release in Uttarakhand Hills at *Kharif* SVT workshop held in May 2021.

Low phytate

The target hybrid for developing a low phytate version was Vivek Maize Hybrid 53 (V 407 x V 409). VMH 53 is a high yielding and 'stay green' single-cross hybrid released and notified in 2014 for J&K, HP, UK and NE Hills. Low phytate donor Lpa2 was used as the source for introgression of *lpa2* allele in the parental inbreds and gene-linked SSR marker umc2230 was used for the selection of the favourable allele. FLPH 19 was evaluated in AICRP Maize trials (NHZ) in *Kharif* 2020. On basis of yield parity (7,552 kg/ha) with VMH 53 (8,336 kg/ha) was promoted for evaluation in AVT-II during *Kharif* 2021.

High provitamin A

Promising advance stage hybrid FH 3626 was selected for development of high provitamin A version. High provitamin A lines CIMMYT 4 and CIMMYT 13 were used as donors, respectively, for introgression of crtRB1 allele into V 400 and V 412. Genic marker crtRB1 3′ TE was used for selection of the favourable allele. The reconstituted hybrid FPVH 1 was evaluated in AICRP Maize trials (NHZ) in *Kharif* 2020 and on the basis of yield superiority (7,576 kg/ha) over the check APQH 9 (6,225 kg/ha), it was promoted for evaluation in AVT-II during *Kharif* 2021.

High amylopectin

Single-cross hybrids CMVL 55 (released for NHZ and PZ in 2017) and VLMH 57 (released in 2019 for NHZ) were selected for developing high amylopectin versions. High amylopectin line Pusa Wax 55411 (provided by IARI centre) was used as the donor. Validation of genic marker WX2507 (for *waxy1* gene) was carried out in the recurrent parents {V 433 and V 412 (parental of VLMH 57) and V 405 and 407 (parental inbreds of CMVL 55) and the donor Pusa Wax 55411 (Fig. 6.2.1). BC_1 of recurrent parents of VLMH 57 (V 433 and V 412) and F_1 of recurrent parents of CMVL 55 (V 405 and V 407) with high amylopectin donor Pusa Wax 55411 have been generated.

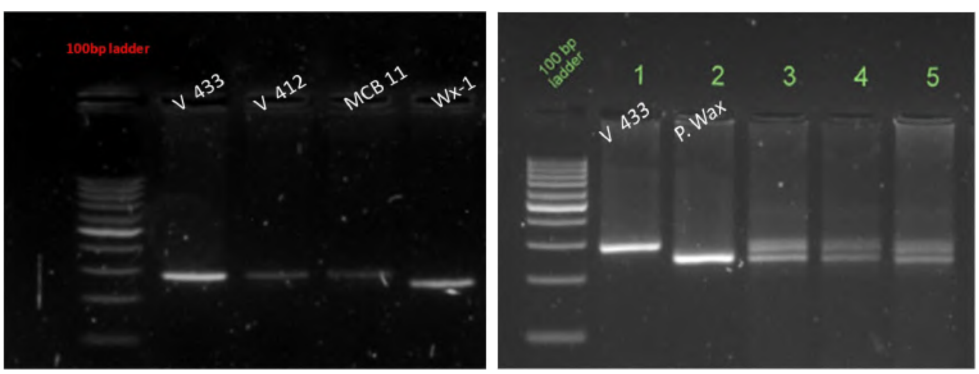


Fig. 6.2.1 (a) Validation of genic marker WX2507 (b) Validation of hybridity in F_1 between recurrent parent V 433 and high amylopectin donor Pusa Wax 55411

Table 6.2.1. Accessions evaluated against loose smut disease

Nursery	Total no. of germplasms evaluated	Total no. of Immune Germplasms	Germplasms showing immune response (0% disease)
Expression	737	152	VL 639, VW 0919, VW 0948, IC 0610815, EC 0595317, IC 0589300, EC 0598077, EC 0598093, EC 0631996, EC 0530169, IC 0078835-A
Confirmation	Set 1 – 78	22	VL 639, VW 0919, VW 0948, IC 0591044, EC 0597830, EC 0597886, EC 0635739, IC 0078836-A, IC 0595233, IC 0538731, EC 0635708, EC 0597885, IC 0599914, IC 0591045, IC 0339627
	Set 2 - 86	59	EC 575981, IC 449061, IC 535217, KRL 210, EC 576159, EC 573974, IC 252954, EC 577050, IC 531524

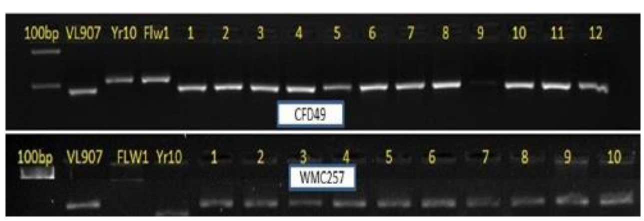
6.2.3. ICAR-CRP on Agrobiodiversity, PGR management, Component II-Wheat

A total of 737 genotypes/advance lines (including 03 highly resistant lines, VL639, VW0919, VW0948, and 03 highly susceptible checks, Sonalika, VW1159 and VL *Gehun* 977) were inoculated during the previous season (*Rabi* 2019-20) were screened in the expression nursery for loose smut resistance under artificially inoculated condition. Two different sets, one comprising of 78 genotypes (Set-1) and another of 86 genotypes (Set-2), which were found resistant/highly resistant/immune during *Rabi* 2019-20 were again tested in the confirmation nursery during the *Rabi* 2020-21. A total of 152 genotypes in the expression nursery were found immune with zero infection. Moreover, 62 entries showed less than 5% infection levels for loose smut. In the set-1 confirmation nursery, 22 genotypes *i.e.* VL 639, VW 0919, VW 0948, IC 0591044, EC 0597830, EC 0597886, EC 0635739, IC 0078836-A, IC 0595233, IC 0538731, EC 0635708, EC 0597885, IC 0599914, IC 0591045, IC 0339627 etc. were immune with zero infection. Similarly, in the set 2 confirmation nursery, a total of 59 genotypes *i.e.*, EC 575981, IC 449061, IC 535217, KRL 210, EC 576159, EC 573974, IC 252954, EC 577050, IC 531524 etc. were found having zero infection. During *Rabi* 2021-22, a total of 384 entries (including 152 found immune in *rabi* 2020-21) will be screened in an augmented block design with three resistant (VL639, VW0919, VW0948) and three susceptible (Sonalika, VL977, VW1159) checks for confirmation of loose smut resistance (Table 6.2.1).

6.2.4. ICAR-CRP on Molecular Breeding Wheat

Two popular wheat varieties VL *Gehun* 907 and VL *Gehun* 892 were selected to improve resistance through marker assisted gene pyramiding of two resistance genes *Yr*10 and *Lr*24. Near Isogenic Lines carrying either *Yr*10 or *Lr*24 (VL *Gehun* 907+*Yr*10, VL *Gehun* 907+ *Lr*24, VL *Gehun* 892+*Yr*10, VL *Gehun* 892+ *Lr*24) were developed through marker assisted selection approach. In order to pyramid both genes, crosses were made between near isogenic lines. F_5 pyramided lines, VL *Gehun* 907+Yr10+*Lr*24 and VL *Gehun* 892+*Yr*10+*Lr*24 were sown in during *Rabi* 2020-21 for rust screening and agronomic evaluation. The pyramided lines were also genotyped with foreground markers Xpsp3000 (*Yr*10) and Sr24#12 (*Lr*24) for confirmation of presence of the genes. Foreground positive plants were also genotyped with background markers which revealed recurrent parent genome recovery from 80% to 95%. Out of 50 lines of VL *Gehun* 907+*Yr*10+*Sr*24 and 49 lines of VL *Gehun* 892+*Yr*10+*Sr*24, 12 lines have been selected for station trial during *Rabi* 2021-22 based of molecular analysis, agronomic superiority and disease resistance (Fig. 6.2.2).

Representative gel picture of foreground selection using Xpsp3000 and SR24#12 markers. 1-12: pyramided lines



Representative gel picture of background primer CFD49 and WMC257 marker confirming presence of recipient allele in pyramided lines. 1-12: pyramided lines

VL *Gehun* 907+*Yr*10+*Lr*24 VL *Gehun* 892+*Yr*10+*Lr*24

Fig. 6.2.2. Promising pyramided lines of VL *Gehun* 907 and VL *Gehun* 892 carrying *Yr*10 and *Lr*24 genes

6.3. UN Environment-GEF Project

For sourcing and deployment of crop diversity to promote conservation of genetic resources farmers' participatory methods have been practiced during 2021-22. Farmers' participatory plant variety selection (PVS) was carried out in 7 mother trials and 39 crowd sourcing trials comprising a total of 184 landraces of 7 traditional crops *viz.*, rice, barley, amaranth, buckwheat, finger millet, black soybean, horse gram sourced from ICAR-NBPGR, New Delhi in the target villages (12) of Ramanna Nyay Panchayat, Almora district. Among the germplasm accessions, local landraces *Gol Mandua, Jhumkiya Mandua, Bhat, Bhura Gahat, Kala Gahat, Safed Chua, Dhudh Dhan, Baurani Dhan, Thapa cheeni, Kawanauli, Kheemu Dhan, Chotiya Dhan, Lal Dhan, Chilak Lal Dhan* and *Lam Bauniya Dhan* have been identified through Farmers' participatory plant variety selection based on their yield performance, disease & insect-pest reaction, climate resilience and suitability for further large-scale multiplication in their farms. In the target crops, 174 landraces were also multiplied for use in next year's crowd-sourcing trials.

Hill germplasm collection of hull-less barley landraces (23) were multiplied and evaluated for 7 qualitative and 9 quantitative traits. Wide range of variability for days to flowering (90-109), plant height (68-110 cm), spike length (5.5-9.9 cm), No. of tillers (6-11), days to maturity (134-147), 100 seed weight (3.06-5.51 g) and grain yield (1,408-4,141 kg/ha) was observed in hill hull less barley collection (Fig. 6.3.1). Accessions *viz.*, EC 578863, IC 47346 and Gallibaseura Local-I were identified as promising accession for their yield performance suitability in the mid hill rainfed condition.

Fig. 6.3.1. Variability in the hull-less barley collection from Uttarakhand

6.4. PVP & DUS test through ICAR-SAU system

Kidney bean: Four candidate flower varieties (1 new *viz.*, 2884/2107 and 3 FV *viz.*, 2887/2075, 2887/2076 & 2887/2077) along with three reference varieties *viz.*, IPR 98-5, HUR 137, and PDR 14 were raised for grow out test and characterized for 22 DUS traits as per national guidelines for the conduct of test for DUS on kidney bean (Fig. 6.4.1).

Fig. 6.4.1. Variation in seed traits of kidney bean (a) candidate varieties (b) pigmented pods of candidate variety TC 2887/2076 (c) flower colour of TC 2887/2107

Soybean: One hundred seventeen varieties of soybean were raised for maintenance breeding during *Kharif* 2021. Measures were taken to ensure the genetic and physical purity of reference varieties at every stage of crop growth by observing varietal characteristics.

6.5. DBT Funded Project

6.5.1. Integrated genomic strategy for accelerating domestication of ricebean (*Vigna umbellata*) under genetic enhancement of minor pulse

A total of 238 accessions belonging to the ricebean core collection were evaluated with four checks in augmented block design during *Kharif* 2021. The data were recorded for 25 agro-morphological traits (Fig. 6.5.1). A list of promising accessions identified in germplasm collection is furnished in Table 6.5.1.

Table 6.5.1 List of promising accessions identified in rice bean germplasm collection

Trait	Range	Promising accessions
Seedling vigour	1-5 scale	IC-129078, IC-137159, IC-140801, IC-621844, IC-199549
Days to 50% flowering	65-95	IC-469199, IC-469207, IC-520896, IC-341914
Days to 80% maturity	100-140	IC-24199, IC-203946, IC-100195
Plant height (cm)	76- 138	IC-262747, IC-342218, IC-350152, IC-599884, IC-340341,
Number of branches/plant	2-6	IC-137142, IC-417831, IC-129093, IC-137133, IC-129053,
Pod length (cm)	3.5-7.5	IC-351545, EC-16136, IC-521363
Number of pods/ cluster	5-16	IC-204097, IC-75447, IC-275988, IC-75448, IC-75462, IC-521114, IC-89648, IC-296532, IC-116125, IC-116128
Number of pods/ plant	40-70	IC-116115, IC-116121, IC-129077, IC-129089
Number of seeds/pod	4-8	IC-137172, IC-137185, IC-140796, IC-141072, IC-141073,

Fig. 6.5.1. Phenotyping of rice bean germplasm and variation for pod size and colour

6.5.2 Collection and characterization of indigenous shiitake (*Lentinula edodes*) and DNA barcoding of oyster (*Pleurotus* spp.) mushroom germplasm for commercial exploitation

Estimation of total polyphenols

The amount of total phenolics in cap aqueous extract was higher (5.80± 0.12 mg GAE/g extract) whereas others had lower phenolic contents, with stipe methanolic extract showing the lowest amount (2.50 ± 0.12 mg GAE/g extract). In the present study, the extracts from the cap showed higher phenolic content than the stipe, in general.

Radical scavenging activity on DPPH and ABTS

The radical scavenging activity (RSA) of shiitake mushroom extracts was tested against the ABTS and DPPH. RSA on DPPH and ABTS of different mushroom extracts varied from 4.1-89.9 and 9.2-99.2, respectively (Table 6.5.2) and increased with increase in concentration. RSA on DPPH was higher for cap aqueous extract (89.9 at 25mg/mL extract concentration) whereas stipe methanolic extract showed the lowest RSA on DPPH (4.1 at 5 mg/mL extract concentration). The scavenging activity was better in aqueous extract when compared to methanolic extract. RSA on ABTS was also better in aqueous extract in comparison to methanolic extract and found to be higher in cap aqueous extract (99.2 at 25 mg/mL extract concentration).

Table 6.5.2. Radical scavenging activity on DPPH and ABTS in methanolic and aqueous extract from *L. edodes* strain DMRO-327 cap and stipe

Conc.	RSA on DPPH				RSA on ABTS			
	Meth. Extract cap	Meth. Extract stipe	Aque. Extract cap	Aque. Extract stipe	Meth. Extract cap	Meth. Extract stipe	Aque. Extract cap	Aque. Extract stipe
5 mg/ml	8.6±0.1	4.1±0.04	44.5±0.1	25.3±0.8	16.6±0.5	9.2±0.2	40.8±1.8	35.8±0.6
10 mg/ml	16.9±0.4	13.2±0.2	68.4±0.4	51.4±0.4	25.3±1.1	15.8±0.3	57.1±1.5	46.2±1.6
15 mg/ml	23.5±0.3	19.1±0.5	75.7±2.6	62.8±1.2	28.9±0.9	16.0±0.3	71.5±2.2	65.8±2.2
20 mg/ml	32.9±0.8	20.6±0.7	85.5±1.7	70.5±1.8	35.2±1.1	19.6±0.6	92.3±1.8	85.6±1.3
25 mg/ml	38.4±1.1	25.6±0.6	89.9±0.7	84.2±1.9	43.1±0.2	24.8±0.8	99.2±2.2	96.4±4.6

Mean of three (n=3) independent measurements + standard error

6.5.3. Popularization of Biofortified Maize Hybrids in Himalayan States with Special Reference to the North Eastern Region for Nutritional Security

To enhance the popularization of biofortified maize hybrids in the hill region for sustainable nutritional security, institute has developed two QPM maize hybrids along with their package of practices. Among the two QPM hybrids, VLQPMH 59 is a recently developed QPM maize hybrid recommended for cultivation in Uttarakhand hills. It is early in maturity (80-90 days), moderately resistant to turcicum and maydis leaf blight and rich in nutritional quality (tryptophan 0.77%, lysine 3.33%).

FLDs were conducted in 10 ha. in Dhanpau-Lakhwad cluster of district Dehradun (Uttarakhand). As a precursor to enhance the awareness about QPM hybrids, their products and nutritional benefits, Maize field day and *Kisan Gosthi* on '*Makka ki QPM Prajati VLQPMH-59 Dwara Parvatiya Kshetron me Poshan Suraksha*' with a major focus on biofortified QPM maize crop was organized for the farmers of village Dhanpau and Lakhwad of Kalsi block. The yield of VLQPMH 59 was about 1.5 to 2 times that of their local cultivar. The yield data collected showed increase ranging from 36.0 to 73.4 percent over the local cultivar

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

6.6.1. Use of plastics in agriculture particularly in protected cultivation, water harvesting and packaging (AICRP on PEASEM)

Modelling of water and nutrient dynamics under mulch and drip irrigated capsicum crop

Effect of irrigation and fertigation frequency on the growth and yield of drip irrigated capsicum crop yield was evaluated under mulch system. The experiment included three irrigation frequencies

Awareness programme (Left) and Maize Field Day (Right) at Dhanpau (Kalsi, Dehradun)

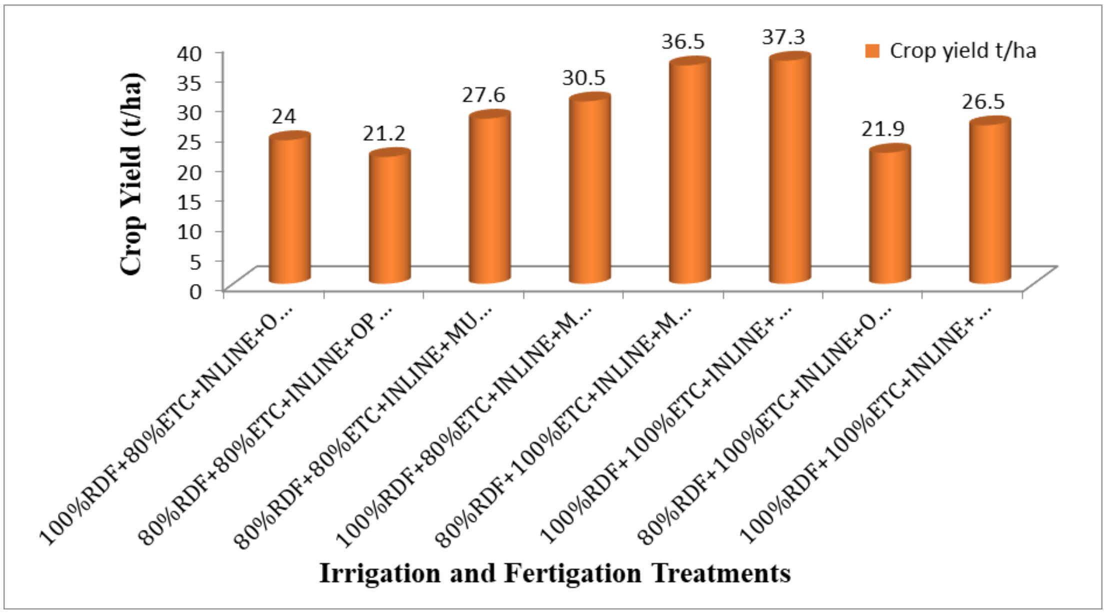


Fig. 6.6.1 Capsicum crop yield under different irrigation and fertigation treatment

namely, N1 (once a day), N2 (once in 2 days), N3 (once in 3 days), and two levels of irrigation *i.e.* 100 and 80% of crop evapotranspiration (ET_c) and fertigation treatment (100 and 80% of RDF). Water contents in various layers of the root zone of crop in irrigation treatment at 48 h after irrigation varied from 16.50-22.70%. Soil matric potential varied from -25 to -65 kPa in different irrigation frequencies. Irrigation scheduled between -18 to -39 kPa had a significant effect on cabbage growth and yield at 5% level of significance. Soil matric potential in the range of -23 to -32 kPa at 30 cm depth and irrigation frequency of once in two days can be used as an index for drip irrigation scheduling during the capsicum growth period in sandy loam soils for attaining higher yields. Mulch cum drip irrigation frequency and irrigation levels significantly affect the crop yield. The maximum yield (37.3 t ha^{-1}) of capsicum crop was obtained by applying water @ 100% of ET_c + 100% RDF + mulch with once in 2 days irrigation frequency followed by 100% of ET_c + 80% RDF + mulch with crop yield (36.5 t/ha) at once in 2 days irrigation frequency. Minimum yield (21.2 t/ha) was obtained at 80% of ET_c + 80% RDF + open condition at once in 2 days of irrigation frequency (Fig. 6.6.1). Hence, water and nutrient become limiting factors, once in two days irrigation would be the most appropriate irrigation level for growing cabbage under mulch cum drip irrigation system in hilly region.

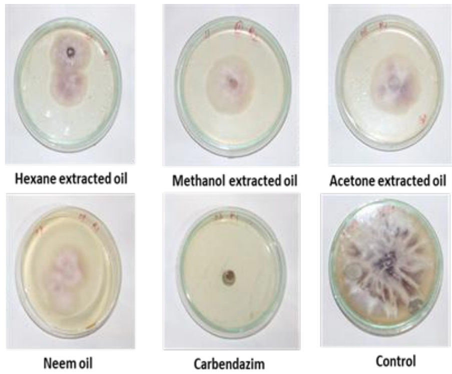
6.6.2. Post harvest technology for value addition and marketing of agricultural produce (AICRP on PHET)

Extraction and quantification of essential oils from dry pine needles

Shade dried pine needles are used to extract the essential oils using different solvents (hexane, acetone and methanol) through the soxhlet extraction process, and extracted essential oils were further used for plant protection investigation. The yield of essential oils varied from 3.5% to 6.3% on a dry weight basis due to variation in solvent polarity and solubility of essential oils. The color of oils varied from light yellow to dark green. The order of getting essential oils from the solvent distillation process was methanol extracted oil > hexane extracted oil > acetone extracted oil.

Antifungal activity of essential oils extracted from pine needles against Fusarium oxysporum

To evaluate the efficacy of extracted essential oils against root colonizing fungus *Fusarium oxysporum*, an *in-vitro* bio-efficacy study was conducted along with standard carbendazim 50% WP and neem oil at different concentrations by poison food technique. The concentrations tested for the bio-efficacy study were 1000, 750, 500, 250, 100, and 50 µg/mL. The effects of tested different extracted oils to inhibit the mycelial growth of *Fusarium oxysporum* are



Botanical extracted oil	Growth inhibition % at different Treatment Conc. (µg/mL)					
	1000	750	500	250	100	50
Hexane extracted oil	96.7	92.2	83.3	67.4	54.4	28.9
Methanol extracted oil	92.2	84.4	75.6	60.0	51.1	20.0
Methanol extracted oil	87.8	80.0	72.2	43.8	28.8	6.2
Neem oil (Std)	94.0	87.3	78.3	57.0	40.0	16.4
Carbendazim (Std)	100	100	100	100	86.7	75.6

Fig. 6.6.2. Effect of extracted oils from dry pine needles along with standard at 250 ppm treatment concentration

Table 6.6.1. Effect of dry pine needles extracted oils on percentage growth inhibition of *Fusarium oxysporum* at various treatment concentrations

depicted in Table 6.6.1 and Fig. 6.6.2. The results revealed that the radial growth of *F. oxysporum* was reduced by all concentrations of extracted oil in a dose dependent manner. Pine needles extracted oils confirmed 6.2 to 96.7% growth inhibitions whereas neem oil and carbendazim showed 16.4 to 94.0% and 75.6 to 100% growth inhibitions of *F. oxysporum* at different treatment concentrations. Among the treated oils, hexane extracted oils provided maximum growth inhibition efficiency which ranged from 28.9 to 96.7% followed by methanol extracted oils which showed 20.0 to 92.2% growth inhibition as compared to the botanical standard neem oil which provided 16.4 to 94% inhibition at various treatment doses, respectively.

Evaluation of germination percentage and growth performance of tomato crop using pine needles residue

A pot experiment was conducted to evaluate the effect of pine needles residue on the germination and growth of tomato seedlings (var. VL *Tamatar*-4). The germination percentage of tomato seeds varied from 60 (T6) to 90% (T5). Whereas, based on the percentage of healthy plants, T2 (88%) provided the best result followed by T3 (86%) and T5 (78%) which might be due to the allelopathic effect of pine needles. Treatment T5 (50% cocopeat + 50% FYM) was found promising followed by T2 (50% pine needles residue+50% FYM), and T3 (50% pine needles residue + 50% soil) based on shoot & root length (cm), total biomass (g fw) and total chlorophyll content (mg/g fw).

6.6.3. All India Network Project on white grubs and Soil arthropod pests (White Grub)

Monitoring of scarab beetle populations at Experimental Farm, Hawalbagh

Scarab beetles were collected with the help of a light trap (VL white grub beetle trap; IN 290170), and from host trees during field surveys (*in-situ* sampling).

A total of 8,504 scarab beetles belonging to 54 species were trapped in 2021. The collected beetles belonged to 6 subfamilies *viz.*, Rutelinae, Melolonthinae, Scarabaeinae, Dynastinae, Geotrupidae, and Aphodiinae of the family Scarabaeidae. Members of the subfamily Melolonthinae predominated with 44.04% of the species, followed by Rutelinae (23.08%), Scarabaeinae (11.83%), Aphodiinae (9.25%), Hybosoridae (5.96%), Dynastinae (5.41%) and Geotrupidae (0.42%) (Fig 6.6.3). The predominant species were *Maladerasimilana* (11.5%) and *Aphodiusnigrovirgatus* (9.25%). The maximum number of scarab beetles (4,412 beetles) were collected during June month (Fig 6.6.4 & 6.4.5).

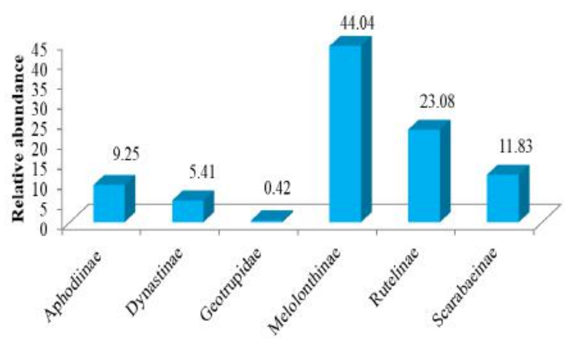


Fig. 6.6.3. Subfamily-wise trap of scarab beetles

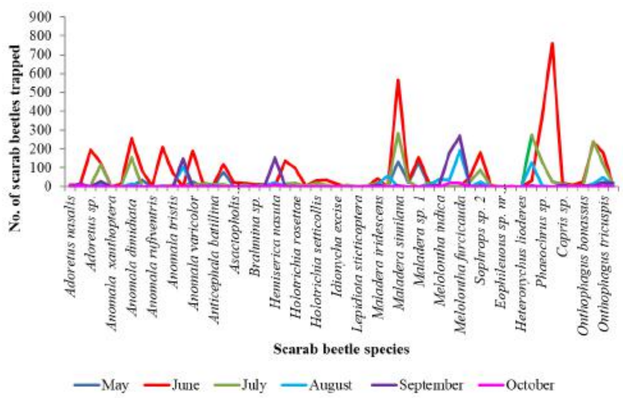


Fig. 6.6.4. Scarab beetles trapped in light traps

In situ sampling

A total of 9,523 pleurostict scarab beetles belonging to 32 species and 18 genera were collected during *in situ* samplings. The collected beetles belonged to 03 subfamilies *viz.*, Cetoniinae (2.32%), Melolonthinae (53.92%), and Rutelinae (43.76%) of the family Scarabaeidae (Fig 6.6.5). Out of 32 species, 16 species belonged to the subfamily Melolonthinae, 11 species belonged to Rutelinae, and 5 species belonged to Cetoniinae. The maximum number of scarab beetles (82.92% of total catch) was collected during June month (Fig 6.6.5). Of 32 pleurostict scarab beetles' species, *H. setticollis* was the predominant species with 26% relative abundance followed by *Sophrops* sp. (21%), *Adoretus versutus* (20.2%), *Anomala lineatopennis* (10.1%) and *Anomala bengalensis* (9.92%). These five species occupied more than 85% of the scarab population *i.e.*, 87.22% of total pleurostict scarab beetles collected, whereas, the rest 36 scarabs represented only 12.78% of the population (Fig. 6.6.6).

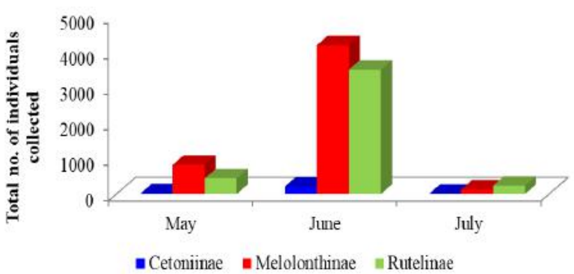


Fig 6.6.5. Month-wise catch of scarab beetles belonging to different subfamilies during *in situ* sampling

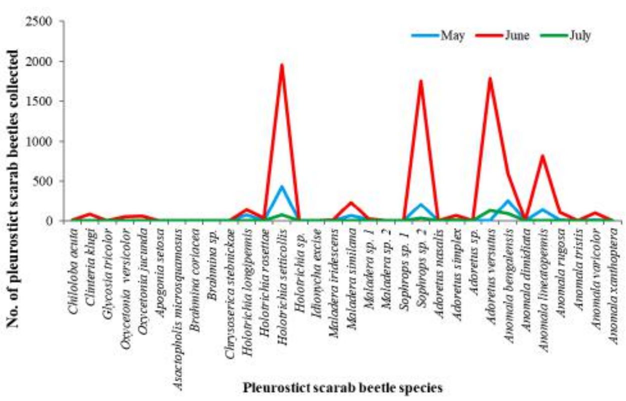


Fig. 6.6.6. Pleurostict scarab beetles collected during *in situ* sampling

Bio-efficacy of entomopathogenic nematodes against native white grub species

The pathogenicity of various entomopathogens against the first instars of two notorious and economically important white grub species, (*Anomala bengalensis* and *Sophrops* sp.) was investigated. The entomopathogenic bacteria and fungi tested against the white grubs recorded mortality of less than 25% whereas, two strains of entomopathogenic nematode (*Heterorhabditis indica*) recorded mortality of more than 70%. The median lethal dose and median lethal time estimation showed LD_{50} v of 1230.27 Infective Juveniles (IJs)/ml and 891.25 IJs/ml against the grubs of *A. bengalensis* for the commercial and native strains of EPN, respectively. While for the grubs of *Sophrops* sp. The LD_{50} value of 1023.29 IJs/ml and 954.99 IJs/ml were recorded for commercial and native strains, respectively. The obtained LT_{50} values were 70.79 h and 91.20 h for *A. bengalensis* grubs and 74.13 h and 77.62 h for *Sophrops* sp. grubs with commercial and native strains of EPN, respectively. Overall, *H. indica* (both commercial and native strains) showed good potential for biological control of grubs of *A. bengalensis* and *Sophrops* sp.

Analysis of the gut bacterial diversity of native white grub species

The gut microbial diversity of four notorious white grub species *i.e., A. bengalensis, H. longipennis, H. seticollis* and *B. coriacea* were carried. A total of 45 bacteria isolated from the gut of white grubs were selected for identification through molecular characterization. The sequences obtained from PCR products of gut bacterial isolates were submitted to GenBank, NCBI, and assigned accession numbers.

Cellulolytic bacteria isolated from white grubs

Twenty five cellulolytic bacteria isolated from the different regions of the gut of white grub species, *A. bengalensis, H. longipennis, H. seticollis*, and *B.*

coriacea were selected for identification through 16s rRNA sequencing and the phylogenetic tree was constructed using MEGA X software (Fig. 6.6.7).

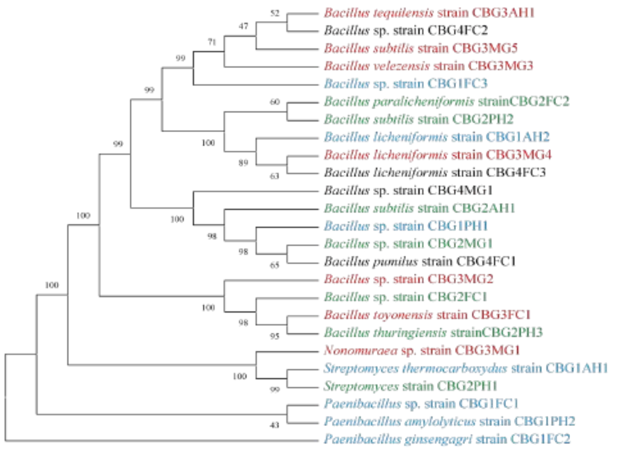


Fig 6.6.7. Phylogenetic tree showing the evolutionary relationship of cellulolytic bacteria isolated from the gut of white grubs. Bacteria isolated from the gut of *A. bengalensis*, *H. longipennis*, *H. seticollis*, and *B. coriacea* are highlighted with blue, green, red, and black colours, respectively

Chitinolytic bacteria isolated from white grubs

Twenty bacterial isolates from different compartments of the gut of selected white grub species showed chitinolytic activity. The gut bacterial pure culture was selected for identification through 16s rRNA sequencing and the phylogenetic tree was constructed using MEGA X software (Fig. 6.6.8).

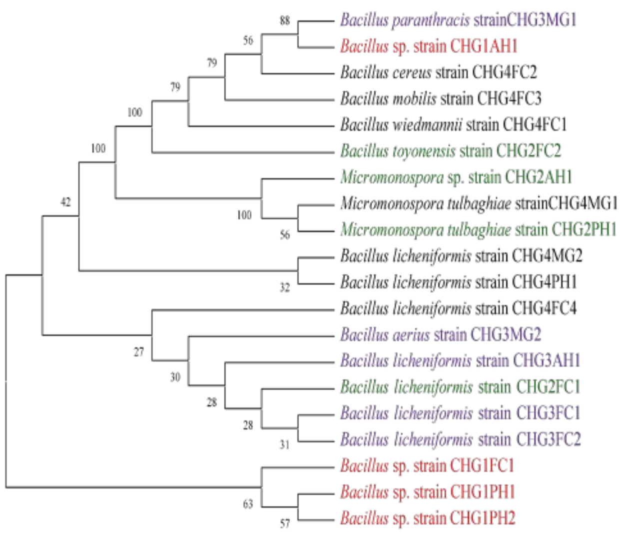


Fig 6.6.8. Phylogenetic tree showing the evolutionary relationship of chitinolytic bacteria isolated from the gut of selected white grub species. Bacteria isolated from the gut of *A. bengalensis, H. longipennis, H. seticollis,* and *B. coriacea* are highlighted with red, green, purple, and black colours, respectively.

6.6.4. Monitoring pesticide residues at National Level (under AINP on Pesticide Residue analysis)

A total of 380 samples were collected from different districts of Uttarakhand. Out of which 246 fruit and vegetable samples, the farm gate samples were directly collected from farmers' fields and local mandis, and 94 fruit and vegetable samples were collected from large markets. During the survey, a total of six districts of Uttarakhand were covered for farmgate samples, and five districts were covered for the market. (Fig. 6.6.9).

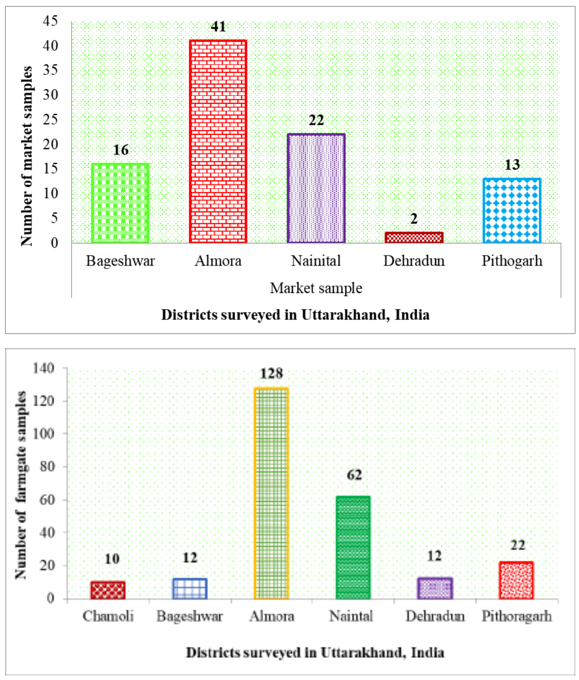


Fig 6.6.9. Number of samples collected from Uttarakhand districts

During the field surveys, a total of 42 villages were covered from six districts of Uttarakhand. The highest number of 21 villages were covered in the Almora district, followed by Nainital, Pithoragarh, Bageshwar, Chamoli, and Dehradun districts (Fig. 6.6.10).

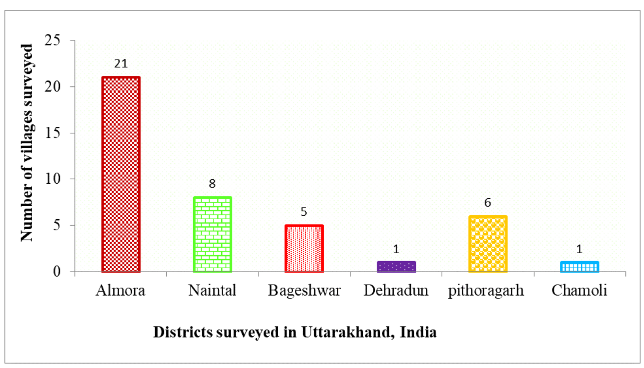


Fig 6.6.10. Number of villages surveyed in six different districts of Uttarakhand for collection of farm gate samples

Pesticide Residue Analysis

Out of 246 farm gate samples, 224 samples had residues less than 0.5 ppb, 12 samples had residues between 10-15 ppb, whereas, 10 samples had residues between 1-10 ppm. The results showed that most of the fruits and vegetables cultivated in Uttarakhand qualify for the organic certification as the residue levels are far lower and farmers rarely use any agro-chemicals for crop cultivation and pest and disease management. However, the trend with respect to market samples was in contrast to farm gate samples, wherein, 76 out of the 94 market samples had the residue levels between 1-10 ppm, thus indicating that market samples were transported from plain areas of Uttarakhand, where the fruits and vegetables are cultivated commercially and agro-chemicals are used excessively for pest and disease management.

6.6.5. All India Coordinated Research Project on Mushroom

Germplasm Collection & Conservation

During the rainy season, a survey was conducted in the forest areas of Binsar forest, district Bageshwar for the collection of wild mushrooms. More than 25 mushroom species were collected and some were identified.

Cantharellus cibarius

Amanita phalloides

Ganoderma lucidum

Russula emetica

Trametes versicolor

Ramaria abietina

Scleroderma sp.

Evaluation of Lion's mane Mushroom (Hericium erinaceous)

Out of five strains/varieties of *Hericium erinaceous* evaluated, strain HE-20-204 resulted in maximum yield (258g/500g dry substrate), however, strain HE-20-203 was the lowest yielder (100g/500g dry substrate) (Fig. 6.6.11).

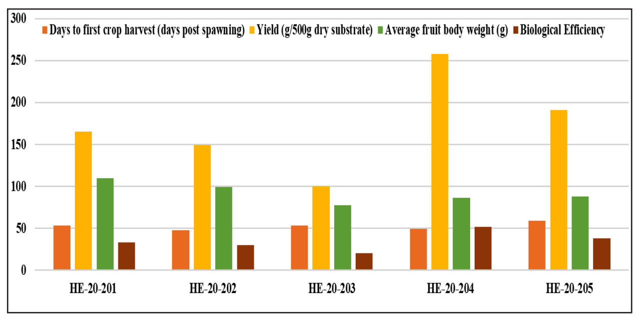


Fig 6.6.11. Yield of *H. erinaceous* strains over wheat straw substrate

6.6.6. Network Project on Organic Farming

Evaluation of organic, inorganic and integrated production systems under rainfed conditions

Four crop management practices *viz.,* organic (100%), organic (50%) + natural farming practices (seed/seedling treatment with beejamrit + ghanjeevamrit @ 250 kg/ha + jeevamrit @ 500 liter/ha twice a month through foliar spray), integrated and chemical crop management were evaluated for two cropping systems (finger millet + black soybean–wheat + toria and grain amaranth–wheat + lentil) under rainfed ecosystem. Out of different

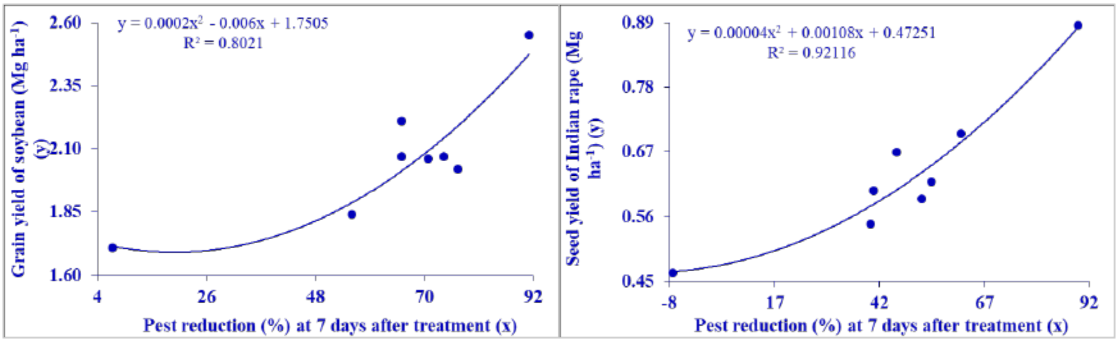


Fig 6.6.12. Relationship of percentage pest reduction with crop yield of soybean and Indian rape

crop management, application of 100% system N requirement through FYM recorded highest system (in terms of finger millet equivalent) productivity (4265.8 kg/ha) of grain amaranth–wheat + lentil system which was 152% higher as compared to 100% inorganic management. Likewise for finger millet+black soybean–wheat+toria system, 100% system N advocation through FYM recorded around 120% higher system yield as compared to 100% chemical crop management practice. Activities of different soil enzymes were estimated in the rhizospheric soil in wheat, lentil, and toria crops at the 90 days crop growth stage. Among different crop management options, the highest dehydrogenase (37.0 ug TPF /g soil/24 h) and urease activity (170.1 µg urea/g/h) were noticed under 50% organic + NF practices treatment followed 100% organic management. With respect to crop, rhizospheric soil of lentil under 50% organic + NF practices recorded highest dehydrogenase activity (42.7 ug TPF /g soil/24 h), followed by toria. The highest acid phosphomonoesterase activity (431.8 µg PNP/g soil/h) was found in 50% organic + NF practice treatment followed by integrated and 100% organic crop management. In case of alkaline phosphomonoesterase, 100% organic crop management and for β-glucosidase integrated crop management and 50% organic + NF practice treatments have shown the highest enzyme activity.

Evaluation of locally available plant extracts and commercial biocontrol agents against soybean sucking bug (Chauliops choprai)

Parthenium leaf extract (5%) was recorded as the superior treatment among plant extracts and botanicals after insecticide with the highest percent pest reduction of 75.4%, 71.5%, and 83.6% at 7 DAT in first, second and third year, respectively. This was followed by *M. azedarach* seed extract (5%) recording 75.2% and 70.4% in the first and second years, respectively. *B. bassiana* showed an 83.5% pest reduction in the third year. The pooled yield data analysis over a period of three years and per cent yield advantage over control showed that Nimbicidine @ 3 mL/L recorded the superior yield over control with a yield advantage of 29% followed by *M. azedarach* seed extract @ 5% and 10%, both recording 21% yield advantage in case of soybean (Fig. 6.6.12).

Organic pest management of mustard aphid (Lipaphis erysimi) through botanicals and biocontrol agents

Based on preliminary laboratory assays, promising treatments were selected for field assays. In the case of aphids (*Lipaphis erysimi*) infesting Indian rape, Nimbicidine 0.03% was found superior in 1st and 3rd year with 73.5% and 57.6% pest reduction, whereas 5% seed extract of *Melia azedarach* was superior in 2nd year with 56.3% reduction 7 DAT. The pooled yield data analysis over a period of three years and per cent yield advantage over control showed that Nimbicidine 3 mL/L was superior, with a yield advantage of 51%, followed by *Beauveria bassiana* @ 3g/L with 44% and *M. azedarach* seed extract 5% with 33% in case of Indian rape (Fig. 6.6.12).

6.6.7. Network Project on AMAAS-Developing PGPR consortia for enhanced micronutrient (iron and zinc) uptake and yield of finger millet (*Eleusine coracana*) in hilly areas

Eight PGP bacterial consortium along with uninoculated control were evaluated for plant growth promotion, micronutrient (Zn and Fe) uptake and yield in three finger millet varieties (VL *Mandua* 376, VL *Mandua* 379 and VL *Mandua* 380) under pot (Fig. 6.6.13) and field (VL *Mandua* 379) conditions. Seed inoculation of finger millet with PGP bacterial consortia had significantly (P>0.05) improved root length (10.2 – 18.6%), shoot length (8.6 – 16.4%),

Fig. 6.6.13. Evaluation of PGP bacterial consortium on finger millet varieties under pot and field conditions

dry root biomass (8.3 – 15.9%), dry shoot biomass (1.2-1.4-fold increase), proline content (2.6-18.6%), total phenolics (4.8-15.2%) in all the three tested finger millet varieties, as compared to uninoculated control. Bacterization with PGP bacterial consortia significantly decreased electrolyte leakage and increase relative water content in finger millet plants as compared to uninoculated control.

Bacterization of finger millet (VL *Mandua* 379) seeds with PGP consortium C3 recorded highest 298.2 mg/g easily extractable-glomalin related protein (EE-GRP) in finger millet rhizosphere followed by C7 (289.9 mg/g) and C8 (276.2 mg/g) as compared to uninoculated control (235.8 mg/g) at 90DAS. Bacterization with PGP bacterial consortium significantly enhanced finger millet grain Zn (ranged from 6.2 to 54.6 ppm) (Fig. 6.6.14a) and Fe (ranged from 5.8 to 20.3 ppm) (Fig. 6.6.14 b) content over uninoculated control (24.4 and 34.5 ppm), while in straw, Zn ranged from 22.8 to 59.5ppm and Fe ranged from 7.2 to 26.5ppm as compared to uninoculated control 10.8 & 121.9 ppm, respectively.

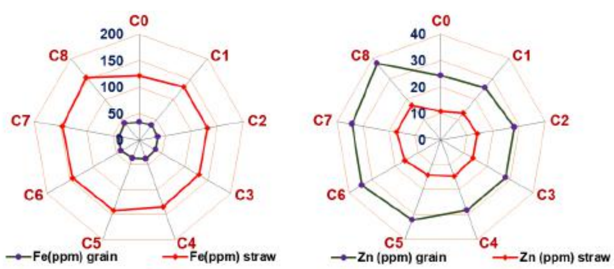


Fig. 6.6.14. Effect of PGP bacterial consortium on zinc (a) and iron (b) content in grain and straw of VL *Mandua* 379

Significantly enhanced Ca content from finger millet grain (ranged from 1.01 to 1.84-fold) and from straw (ranged from 1.11 to 1.57-fold) over uninoculated control (0.251 and 0.240% in grain and straw, respectively) at final harvesting was recorded (Fig. 6.6.15). PGP consortium C8 significantly enhanced Zn and Fe content in grain by 54.6 & 20.3% as compared to uninoculated control (24.4 & 34.5 ppm). It significantly enhanced per cent Ca content in grain & straw by 1.84 and 1.44 over uninoculated control (0.251 and 0.240% in grain & straw, respectively).

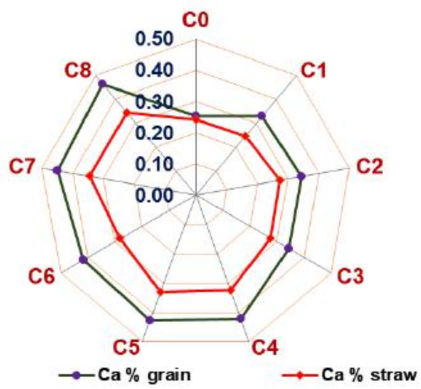


Fig. 6.6.15. Effect of PGP bacterial consortium on Ca content in grain and straw of VL *Mandua* 379

Priming of finger millet var. VL *Mandua* 379 seeds with PGPR bacterial consortium C1 {CS11RH4+CS11RH1+CT4RH2(2)} and C3 {PB2RP1(2)+CS11RH4+CT4RH2(2)} significantly enhanced grain yield by 1.24-fold followed by C2 {RT5RP(2)+BFMRpN2+CT4RH2(2)} (1.10-fold) over uninoculated control (2,359 kg/ha) (Fig. 6.6.16).

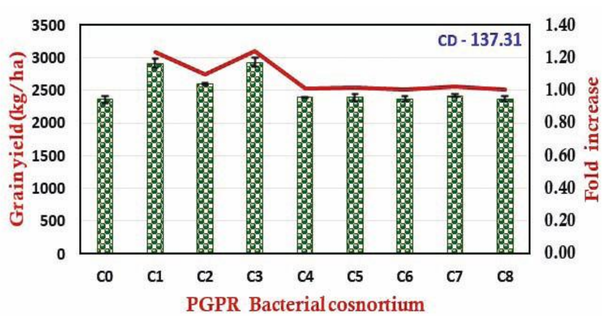


Fig. 6.6.16. Effect of PGP bacterial consortium on grain yield of finger millet VL *Mandua* 379

6.7. NICRA project under Competitive Grants Component (CGS)

6.7.1 Design & development of protective structures for high value crops to reduce damage from hail and frost

VL Single Tree Anti Hail Net Structure

"VL Single Tree Anti Hail Net Structure" was developed under the NICRA project of Institute. It is a small circle cone shaped structure with circular diameter ranging from 2 to 4m depending canopy size and type of tree. The height of center pole is 3 to 6m depending on height and type of tree and is adjustable. It is made up of GI pipes (½ and ¾ inch), 5 SWG hard iron wire, pieces of GI square pipes (25 x 25 mm and 32 x 32 mm), GI nut-bolt (6 mm diameter and 50 mm length), MS bar (8 mm diameter) and UV stabilized white anti hail net with mono flament. The whole structure can be put on the fruit plants just before flowering and only anti hail net can be removed just after harvesting the fruits while the structure remains permanently on the tree. A total of 26 units of VL Single Tree Anti Hail Net Structure were demonstrated at farmer's fields in Darim village (district Nainital) covering apple, peach, pear, plum and apricot fruit trees.

"VL Single Tree Anti Hail Net Structure" demonstration at farmer's field

6.8. National Mission on Himalayan Studies (NMHS) Project

6.8.1 Characterization of Kidney Bean (*Rajmash*) Rhizosphere Microbiome from Higher Altitude of Indian Central Himalaya

Cold adapted bioinoculants *Pseudomonas lurida* NPRp15 and *Pseudomonas* sp. PPERs23 were applied with kidney bean seeds at farmer's field of Kailashpur & Parsari village, Joshimath block of Chamoli district. At Kailashpur (lower) village, inoculation of kidney bean seeds with *Pseudomonas lurida* NPRp15 significantly enhanced easily extractable glomalin related soil proteins (EE-GRSP) and total extractable glomalin related soil proteins (TE-GRSP) by 7.4 and 9.4%, respectively over uninoculated control (2.24 & 2.12 mg/g of rhizosphere soil). However, at Kailashpur (upper), *Pseudomonas* sp. PPERs23 enhanced EE-GRSP and TE-GRSP by 9.9 and 26.1%, respectively over uninoculated control (2.32& 2.22 mg/g of rhizosphere soil). At Parsari (lower) village, inoculation of kidney bean seeds with *Pseudomonas lurida* NPRp15 significantly enhanced EE-GRSP and TE-GRSP by 7.5 and 11.6%, respectively over uninoculated control (2.12 & 2.68 mg/g of rhizosphere soil). However, at Parsari (upper), *Pseudomonas* sp. PPERs23 enhanced EE-GRSP and TE-GRSP by 24.8 and 4.5%, respectively over uninoculated control (1.41 & 1.76 mg/g of rhizosphere soil).

Inoculation of kidney bean seeds with *Pseudomonas lurida* NPRp15 enhanced yield contributing characters (pod length, pod width, number of pods/plant, number of seeds/pod, grain yield/ plant by 9.1, 1.81, 9.7, 20.0, 10.2% respectively, over uninoculated control) at Parsari village. At Parsari village, inoculation of kidney bean seeds with *Pseudomonas lurida* NPRp15 and *Pseudomonas* sp. PPERs23 significantly enhanced grain yield by 25.9 and 6.6%, respectively over uninoculated control (615.1 & 704.3 kg/ha). However, at village

Crop of kidney bean at farmer's field of Joshimath block, Chamoli

Kailashpur, inoculation of kidney bean seeds with *Pseudomonas lurida* NPRp15 and *Pseudomonas* sp. PPERs23 significantly enhanced grain yield by 22.9 and 13.6%, respectively over uninoculated control (625.5 & 692.8 kg/ha). At Parsari village total area under treated and untreated cultivation was 3.69 hectares, benefiting forty-two (42) farmers at village Parsari, Joshimath Block, Chamoli district. While at Kailashpur village, Joshimath Block, Chamoli district, total beneficiaries were forty-seven (47) farmers belonging to seven SHGs.

6.9. Gender Dynamics in Agriculture Information Usage in Hills of North-Western and North-Eastern Himalayan region of India

Gender dynamics in vegetable cultivation

Data was collected from three villages of Almora district namely Gwar estate of Valna village, Mauna Chaukuni and Balta village. Focussed group discussions were held in these villages with the participation of key informants and qualitative information was collected (Table 6.9.1). The women dominant activities in vegetable cultivation were nursery raising, weeding, watering, sowing seeds, hoeing operation, and cleaning field. Women were involved in almost each and every operation except ploughing as ploughing is considered as men's activity. Men had more participation in applying chemicals/insecticides/pesticides and in managing post-harvest activities including marketing.

Table 6.9.1. Gendered role in vegetable cultivation

Activity	Men	Women	Jointly
Land preparation	31.67	65.00	3.33
Ploughing	100.00	0.00	0.00
Cleaning of field	20.00	65.00	15.00
Levelling	46.67	30.00	23.33
Nursery	15.00	81.67	3.33
Sowing	6.67	78.33	15.00
Transplanting	5.00	76.67	18.33
Hoeing	15.00	63.33	21.67
Weeding	6.67	86.67	6.67
Irrigation/ Watering	28.33	63.33	8.33
Plant protection measures	85.00	3.33	11.67
Harvesting/ Picking	18.33	48.33	33.33
Marketing	71.67	5.00	23.33
Storage	56.67	18.33	25.00

The time utilization pattern of women in vegetable cultivation showed that vegetable cultivation is a time demanding task with maximum time on manure application, cleaning the field, weeding and transplanting. The time use pattern of women in vegetable cultivation showed that hill women spend a major share of their days' time in carrying out activities in vegetable cultivation (Table 6.9.2).

Table 6.9.2. Time utilisation of women in vegetable cultivation

Activity	Time (Min/Day)
Manure application	166.8
Cleaning of field	132.8
Levelling	12.3
Sowing	10.65
Nursery raising	34.91
Transplanting	105.6
Weeding	135.4
Watering plants	25.05
Plant protection	18.21
Harvesting	29.3

The resources related to vegetable cultivation were ascertained across gender for access to and control over them. It was found that in most of the resources related to farming, access to and control over resources were more for men farmers of the household (Table 6.9.3). Comparatively across the resources, access to inputs like seeds, manure, etc was more of women than any other resource. Reason could be that women were taking care of seed, manure and its sowing and spreading of manure in the fields.

Table 6.9.3. Access and control over resources related to vegetable cultivation

Resource	Men	Women	Jointly
Land	96.67	3.33	0.00
Credit	93.33	6.67	0.00
Inputs like seeds, manure,etc	75.00	20.00	5.00
Farm implements	51.67	10.00	38.33
Income from farm produce	61.67	15.00	23.33
Trainings	46.20	34.0	19.80
Tools	4.00	4.00	92.00

Status of information accessibility to farmers

Most of the respondent (88.9%) had own mobile phone while some have (11.1%) mobile phone in family. 58.7% of respondent had basic phone while 41.3% had a smartphone. Only 31.7% of the respondent had access to the internet while most of the respondent (68.3%) don't have access to the internet.

Information sources used by vegetable growers

Most of the male farmers relied on informal localite sources of information as they had more access to them when required. Among other sources, horticulture/agriculture department, shopkeepers, input dealers were the most sought information sources. Men had more contact with input dealers, shopkeepers and private companies for information in comparison to women. This is due to less mobility of women in comparison to their male counterparts.

Constraints in vegetable production

The farmers reported the main constraints in vegetable production as lack of quality input material, lack of good trainings, lack of fair prices, non-availability of seeds in time and no information on schemes for vegetable growers (Table 6.9.4).

Table 6.9.4. Constraints perceived in vegetable farming

Constraint	Weighted Mean Score	Rank
Lack of quality input material	20.17	1
Lack of training	19.67	2
Lack of fair price in market	18.33	3
Non availability of seed & other input in time	18.00	4
Less knowledge about schemes for vegetable growers	16.67	5
High cost of input	15.83	6
Lack of knowledge about marketing linkage	15.67	7
Difficulty in getting loan	15.17	8
More distance from market	14.83	9
Lack of demand in market	13.17	10
Untimely supply of inputs	13.17	11
Lack of financial institution in area	12.67	12
Lack of storage facilities	12.33	13
Lack of irrigation source	11.17	14

Information needs of vegetable growers

The farmers reported that they required information mainly on suitable crop varieties, disease management, farm tools/implements, storage, price related information, crop insurance related and schemes for vegetable growers (Table 6.9.5).

Table 6.9.5. Prioritised Information needs of farmers in vegetable production

Areas of Information	WMS	Rank
Pre-sowing phase		
Land/area allocation	7.67	3
Crops Varieties	10.17	1
Land preparation methods	7.67	3
Farm implements	9.5	2
Sowing phase		
Right time of sowing	7.5	2
Sowing methods	7.5	2
Spacing	7.33	3

Areas of Information	WMS	Rank
Use of farm implements	9.5	1
Post sowing phase		
Weed control/ Management	11	2
Irrigation/water requirement	10.17	3
Manure requirement	11	2
Disease control/ Management	14.5	1
Post harvest related		
Processing technique	8	2
Storage	8.5	1
packaging	7.33	4
Value addition	7.83	3
Agriculture Marketing		
Transportation	7.83	3
Market availability to sell	8	2

Areas of Information	WMS	Rank
Price related service	9.17	1
Credit and insurance		
Organisation (Bank, NGO, Cooperative society Etc.)	8.5	3
Crop insurance	9.67	1
Interest rate, No. and time period of instalment	9.5	2
Government Schemes/ programme		
Agriculture Schemes and programmes for benefits of farmers	14.5	1
Eligibility criteria and documents requirements to avail benefits of schemes	13.17	2
Sources/offices to contact for a particular scheme	13	3

7. Technology Assessment and Transfer

Krishi Vigyan Kendra, Chinyalisaur, Uttarkashi

Krishi Vigyan Kendra, Kafligair, Bageshwar

7. Technology Assessment and Transfer

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

7.1. Krishi Vigyan Kendra, Chinyalisaur

7.1.1. Trainings

Krishi Vigyan Kendra (ICAR-VPKAS) Chinyalisaur, Uttarkashi has offered 23 training courses for the practicing farmwomen, farmers, and rural youths on various topics related to disciplines of Horticulture, Agricultural Extension and other projects operational at KVK with an objective to uplift the socio-economic status of underprivileged farmers through improvement in agriculture production and allied enterprises. Total 1,160 participants (721 female and 439 male) attended the programme (Table 7.1.1).

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

Discipline	No. of courses	No. of participants		
		Male	Female	Total
Horticulture	15	373	455	828
Agricultural Extension	04	66	49	115
Sponsored trainings	04	00	217	217
Total	**23**	439	721	1160

7.1.2. Front Line Demonstrations

Front line demonstration on vegetable, cereals, pulses and other crops were conducted at the farmers' field covering an area of 29.0 ha during *Rabi* 2020-21, 2021-22 & *Kharif* 2021 and a total of 605 farmers were benefited (Table 7.1.2 & 7.1.3).

Table 7.1.2. Front line demonstration conducted during *Rabi* 2020-21 and 2021-22

Crop/ livestock	Variety	Area/ Nos.	No. of farmers
Pea	*Vivek Matar* 10, *Vivek Matar* 11, *Vivek Matar* 12, *Vivek Matar* 13, *Vivek Matar* 15	2.0	82
Lentil	VL *Masoor* 514, VL *Masoor* 126, VL *Masoor* 133	15.0	241
Hybrid Napier	Co3	1.0	08
Wheat	VL *Gehun* 829, VL *Gehun* 953	10.0	210
Total		28	541

Table 7.1.3. Front line demonstration conducted during *Kharif* 2020-21

Crop	Variety	Area/ Nos.	No. of farmers
Bhindi	VL *Bhindi* 2	1.0	64
Total		1.0	64

7.1.3. On Farm Trials

Total four On-Farm Trials (OFTs) were conducted covering 19 farmers (Table 7.1.4).

Table 7.1.4. On farm trials

S. No.	Title	Crop/ Variety	No of Farmers
1	Assessment of high yielding variety of Amaranthus for mid and lower hills of Uttarkashi District	VL *Chua*110	4
2	Control of bitter pit in apples	Apple -Royal delicious	7
3	Assessment of yield and quality of saffron in different altitude of higher hills of Uttarkashi district.	Saffron	5
4	Assessment of High yielding verities of vegetable pea for mid and lower hills of Uttarkashi District	*VL Sabji Matar* 13, *VL Sabji Matar* 15	3

7.1.4. Seed Production

A total 36.12 q seeds of cereals, pulses and vegetables and 45,960 seedlings were produced at KVK farm.

7.1.5. Other Extension Activities

- KVK Uttarkashi organized *Kisan Goshthi* and briefed farmers about soil sampling and its importance in NICRA adopted village Dunda on January 04.
- On January 19, farm implements were distributed to 27 farmers under SCSP project in Bagiyalkhet village.
- Exposure Visit of 20 farmers brought by Reliance Foundation was organized by KVK Uttarkashi on February 20.
- International Women's day was celebrated at KVK Uttarkashi on March 8. Various programs like *Goshthi* and scientist-women farmers interactions were organized. There were 116 participants in the programme.
- Exposure Visit of 12 B.Sc. students to KVK Uttarkashi was organized on March 19.
- World Water Day was celebrated at KVK Uttarkashi on March 22 in which 38 persons including KVK staff participated.
- Concentrate Feed & Seed were distributed to Farmers at KVK Uttarkashi on March 22.
- 16th Scientific Advisory Committee meeting was organized at KVK, Chinyalisaur on April 07 through virtual mode.
- KVK Uttarkashi organized a webinar cum *Kisan Gosthi* on World Milk Day on June 01.
- KVK Uttarkashi organized a Plantation drive & *Gosthi* on Environment Day on June 05. On this occasion, several medicinal and aromatic plants were planted in the KVK campus.
- Visual online training programme on "Recent Advances in Horticulture" was organized on June 08.
- KVK Uttarkashi organized Webinar on "Balanced Use of Fertilizers" on June 18.
- International Yoga day 2021 was celebrated at KVK Chinyalisaur on June 21. All staff members of KVK practiced yoga at home.
- Seventy-four B.Sc. (Ag.) students from different agriculture colleges of Uttarakhand joined KVK Uttarkashi for 04 months Rural Agricultural Work Experience (RAWE) training.
- KVK, Uttarkashi celebrated Parthenium Eradication week during August 16-22. Various programmes like farmers gosthi, rallies, parthenium eradication drive at KVK and nearby villages etc. were organized.
- KVK Uttarkashi celebrated Hindi Diwas on September 14 and organized various programs during *Hindi Chetna Maas* during September 14-30.
- KVK Uttarkashi organized webinar on "Role of Nutri-gardens in nutrition security of hill community" on September 17.
- *Mahila Krishak Diwas* 2021 was celebrated by KVK officials along with 49 women farmers at Patara village on October 15.
- The Food Day was celebrated by KVK officials along with 71 participants on October 16.
- KVK, Uttarkashi organized integrity oath, extempore competition, essay competition, slogan competition, poem recitation competition, speech competition and *Kisan Gosthi* during the observance of Vigilance Awareness Week during October 26-November 02.
- Special *Swachhta* Campaign was organized during October 02-31 at KVK Uttarkashi, nearby areas and adopted villages.
- KVK, Uttarkashi celebrated National Milk day organized by ICAR-NDRI, Karnal on November 26.
- KVK Uttarkashi celebrated World Soil Day and distributed soil health cards on December 05. A total of 76 farmers, students and officials participated in the program.
- KVK, Uttarkashi organized and performed various activities under *Swachhta Pakhwada* during December 16-31 at different locations. KVK staff, RAWE trainees and field workers actively participated in all the activities.
- KVK, Uttarkashi organized *Kisan Diwas* on December 23. A total of 62 farmers and students participated in the programme. On the same day,

animal husbandry camp by Govt. Veterinary Hospital, Chinyalisaur was also organised.

7.2. Krishi Vigyan Kendra, Kafligair

7.2.1.Trainings

Krishi Vigyan Kendra (ICAR-VPKAS) Kafligair, Bageshwar organised 49 training programmes, with the participation of 1,058 farmers (669 males, 389 females) including 15 numbers of sponsored training programmes on various topics (Table 7.2.1.).

Table 7.2.1. Training programmes organized during 2021-22

Discipline	No. of trainings	No. of Trainees		
		Male	Female	Total
Plant Protection	11	144	61	205
Horticulture	15	198	78	276
Home Science	08	56	94	150
Sponsored Training	15	271	156	427
Total	**49**	**669**	**389**	**1058**

In addition, two training programme of 200 h under Skill India Mission –Agriculture Skill Council of India (ASCI) on Quality Seed Grower and Mushroom Grower were also organized. Each training had 25 trainees. Two vocational training programmes of seven days each on "Scientific Bee Keeping" were organized under National Bee and Honey Mission. Fifty trainees successfully completed these trainings.

7.2.2. Front Line Demonstrations

Front Line Demonstrations (FLDs) on various crops were conducted on 71.93 ha (35.43 ha in *Kharif* and 36.5 ha in *Rabi*) benefitting 1,772 farmers (Table 7.2.2). The FLDs resulted in increasing the average yield of various crops from 14.5 to 46.5 percent.

7.2.3. On Farm Trials

Management of purple blotch disease in onion seed production: Three sprays of Defenoconazole @ 0.01% at 10 d interval after flowering was found superior and gave highest onion seed yield of 445 kg per ha which was followed by four sprays of Tebuconazole @ 0.01% at 10 d interval after

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

Season	Crop	Variety	Area (ha.)	No. of beneficiaries
Kharif 2021	Cereals & Millets	VL *Dhan* 65,VL *Dhan* 68, *Vivek Dhan* 156, *Vivek Dhan* 158 Pusa Basmati 1509, VL *Mandua* 379, VL *Mandua* 380 &VL *Madira* 207	28.65	361
	Oil seeds	VL Soya 47,VL Soya 89, VL Soya 65	6.12	215
	Vegetables and fruits	Okra (VL *Bhindi* 2)	0.66	45
		Sub-total	**35.43**	**621**
Rabi 2021-22	**Cereals**	VL *Gehun* 829 and VL *Gehun* 953	10.25	203
	Oil seeds (CFLD)	Pant Hill Toria-1and Pant Shweta	10	255
	Pulses (CFLD)	VL *Masoor* 133 and PL-4	10.25	293
	Vegetables	Onion ALR	2	80
		Vegetable Pea P10	1	65
		Cauliflower Snowncrown F1	1	85
		Cabbage Varun F1	1	85
		Brocolli Paraiso F1	1	85
		Sub-total	**36.50**	**1151**
		Grand Total	**71.93**	**1772**

flowering that yielded 380 kg onion seed per ha, while farmer's practice gave only 160 kg seed per ha.

***Assessment of different date of sowing on button mushroom (Agaricus bisporus) production at areas 1,650 m amsl*:** First week of March was found best for mycelial run as well as crop growth (14-22^{0}C) with the highest yield of 25 kg/q compost.

***Varietal assessment of newly released varieties of vegetable pea*:** GS 10 resulted in highest yield of 81.6 qtl per ha and B: C ratio of 1.94, followed by *Vivek Matar* 12 (75.8 qtl per ha and B: C ratio 1.89) and *Vivek Matar* 15 (71.2 qtl per ha and B: C ratio 1.78).

7.2.4. Production of Seed and Bio-products

A total of 31.49 q quality seed, 1,06,825 numbers of vegetable seedlings, 160 q vermi-compost and 6,321 litre milk were produced and total revenue of Rs 2.90 lakhs was generated.

7.2.5. Other Extension Activities

- Field Day on demonstration of cutting technology of dual-purpose wheat VL *Gehun*-829 was conducted at Kansyari village of Garur Block. Total 62 farmers were benefitted.
- Field Day on toria variety Uttara was conducted at Uttraura village of Kapkote Block. Total 32 farmers were benefitted.
- KVK, Bageshwar organized field day on VL *Masoor* 126 at Baidibagad village on March 24.
- KVK, Bageshwar celebrated International Women's Day on March 08 at its campus by organizing various activities such as quiz competition for farm women, distribution of vegetable seed kits and felicitation of progressive woman farmer.
- KVK, Bageshwar celebrated World Water Day on March 22. NSS students from GIC, Kafligair participated in awareness programme and in quiz competition.
- KVK, Bageshwar organized 03 days online training programme on Scientific Bee keeping during April 15-17 sponsored by National Bee Keeping and Honey Mission. Twenty-five farmers participated in the training programme.
- KVK, Bageshwar successfully completed two training programmes under skill development for Quality Seeds Grower and Mushroom Grower during February. 17-March 18. The total duration of training was 200 h each.
- KVK, Bageshwar celebrated World Milk Day on June 01 by organizing online *gosthi*.
- Online Scientific Advisory Committee meeting of KVK was organized on June 21 under the chairmanship of Director, ICAR-VPKAS, Almora. Director, Extension Education, GBPUAT, Pantnagar was the Chief guest of the meeting.
- Plantation drive was organized on ICAR foundation day on July 16.
- KVK, Bageshwar virtually participated in ICAR-VPKAS, Almora foundation day on July 04.
- KVK, Bageshwar celebrated parthenium eradication awareness week during August 16-22.
- *Kisan gosthi* on "Kisano ke liye khadya evam poshan" was organized under *Azadi ka Amrut Mahotsav* on August 26.
- KVK, Bageshwar virtually participated in Vanijya Utsav organized by APEDA, New Delhi along with 75 farmers.
- Different activities under Special *Swacchata* Abhiyan were organized at *Kendra* from October 02-31.
- KVK, Bageshwar celebrated *Mahila Kisan Diwas* on October 15 by organizing *kisan gosthi* at Chauna village.
- Awareness programme for world food day was organized at Duni village of Kapkote block.
- KVK, Bageshwar along with 45 farmers of Bageshwar district participated in *Kisan Mela* organized by ICAR-VPKAS, Almora on October 09.
- KVK, Bageshwar participated in different activities under Vigilance Awareness Week during October 26-November 01.
- KVK, Bageshwar organized competitions under 'Agriculture and Environment: The Citizen'

Face for school children of Country Wide Public School, Kathpuriachina, and Bageshwar on November 26.

- KVK, Bageshwar participated in workshop on preparation of district contingency plan at Directorate of Research, GBPUAT, Pantnagar from November 16-17.
- KVK, Bageshwar celebrated World Soil Day on December 05 by organizing *gosthi* at Matela village.
- KVK, Bageshwar organized *gosthies* under Jai Jawan Jai Kisan "*Uttam Kheti Unnat Kisan*" at its KVK, Chauna and Dofad villages.
- KVK, Bageshwar shared 24 short video clips and solved 165 queries of farmers through its whatsapp group "*Krishi avam Vigyan Sanchar*" having 242 members.

7.3. Institute Headquarter

7.3.1. Trainings Organized

Institute organized 20 trainings for farmers & agricultural officers benefitting 658 persons during 2021 (Table 7.3.1).

Table 7.3.1. Trainings organized for farmers at the Institute

Topic	District	Duration	Coordinators	No. of Trainees
Training Programme on "*Jaivik Kheti*" Sponsored by State Agricultural Management Institute, Uttar Pradesh	Seven districts of UP	Feb. 08-12 (5 days)	Drs. Kushagra Joshi, Manoj Parihar and Devendra Sharma	30
Training Program on "*Rabi Fasalon Ka Bijotpadan*" under D.B.T. Biotech Kisan Project	District Haridwar and Udham Singh Nagar of Uttarakhand	Feb. 09-11 (3 days)	Drs. Renu Jethi and Naveen Gahatyari	21
Training Program on "*Mashroom Utpadan*" under Institute TSP Programme	District Chamoli, Uttarakhand	Feb. 17-19 (3 days)	Dr. K. K. Mrshra and Mr. Jeevan B.	35
Training Program on "*Unnat Krashi Utpadan Takniki se Krashak Aay Mein Vridhi*" sponsored by Deputy Agricultural Director, Farukhabad, Uttar Pradesh	District Farukhabad, UP	Feb. 23-27 (5 days)	Drs. R.P. Yadav, Kushagra Joshi and Jitendra Kumar	26
Training Program on "*Sabjiyan Ki Sanrakshit Kheti*" under SCSP Programme	Districts Bageshwar and Almora of Uttarakhand	Feb. 27-March 01 (3 days)	Drs. Sher Singh and Jitendra Kumar	37
Training Program on "*Fasal Bijotpadan Hetu krishakon Ka Kaushal Vikas*" under ICAR- Seed Project	District US Nagar, Uttarakhand	Feb. 28-March 04 (5 days)	Drs. Renu Jethi, Naveen Gahatyari and Ashish Kumar	19
Training Program on "*Ugal Utpadan Hetu Darma Ghati Ke krishakon Ka Kaushal Vikas*" sponsored by Chief Agriculture Officer, Pithoragarh	District Pithoragarh, Uttarakhand	March 03- 04 (2 day)	Drs. B. M. Pandey and Dinesh Joshi	20
Training Program on "*Unnat Krishi Utpadan Taakniki Hetu Seemant Uchha Parvatiya Kshetron Ke krishakon Ka Kaushal Vikas*" under Institute TSP Programme	District Chamoli, Uttarakhand	March 05 - 09 (5 days)	Drs. B. M. Pandey, Kushagra Joshi and Mr. Amit Pashchapur	32
Training Program on "*Unnat Krishi Utpadan Taakniki Hetu Seemant Uchha Parvatiya Kshetron Ke krishakon Ka Kaushal Vikas*" under Institute TSP Programme	District Chamoli, Uttarakhand	March 10 - 14 (5 days)	Drs. B. M. Pandey, Kushagra Joshi and Mr. Amit Pashchapur	40
Training Program on "*Fasal Beejotpadan Hetu Unnat Utpadan Taknikiyan*" under D.B.T. Biotech Kisan Project	Block – Sitarganj, Bahadurabad District– Udhamsingh Nagar, Haridwar	March 15 - 17 (3 days)	Drs. Renu Jethi, Naveen Gahtyari and Devender Sharma	21

Topic	District	Duration	Coordinators	No. of Trainees
Training Program on "*Unnat Krishi Utpadan Taakniki Hetu Seemant Uchha Parvatiya Kshetron Ke krishakon Ka Kaushal Vikas*" under Institute TSP Programme	District Chamoli, Uttarakhand	March 15 - 19 (5 days)	Drs. B. M. Pandey, Priyanka Khati and Ashish Kumar Singh	42
Training Program on "*Unnat Krishi Utpadan Taakniki Hetu Seemant Uchha Parvatiya Kshetron Ke krishakon Ka Kaushal Vikas*" under Institute TSP Programme	District Chamoli, Uttarakhand	March 21-25 (5 days)	Drs. B. M. Pandey, Tilak Mandal and Asha Kumari	42
Training Program on "*Fasal Bijotpadan Hetu Krishakon Ka Kaushal Vikas*" under T.S.P.-I.I.S.S Scheme	District US Nagar, Uttarakhand	March 22-24 (3 days)	Drs. Renu Jethi, Naveen Gahtyari and Devender Sharma	20
Training programme on "*Parvateey mein aay srijan hetu paaramparik fasalon ki unnat utpaadan, prasanskaran evam moolyavardhan takneeki*" under UNEP GEF project	Tehri Garhwal, Almora and Chamoli districts, Uttarakhand	Sept. 01-06 (06 days)	Drs. Anuradha Bhartiya, Kushagra Joshi and Jitendra Kumar	113
Training programme on "*Parvatiya kshetron men aay vridhi ke liye sanrakshit kheti*" sponsored by GRAMYA, Almora	District Almora, Uttarakhand	Sept.14-15 (2 days)	Drs. Rahul Dev and Tilak Mondal	35
Training Programme on Maize Cultivation under DBT Maize Project	Bageshwar and Nainital districts of Uttarakhand	Sept. 17-18 (2 days)	Drs. Rajesh Khulbe, and Devender Sharma	20
Training Program on "*Sabjiyan Ki Sanrakshit Kheti*" under DBT Biotech Kisan Project	Districts Haridwar and Udham Singh Nagar of Uttarakhand	Sept. 21-25 (5 days)	Drs. Renu Jethi and Rakesh Bhowmick	21
Training programme on "*Parvatiya kshetron men aay vridhi ke liye sanrakshit kheti*" sponsored by GRAMYA, Bageshwar	District Bageshwar, Uttarakhand	Nov. 29- Dec. 01 (3 days)	Drs. NK Hedau, Mr. Amit U. Paschapur Dr Hitesh Bijarniya	29
Training programme on "*Rabi faslon ki unnat utpadan taknikein*" sponsored by HIMMOTHAN, Dehradun	Districts of Uttarakhand	Dec. 13-15 (3 days)	Drs. Anuradha Bhartiya, Manoj Parihar and Ashish Kumar	29
Training Program on "*Sanrakshit Vatavaran Mein Unnat Sabji Utpadan*" under SCSP Programme	District Bageshwar, Uttarakhand	Dec. 20-24 (5 days)	Drs. NK Hedau, Renu Jethi, Jitendra Kumar and Shyam Nath	26

Exposure Visits Organized

Topic	District	Duration	Coordinators	No. of Participants
Exposure visit of students, Govt. Inter College, Hawalbagh, Almora	Almora, Uttarakhand	Feb. 28	Dr. Anuradha Bhartiya	43
Exposure visit of students, G.E.H.U. Dehradun	Dehradun, Uttarakhand	March 12	Dr. B.M. Pandey and Er. D.C. Mishra	44
Exposure visit of famers under PKVY sponsored by SIMFED, Gangtok	Pithoragarh, Uttarakhand	Sept. 03	Dr. Amit Kumar	20
Exposure visit of famers under PKVY sponsored by SIMFED, Gangtok	Pithoragarh, Uttarakhand	Sept. 03	Dr. Hitesh Bijarniya	18

7.3.2. Front Line Demonstrations and Field Days

To assess the performance of newly released varieties of small millets, soybean, rice, wheat and maize hybrids at farmers' field, Front Line Demonstrations (FLDs) were conducted benefitting more than 250 farmers.

Rice

Front Line Demonstrations (FLDs) of released variety, VL *Dhan* 68 were conducted under irrigated conditions during *Kharif* 2021 in 1.6 ha area among 30 farmers of 03 villages of Bageshwar district. In the FLDs, the average yield of improved cultivar VL *Dhan* 68 (42.30 q/ha) was 26.45% higher than the local check Thapachini (33.4 q/ha).

Maize

Frontline demonstrations of VLQPMH 59, VMH 53, VLMH 57 and VMH 47 were conducted in Shama (4.0 ha), Niti (1.50 ha) and Bhanar (0.50 ha) village in block Kapkote of district Bageshwar. In the FLDs, the yield superiority of VL hybrids ranged from 32.47 to 87.15 per cent (Table 7.3.2). Maize Field Day was organized at Shama and Liti (Kapkote, Bageshwar) on Sept. 30.

Table 7.3.2. Details of maize hybrids and percentage superiority over the local cultivar

S. No.	Variety	Area (ha)	Location	Average Yield (q/ha)	% gain over local cultivar
1	VLQPMH 59	6.0	Shama & Liti	38.89	54.09
2	VMH 53		Liti	37.87	48.85
3	VLMH 57		Shama & Liti	39.29	54.29
4	VMH 47		Bhanar	39.90	66.76

Soybean

Front Line Demonstrations of improved soybean and black soybean varieties (VL Soya 89, VL Soya 63 and VL *Bhat* 201) with the recommended package of practices were conducted involving 72 farmers (33 male and 39 female) in about 3.88 ha area at Bhatgaon and Kotyura villages of Almora district. The improved varieties VL *Bha*t 201, VL Soya 89 and VL Soya 63 exhibited 38.91%, 23.17% and 18.90% yield superiority, respectively, over farmers' practice (local cultivars, broadcasting, mixed cropping with finger millet, no fertilizers and seed treatment). B:C ratio was found highest in black soybean VL *Bhat* 201 (0.97) followed by VL Soya 89 (0.87) and VL Soya 63 (0.73).

Horse gram

Front Line Demonstrations of improved Horse gram varieties (VL *Gahat* 15 and VL *Gahat* 19) with recommended package of practices were conducted involving 35 (17 male and 18 female) beneficiaries in about 2.20 ha area at Bhatgaon village, Almora. The improved varieties VL *Gahat* 15 and VL *Gahat* 19 exhibited yield superiority of 31.62% and 32.22%, respectively, over the farmer's practice (local cultivars, broadcasting, mixed cropping with finger millet, no fertilizers and seed treatment) in the fields which were barren for long and were not suitable for cultivation of any other crop.

Maize hybrid VMH 53 at Niti village (Left) and VLQPMH 59 at Shama village

Field day of soybean, black soybean and horse-gram

A field day on soybean and horse-gram was organized on 29.09.2021 at Bhatgaon village of Almora district. Farmer-Scientist interaction was also organized and a team of breeders, agronomist, pathologist and entomologist interacted with farmers to exchange views and experiences on different problems encountered during crop production. Total 45 farmers participated in the event.

7.3.3. Mera Gaon Mera Gaurav

In synchronization to the programme, five interdisciplinary team of scientists have been formed who visited the villages adopted in 5 clusters of Uttarakhand to cater the agriculture related needs of the farming communities. During the year 2021, the teams visited 26 villages from five blocks of Almora district regularly. The areas of national priority likewise soil and water conservation, mechanization, agricultural productivity, insect-pest management measures were taken care of. Due to the pandemic, as the social distancing measures were imposed, the teams utilized ICT tools to provide mobile advisory to the farmers in their respective clusters.

Activities organized under MGMG by the Institute

Name of activity	No./ quantity	No. of farmers participated/ benefitted
Visit to village by teams	11	179
Interface meeting/ *Goshthies*	09	172
Trainings conducted	00	00
Mobile based advisories	30	249
Literature support provided	05	05
Awareness created	04	85

Details of demonstrations conducted under MGMG by the Institute

Title of demonstrations	No. of demonstration	Area covered under demonstration (ha)/ number of units)	No. of farmers benefitted
Demonstration of manual/ battery-operated power spray pump	01	01 unit	15
Demonstrations on tomato (var. Heem Sohna)	01	0.02	20
Demonstrations on capsicum (var. Doller)	01	0.02	20

7.3.4. *Krishi Samridhi* Programme

Krishi Samridhi, a radio based programme, is an initiative of ICAR-VPKAS, Almora for promoting Good Agricultural Practices among farmers. It is a live 10-minute syndicated talk-based radio programme for farmers of hill districts of Uttarakhand. In this programme, experts from the institute share up-to-date information on crop cultivation, technology adaptation, socio-economic improvement and various agricultural schemes which is broadcasted every Sunday at 1910 h. Content analysis of the talks broadcasted showed that forty seven talks were broadcasted on information related to crop protection (17%), vegetable cultivation (6%), cereal, millet and pulses production techniques (17%), natural resource management techniques (17%), post-harvest management (11%), mechanization and occupational health (4%), fruit trees management (2%), income generation activities (9%), extension and awareness generation related aspects (11%) and nutrient management (6%).

7.3.5 Krishak Helpline

To facilitate farmers, the institute offers a toll-free helpline service to answer the queries raised by hill farmers on various aspects like crop varieties, seed availability, insect-pest and disease management, schemes, etc. Farmers can reach agriculture experts by dialing 1800-180-2311 on working days during 10 am to 5 pm. In year 2021, 75 queries were received from farmers, majority of which were related to crop protection (15%), seed availability (12%), vegetable cultivation (9%), fruit plantation (9%), training related (7%), mushroom cultivation (5%) mechanization (5%), weather related (5%) and extension related (19%).

7.3.6 Agro-advisory through ICT platforms

Agro-advisories are provided to farmers through Need based SMS services and *m-Kisan* portal. Informations 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. National level agro-advisories prepared by ICAR were also issued to farmers through SMS services and whatsapp during lockdown period due to COVID 19. Institute also issued various advisories related to safety measures with current farming operations such as harvesting, post-harvest management. Besides, 68 advisories were sent to 673 farmers through 21 WhatsApp groups, 75 phone calls were replied through Help Line, 6 messages through *mKisan* to 9,740 farmers; 26 need based messages to 936 farmers through phone were sent during reporting period.

7.3.7 Social media Platforms

Social media is the most recent form of digital communication. Social media platforms like facebook and twitter have a unique opportunity for institutes to reach an increased number of audiences in lesser time and with reduced resources. ICAR-VPKAS has its official facebook page https://www.facebook.com/www.vpkas.icar.gov.in and twitter account https://twitter.com/IVpkas to enhance its visibility in social media. Information on different field level activities, technologies developed by the institute and other information are being updated regularly.

7.4 *Swachhata Pakhwada*

On the first day of the "*Swachchhata Pakhawada*", a programme entitled, **"***Prakritik Kheti Sammelan***"** was organized under a national programme Vibrant Gujarat Summit. Honourable Sh. Raghunath Singh Chauhan, Deputy Speaker, Uttarakhand Assembly and MLA Almora chaired the programme. A total of 97 farmers from Almora, Bageshwar and Nainital districts of Uttarakhand and 72 staff members of the institute participated in the programme. During the programme, *address of Hon'ble Prime Minister to the nation on 'Natural Farming' was displayed to farmers.* The farmers were sensitized to disposal of organic waste under the theme "waste to wealth" and its importance in Natural Farming. Besides, a cleanliness campaign was organized at ICAR-VPKAS Experimental Farm, Hawalbagh under the supervision of Er. DC Mishra, Farm Superintendent.

Organization of *Prakritik Kheti Sammelan* at ICAR-VPKAS, Almora

A cleanliness drive was carried out at ICAR-VPKAS, Almora campus and Experimental Farm, Hawalbagh. A committee of senior officers in both campuses reviewed the progress. All files and other documents were kept properly in Almirah after weeding out old records in offices. Roads and

Cleanliness campaign at Experimental Farm, Hawalbagh

barren land in experimental farm were cleaned. In addition, staffs were sensitized about the importance of biodegradable and non-biodegradable waste disposal.

A demonstration was conducted on preparation of composting/vermi-compost from residues for the members of residential colony of ICAR-VPKAS and experimental farm, Hawalbagh. Plastic wastes were collected and disposed off to create the experimental farm as plastic-free zone.

On the occasion, a *gosthi* was organized in the ICAR-VPKAS Experimental Farm, Hawalbagh. The farmers of adopted village Lakhani and staff members of ICAR-VPKAS, Almora participated in the programme. A lecture was delivered on organic waste management from farms and kitchen, with focus on various techniques that can convert organic waste into value-added products like jeevamrut, beejamrut etc., which can further be utilized to enhance productivity of the raising crops. Various organic mulches and organic pesticides like '*Neemastra*', '*Aagnayastra*', which can be developed through farm waste along with few other ingredients (neem seed, chillies etc.), were told to the audience. An awareness session was organised on recycling of wastewater for its use in agriculture to aware the farmers on the subject. The farmers were explained

Cleanliness and sanitation drive at Almora and Experimental farm, Hawalbagh

Awareness session on recycling of waste water at Hawalbagh

about the construction of water structure and safe use of wastewater in agriculture. A total of 27 farmers of adopted village Lakhani participated in the programme.

A technology demonstration on agricultural technologies for conversion of waste to wealth was organised at Organic Block of Experimental Farm, Hawalbagh to aware the farmers on scientific ways of composting. Scientist explained the need of proper decomposition of organic waste to avoid the infestation of white grub.

Kisan Diwas (farmer's day) was organized at Experimental Farm, Hawalbagh as a part of *Swachhta Pakhwada* on December 23, 2021. This special day is celebrated every year to promote awareness amongst people about the importance of the farmers to the society. A Scientist-Farmer-Interaction programme was organized. The farmers were apprised of importance and benefits of scientific cultivation. A lecture on Disease management under Protected cultivation was delivered to the farmers.

A cleanliness *goshthi* was organized in the premises of the Institute at Almora on December 30, 2021. Shri Prakash Chandra Joshi, Hon'ble chairman of Municipal Corporation, Almora and Shri Hem Tiwari, Hon'ble member, Vivekananda Puri Ward, Almora graced the occasion as Chief Guest and Guest of Honour. All employees working in Almora campus participated in the programme. Appreciating the efforts of the Institute, the Hon'ble Chief Guest said that the Institute is a source of inspiration for offices and various institutions at Almora on cleanliness, which could be followed, by other institutions/offices in Almora. He said that the Institute has been making commendable contributions for the cleanliness of Almora City from time to time under which cleanliness in the *naula* (natural small drinking water reservoir) in the middle of the city adopted by the Institute is a notable one. Member, Vivekananda Puri Ward, Almora, in his remark gave the example of cleanliness of the Institute. On this occasion, Shri Vijay Kumar, an environment Mitra working in the Institute, was felicitated with cash awards and certificates for his outstanding contribution.

The valedictory programme of *Swachhata Pakhwada* was organized at ICAR-VPKAS Experimental Farm Hawalbagh on December 31, 2021. Dr. Ranjan Tiwari, Incharge Doctor of Community Health Centre, Hawalbagh and Mr. Amit Sah, Gram Pradhan of Hawalbagh village graced the occasion as Chief Guest and Guest of Honour. All employees working in Hawalbagh and few farmers of Hawalbagh and Udiyari villages participated in the programme. Dr. Ranjan Tiwari appreciated the activities of the institute in campus as well as in nearby villages and vision of Gram Pradhan, Mr Amit Sah, for his dream of Hawalbagh village as "*Kuda mukt gaon*." Mr. Amit Sah, requested the institute for adopting Hawalbagh village for agriculture and cleanliness activities. On this occasion, Shri Mantraj, an environment Mitra working in the Institute, was felicitated with cash awards and certificates for his outstanding contribution. Besides, 12 other staff members were also honoured for their valuable support in organizing a successful *Swachhata Pakhwada* programme.

Organization of cleanliness programme at Almora

Organization of Valedictory Programme during Swachchhata Pakhawada

7.5. Tribal Sub Plan (TSP)

Village clusters in four districts of Uttarakhand *viz.*, Chamoli, Dehradun, Almora and Udham Singh Nagar and Rajouri, Udhampur, Kathua, Poonch and Kupwara, Anantnag in J&K are adopted by the institute under Tribal Sub Plan with the objective of socio-economic development of the tribal communities of Uttarakhand and J&K. During the reporting period, a number of programmes were organized at the institute as well as at farmers' fields.

7.5.1 Farmer Trainings and Exposure Visits

Skill Development on Mushroom Cultivation for Income Enhancement

Three days training program on "Mushroom cultivation" was organized at Experimental farm, Hawalbagh during February 17-19, 2021 in which thirty-five participants from 4 villages *viz.*, Gamshali, Parsari, Malari, and Merag of Joshimath, district Chamoli participated. Farmers

Training programme on mushroom cultivation

were trained on cultivation technologies of button and oyster mushrooms. Farmers were given ready-made button mushroom bags, spawn of oyster mushroom and raw materials.

Skill Development on Improved Production Technologies

Four 5 days training programmes on "Skill development of farmers of high hills and border areas on improved production technologies" were organized at ICAR-VPKAS, Experimental Farm, Hawalbagh during March 05-25, 2021 for 156 farmers of Malari and Mana villages of Joshimath block of Chamoli district. The farmers were imparted information on improved varieties of hill crops, improved crop production technologies, disease and insect-pest management, seed production, small tools and farm machinery, and mushroom production. They were also sensitized on '*Swachha Bharat Abhiyan*'. Exposure visits of progressive farmers to adopted village Bhagartola and Krishi Vigyan Kendra, Gwaldam were also organised for awareness generation.

During the *Kisan Mela* organized at GBPUAT, Pantnagar in March 2021, an exposure visit of 42 tribal farmers was conducted. The farmers were exposed to progressive agricultural technologies including crops/seed production, medicinal plants, machineries, post harvest processing technology, and other technologies developed by various organization.

7.5.2 Krishak Goshthis and Farmer-Scientist Interactions

A '*Krishak Gosthi* on *Fall Sainik Keet: Lakshan, pehchaan evam prabandhan'* was held at Dhanpau of Jaunsar tribal area of district Dehradun on July 13, 2021. Farmers were imparted information about identification and control of fall armyworm in maize. Information regarding scientific methods of cultivation of important *kharif* crops was also shared and agriculture-related problems faced by them were addressed. Feedback of the farmers on the performance of institute's varieties was also obtained. During field visits, on-spot solutions for management of diseases and insects were provided. A total of 21 farmers participated in the programme. A visit was undertaken to Kwanu and Dhanpau-Lakhwad village cluster in November 2021, for monitoring of ongoing FLDs and conduct the programme '*Buwai-poorva prakshikshan evam rabi pradarshanon hetu beej vitran*'. On the occasion, seed of onion variety VL *Piaz* 3 and garden pea varieties VL *Sabji Matar* 13 and Arkel were

Skill Development through Training Programme

provided to the farmers for demonstrations. Total 17 farmers participated in the programme. Field monitoring visits were also conducted in Kwanu and Dhanpau-Lakhwad clusters in mid November 2021. During the Kwanu visit, demonstrations of garden pea varieties VL *Sabji Matar* 13 and Arkel were monitored and a programme '*VL Sabji Matar 15 ka prakshetra pradarshan: gosthi evam beej vitran*' was organized. Seed of VL *Sabji Matar* 15 and GS 10 was provided to selected farmers for conducting demonstrations during *Rabi* 2021-22. During visit to Dhanpau-Lakhwad cluster, ongoing FLDs were monitored and a farmer-scientist interaction was held primarily to discuss introduction of new and profitable interventions, such as rajmash cultivation, in the cluster.

7.5.3 Development of IPM Modules

Designing and development of full fledged IPM programme for management of Cut worm in Rajma and other vegetable crops in Niti and Mana village clusters

The black cut worm (*Agrotis segetum*) is highly polyphagous and notorious pest of Rajma and other vegetables in Niti and Mana village clusters of Uttarakhand, India. Cutworms infest the crop in the early stages of the crop, especially at the time of transplantation. Scientists visited the tribal villages in the month of May-June, 2020, observed the damage symptoms, and collected the hidden larval stages for morphological and molecular characterization. Based on morphology of the larvae, it was identified as black cut worm (*Agrotis segetum*) and the management strategies were planned accordingly and the damage of cut worm was reduced to a tune of 65-80% in rajma crop and other vegetables in Niti and Mana village clusters of Uttarakhand, India.

7.5.4 Distribution of inputs

For *Rabi* 2021-22 demonstrations, a total of 70.0 q seed of four wheat varieties, namely, VL *Gehun* 829, VL *Gehun* 907, VL *Gehun* 953 and VL *Gehun* 967 was distributed in Dhanpau-Lakhwad village cluster and 55.0 q of the same four varieties was distributed in Kwanu cluster of Jaunsar tribal area of district Dehradun. In addition to this, seed of turmeric (25 q), ginger (1 q), garden pea (15 q) and onion (40 kg) was also distributed for demonstrations.

Distribution of seeds in Dhanpau and Kwanu cluster

For demonstration in the newly adopted tribal clusters, 80.0 q seed of wheat varieties was supplied to SKUAST-Jammu for conducting demonstrations in tribal areas of district Rajouri, Kathua, Poonch, Udhampur, Kupwara and Anantnag in Jammu & Kashmir. In addition to seed, other inputs such

Distribution of fertilizers and weedicides in Jhankat and Nakulia tribal clusters

as fertilizers (urea and NPK) and weedicides were distributed for wheat seed production demonstrations in about 23.0 ha. in Jhankat and Nakulia tribal villages of block Sitarganj Udham Singh Nagar district, Uttarakhand.

7.5.5 Technology demonstration

Institute's new technologies were demonstrated to the farmers. These included demonstration of early maturing garden pea variety VL *Sabji Matar* 13 and first white finger millet variety of the state VL *Mandua* 382. On-site demonstration and hands-on training on '*Padap vriddhikarak jeevanu ke prayog se gehun utpadakta mein vriddhi*' was also conducted in Kwanu tribal cluster to demonstrate the yield-enhancing effect of PGPR VL Bioagent 23.

7.5.6 Technology impact assessment

The impact of drudgery-mitigating and energy-efficient interventions (power-operated chaff cutter and VL *Syahi* Hal) introduced in the village clusters was assessed. Introduction of power-operated chaff cutter considerably reduced time and energy compared to manual fodder chopping. According to the farmers, VL *Syahi Hal*, besides being lightweight and therefore, convenient to carry, was more efficient in turning soil over compared to their traditional wooden *hal*. It was also cheaper and easier to maintain than the wooden hal. Another important impact of introduction of VL *Syahi Hal* was that it obviated the need to fell trees for making the *hals* and thereby, contributed to conservation of forest trees.

7.5.7 Establishment of Farmer Participatory Seed Production System

Seed production programme was undertaken at Kailashpur (3300 amsl) in Niti Valley during *Kharif* season. A total of 600 kg seed of French bean variety VL *Bean* 2 was procured from six Self Help Groups of the village. Approximately 90 percent VL Bean 2 seed of last year produce was distributed among 500 tribal farmers of Niti-Mana valley.

Farmer participatory seed production (FPSP) activities were undertaken in TSP during *Rabi* 2021-22 for the tribal farmers of Jhankat and Nakulia Villages, Sitarganj, District Udham Singh Nagar, Uttarakhand. A total of 54 beneficiary farmers from the two villages were selected for producing truthfully labelled (TLS) seed of four improved, high yielding wheat varieties, i.e., VL *Gehun* 907, VL *Gehun* 953, VL *Gehun* 967 and VL *Gehun* 2014 from ICAR – VPKAS, Almora. These beneficiary farmers committed their 23 hectares land area (average size – 1 acre) for FPSP seed production and accordingly, inputs, i.e., seed of four varieties (23 q), fertilizers (basal and top-dress) [urea: 71.6 q; NPK: 51 q], weedicides (Pinoxaden and Metasulfuron) [26.3L] and fungicides (Propicanazole) [12.5 L] were distributed to them as per recommended doses. IFFCO-NPK (12-32-16) and neem coated urea were initially distributed for basal dose, followed by two split doses of urea at appropriate stages. Weedicides (Pinoxaden and Metasulfuron) were distributed for managing narrow and broadleaf weeds in the wheat crops. Fungicide (Propicanazole) was given to them as a prophylactic spray for managing the Karnal bunt. Along with input distribution, different *gosthis* were organized regarding diverse topics like recommended use of inputs, weed control, disease control and other good practices for quality wheat seed production through farmers' participatory seed production (FPSP). Farmer's fields were monitored by the team of scientists and technical staff in due intervals. The post-flowering rouging in the field was also practiced by the farmers in the supervision of the technical staff of ICAR-VPKAS, Almora.

7.6. Scheduled Caste Sub-Plan (SCSP) Programme

7.6.1 Handing over of polyhouses

Fabrication of 52 naturally ventilated polyhouses was completed for Scheduled Caste (SC) farmers in Bageshwar, Nainital and Almora districts of Uttarakhand. These polyhouses were 18.2 m long, 5.5 m wide with 2.3 m height on sides and 4.0 m height in the center with total area of 100 sq m. A *Kisan Goshthi*-cum-interaction meeting was held on March 17, 2021 in the village Lakhani of Bageshwar district. Dr. H.S. Gupta, Ex-Director General, Borlaug Institute of South Asia (BISA) was the chief guest and Dr. J.C. Rana, Member International Agro-biodiversity was the special guest. The newly fabricated naturally ventilated polyhouses (100 sq m size each) were handed over to the concerned farmers for the purpose of enhancing income from

Handing over of fabricated polyhouses to farmers

hill farming. More than 150 farmers participated in the *Kisan Gosthi*.

7.6.2 Agriculture input distribution

Krishak Gosthi was organised in Lakhani and Uderkhani villages on July 28 in which different agriculture inputs were distributed to SC farmers. A live demonstration on honeybee keeping and use of power operated knapsack sprayer was also distributed. On the occasion, 42 battery operated knapsack sprayers (22 from AICRP on Vegetable SCSP and 20 from AICRP on Mushroom SCSP), 1,600 citrus plants (800 kaagazi nimboo, 400 malta and 400 narangi), 56 kg *Bacillus cereus* WGPSB2 powder, 200 fodder trees (60 oak, 50 bhimal, 50 kachnaar and 40 kharik) and 4 honey bee boxes were distributed.

Distribution of agriculture inputs to farmers

7.6.3 Training on vegetable production under protected conditions

A 5-days training program on "vegetable production under protected condition" was organized at Experimental Farm, Hawalbagh during December 20-24. A total of 26 progressive farmers from Lakhani village of Bageshwar district participated in the training program. Farmers were made acquainted with polyhouse technology, nursery preparation, water management, insect-pest management, nutrient management and small farm machinery utilised under protected conditions. In order to showcase the model of socio-economic empowerment of farmers through multiple interventions in institute's adopted village Bhagartola, one-day exposure visit of trainee farmers was organised.

Training program on vegetable production under protected condition

7.6.4 Insect Pest management

Visits were conducted regularly to control insect-pest in vegetables under protected condition. Three quintals of *Bacillus cereus* WGPSB2 for management of first instars of white grubs was distributed to famers of adapted villages. On farm demonstration was organized and farmers were shown to formulate the biocontrol agent in well decomposed farm yard manure and different methods of field application were demonstrated. A training programme was organized at Lakhani village regarding rodent pest management. The farmers were educated about the life cycle of field rats, their breeding sites, damage symptoms and ways to manage the rodent pests. Zinc phosphide (0.05%) was distributed to the farmers.

Control of cutworm under protected conditions

7.6.5 Bee keeping

Four bee boxes of Indian bee (*Apis cerena indica*) were distributed to famers and they were demonstrated

about summer and winter management. Training was provide on cleaning the colony, honey extraction procedure, sieving and packaging of honey.

7.6.6 Frontline Demonstrations

A frontline demonstration of improved wheat variety of VL *Gehun* 967 was conducted in village Pokhari, block Takula, District Almora with active participation of women SC farmers to demonstrate the potential of new varieties to the farmers.

Demonstration of VL *Gehun* 967

7.6.7 Interaction meetings

On January 06, Scientist-farmer's interaction meeting was conducted in Lakhani and Uderkhani villages to monitor agriculture development activities. Farmers of both the villages participated in the meeting. On August 28, 2021, *Krishak Gosthi* was organised with the theme "Food and Nutrition

Interaction meeting at Uderkhani

***Krishak Gosthi* at Lakhani**

Poshan Vatika Mahabhiyaan evam Vriksharopan

for farmers" at Lakhani village. Farmers and farm women were made aware about the nutritional importance of millets and other traditional crops of hills. On the occasion of curtain raiser of International Year of Millets 2023, a programme on "*Poshan Vatika Mahabhiyaan evam Vriksharopan*" was conducted and fruits plants were distributed amongst farmers. Under the event of Hon'ble PM Programme, a farmers'-Scientists Interaction was organized at ICAR-VPKAS Experimental Farm, Hawalbagh, Almora on September 28 as well as virtual programme was displayed. On this occasion, a Farmer-Scientist dialogue was organized by the institute. The farmers were informed about the various technologies of the institute.

7.6.8 Nursery Management

Nurseries of onion (VL *Piaz* 3) were laid out in farmer's field. Field training on scientific practices of onion nursery preparation and management was imparted. Around 20,000 seedlings of onion were bought back from farmers which encouraged them to enhance their farm income through nursery preparation.

Nursery preparation of onion at farmer's field

7.6.9 Off Season Vegetable Production

During the year 2021, farmers were able to fetch B:C ratio of 2.34 from production of tomato, capsicum, cauliflower, cabbage, etc.

7.6.10 Soil Health Card

Soil heath cards of SC farmers of Lakhani village were prepared and distributed to farmers on Soil

Health Day. These cards showed the status of soil health of the concerned farmer and soil test based nutrients recommendations for important crops.

Soil Health Card Distribution

7.6.11 Demonstration of button mushroom production technology

During *Rabi* 2020-21, button mushroom compost (80.0 q) was supplied among 14 farmers of villages Uderkhani and Lob, district Bageshwar and Krishi Vigyan Kendra, Kafligair, Bageshwar (20 q). Out of total compost, a total of 1914.0 kg of fresh button mushroom were harvested. Farmers were able to sale fresh mushrooms at an average price of Rs. 170.00 per kg in the local market and Bageshwar district market. They earned approximately Rs. 3, 25,380.00 from a very short span (2.5-3 months) of time.

During *Rabi* 2021-22, a total of 106.0 q button mushroom compost was supplied among 32 farmers of villages Lakhani, Uderkhani and Lob, district Bageshwar and Krishi Vigyan Kendra, Kafligair, Bageshwar.

7.6.12 Group Formation

Economic situation and empowerment of women can be improved through formation of groups as a platform for joint activities, savings and solidarity. Women SC farmers of Lakhani village were mobilised to form SHGs to encourage collective action. One women SHG "*Vivekananda Mahila Kisan Samooh Pratham*" was formed and linked to bank.

Group mobilising activities

Button mushroom production at farmer's field

7.6.13 Demonstration of improved agriculture practices

Improved varieties of wheat, rice, pulses and vegetables were demonstrated at farmer's field with improved agriculture practices *viz*. line sowing, proper spacing, insect-pest management, water management and use of improved small agricultural implements.

Line sowing in wheat crop

Water harvesting at farmer's field

8. Success Stories

8.1. Mushroom Production: A source of income generation

The Challenge

Mr. Nandan Prasad, a 61-year-old Scheduled Caste (SC) farmer of village Uderkhani of district Bageshwar, is having the responsibility of seven members' joint family living below poverty line (BPL). His primary occupation is agriculture; however, previously he was also engaged in traditional occupation of copper smithy. He is having around 18-nali land (3,600 sq m), out of which 10 nali (2,000 sq m) is irrigated. He along with his young son Mahendra Prasad has been growing various crops for their family survival. However, enhancement of income from small piece of land for seven-member family has always been a challenge.

The Solution

ICAR–Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora along with its KrishiVigyan Kendra, Kafligair (Bageshwar) selected Uderkhani village of Bageshwar district for implementation of its Scheduled Cast Sub-Plan (SCSP) Programme. During the visit of scientists in the village and interaction meetings with farmers, Mr. Nandan Prasad and some other farmers showed interest for mushroom production. However, they were not having any experience or skill of this venture.

It was a new venture in this village since nobody was involved in mushroom production. A training programme was organized by ICAR-VPKAS, Almora for the farmers of village Uderkhani at KVK (ICAR-VPKAS), Kafligair, Bageshwar under SCSP Programme. Demonstrations of button mushroom were also laid down at farmers' field.

The Application

After getting training on mushroom production and demonstrations of button mushroom, Mr. Nandan Prasad started to take keen interest in mushroom production. He started this venture with 5 Qtl pasteurized compost in an abandoned room after proper cleaning and sanitation. He remained in touch with the experts and performed all the processes. The close monitoring, awareness, zeal to grow a new product of the area and sincerity led to produce a bumper crop of button mushroom and Mr. Nandan Prasad produced 100 kg saleable button mushroom. It was the first mushroom production in the area.

The Impact

He sold his produce at an average price of Rs. 170/- per kg in the nearby market and earned Rs. 17000/- from a very short span of time. Thus, he could develop the belief among the fellow farmers about this new commodity of the area. Now, he has

Dr H. S. Gupta, Former DG, BISA; Dr J C Rana, National Coordinator, UN Environment GEF project and Country Representative, India Office of Alliance of Biodiversity International & CIAT, New Delhi; Dr Lakshmi Kant, Director, ICAR-VPKAS visiting the mushroom production room of Mr Nandan Prasad

become the lead mushroom grower of the area and many other farmers are approaching him to know and adopt the mushroom farming. In the words of Mr. Nandan Prasad "Mushroom production is a profitable venture especially for the marginal farmers, it is safe from the two major threats of hill agriculture *viz.,* wild animals and weather vagaries."

8.2. Enhancing horse gram production through improved technologies is paving a way to livelihood security among hill farmers in Uttarakhand

The Challenge

Horse gram is one of the major *kharif* pulse in North Western Himalayan hills particularly, in the state of Uttarakhand. It plays an integral role in hill agriculture as well as provide livelihood and food security to the millions of rural inhabitants. Due to non-availability of quality seeds of improved varieties, improper crop management, poor agricultural mechanization and post-harvest processing, farmers of the region were not able to reap the potential benefits from its cultivation.

The solution

Improved high yielding cultivars of horse gram (VL *Gahat* 15 and VL *Gahat* 19) have appreciable yield potential of 8-10 q/ha as compared to local landraces along with resistance against wilt, anthracnose and other prevalent diseases. These varieties also have suitability for organic farming conditions. In addition to improved varieties, scientific crop management practices, farm mechanization implements and post-harvest processing methods offer an excellent solution for enhancing the profitability of farmers.

The Application

High yielding varieties along with improved crop management practices were demonstrated in the different villages namely Mujholi, Bhat gaon, Gallibaseura of Almora district, where horse gram is grown at large scale. Improved small tools were also introduced for ease in adopting the improved agricultural practices and preparation of value added products like tofu and milk were also demonstrated to farmers for income generation.

The Impact

Appreciable yield enhancement and profitability was realized through the adoption of improved varieties with recommended package of practices. With full package of practices, the crop yield improved significantly in horse gram by 30-35%, respectively than traditional crop cultivation practices. The income of farmers with the improved technologies was enhanced from ₹36,070- 66,270 per ha due to premium prices of horsegram in the market. The B:C ratio also improved from 0.66-1.21. Overall,

from the cultivation of improved varieties farmers earned the benefit of ₹30,200/ha than traditional cultivars.

8.3. Microbial Stimulant for Shortening Mushroom Pinhead Initiation and Enhancing Yield

The Challenge

Commercial mushroom production is based on a series of solid fermentation stages under controlled conditions in which bacteria and fungi have major roles in processing raw materials, minimizing fungal competitors and inducing fructification. A wide variety of interactions between bacteria and cultivated mushrooms has been described leading to both positive and negative outcomes for the fungus, depending on the bacterial isolate and the developmental stage of the fungus. The casing is the coverage material placed onto the substrate colonized by the host mycelium. Some of the most commonly cultivated species of mushrooms *i.e. Agaricus bisporus* and *Macrocybe gigantea* require casing to fructify. The mycelium of these fungi secrete volatile organic compounds (VOCs) which act to suppress the initiation of fructification. Normally in *Macrocybe gigantean* and *Agaricus bisporus* primodial/pinhead initiation period is longer (~13-15 days) and yield of crop is low. Therefore, there is need to be reduce the primordial initiation period and to enhance the yield of edible mushroom.

The Solution

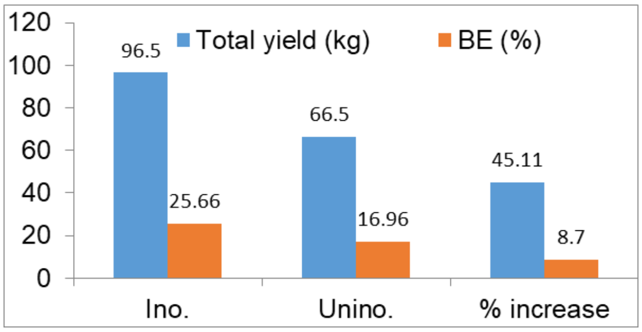
Casing application of *Pseudomonas* sp. NARs9 enhanced *Macrocybe gigantea* fruiting body yield by 116.1% and 104.4% in comparison to untreated control during 2018 & 2019, respectively. The pinhead initiation period was also reduced (7.5 and 7.0 days) in comparison to control (13.5 and 12.0 days). During *rabi* 2018-19 and 2019-20, casing application of *Pseudomonas* sp. NARs9 resulted in 38.3% and 43.0% higher yield of *Agaricus bisporus* in comparison to untreated control, respectively. The pinhead initiation period was also reduced (8.7 and 8.0 days) in comparison to control (11.0 and 11.3 days), respectively.

The Application

We found shortening of primodial initiation period in edible mushroom by adding a microbial stimulant *Pseudomonas* sp. NARs9 strain, which results in enhancement in yield of edible mushrooms. The liquid formulation of microbial stimulant/enhancer was found to shorten pinhead initiation period in edible mushrooms, *Macrocybe gigantea* and *Agaricus bisporus* with enhanced yield. Yield enhancement in edible mushroom, *Macrocybe gigantea* (>75%) and white button mushroom, *Agaricus bisporus* (>30%) in comparison to uninoculated control was recorded. The primordial initiation duration was shortened by 6 and 3 days in *M. gigantea* and *A. bisporus*, respectively, as compared to uninoculated control.

The Impact

The promising *Pseudomonas* sp. NARs9 was inoculated at farmer's field. The bioagent was applied in 47 bags (8 kg compost) of button mushroom at the time of casing soil application, whereas 49 bags were kept uninoculated. The total yield obtained was 96.5 kg (25.7% biological efficiency, BE) against 66.5 kg of uninoculated control (16.96% BE). The per cent increase in yield and BE were 45.1% and 8.7%, respectively.



When this strain was applied in casing soil of *Macrocybe gigantea* mushroom bags at farmer's field, average yield obtained was 850g per bag (85.0% BE) which was 54.5% higher than that of untreated control.

9. Farmers' Feedback

I have been associated with ICAR-VPKAS, Almora since 2016-17. I am cultivating both button and oyster mushrooms. I highly appreciate the Institute for its commendable work in providing technical guidance for mushroom cultivation and good quality spawn of mushrooms and solutions to various diseases/abiotic disorders prevailed during cultivation. I am thankful to the Institute for the support and hope it will continue in future also.

Smt. Bhawana Arya
Vill. Kanar, Dwarahat, Almora

I came in contact with ICAR-VPKAS, Almora during 2020-21. The institute has installed a polyhouse and a polytank at my field under SCSP programme and I have started cultivating vegetables under polyhouse. Besides, we have been given button mushroom compost, quality spawn and casing soil for button mushroom production. I have been getting agricultural machineries and seeds of *rabi* and *kharif* seasons from time to time and also training on improved farming which makes it easier for me to do improved farming. I thank the Institute and hope to continue to provide schemes related information by guiding the schedule caste farmers.

Shri. Pratap Ram Vill. Lakahni, Bageshwar

I have been cultivating maize from long ago but cultivation of local cultivars of maize was not very profitable due to low yield, proneness to lodging and susceptibility to insect & disease. During 2019, I came in contact with ICAR-VPKAS during front line demonstrations of improved varieties at my village. By adopting improved varieties (VMH 45, VMH53, VLMH 57 and VLQPMH 59) with recommended production and protection technologies, I had achieved 35-60% higher production than local cultivars. I would like to continue growing improved maize varieties with technical guidance of scientist of ICAR-VPKAS.

Mr. Rajender Singh Koranga,
Village Shama, Bageshwar

I used to grow local rajmash and pea varieties for a long time. Due to poor productivity of these varieties, I received very low profit. With the help of ICAR-VPKAS, I along with other farmers started using bioagents in rajmash and getting more yield as compared to uninoculated control. I had treated garden pea seed with VL *Bioagent* 23 and got enhanced green pea yield by 1.5 fold as compared to untreated control. Use of bioagent provided good profit from garden pea production. We are also benefitted by the field demonstrations and on-farm training on bio-inoculants by the institute under NMHS project.

Mr. Govind Singh, Parasri,
Chamoli, Uttarakhand

10. Trainings & Capacity Building

Training of Institute Personnel

The following institute personnels were deputed for different HRD programmes as per Annual Training Plan (ATP) during 2021 (Table 10.1).

Table 10.1. Details of trainings undergone by institute staff

Duration	Participant	Topic	Venue
Scientific staff			
May 3-5, 2021	Mr. Amit Umesh Paschpur	Inspection and Sampling under Insecticide Act, 1968	NIPHM, Hyderabad
May 18-20, 2021	Mr. Chandan Maharana	Entrepreneurship Development in Mushroom Cultivation	ICAR-Directorate of Mushroom Research, Solan, H.P.
June 14-25, 2021	Dr. K.K. Mishra	Management Development Programme on Leadership Development (online)	ICAR-NAARM, Hyderabad
July 12-14, 2021	Drs. R.S. Pal, Devender Sharma and Navin C. Gahtyari	International training on Bio-fortification: A Key to Nutritional Security virtual/online	MANAGE and Harvest Plus India
July 26-30, 2021	Er. Hitesh Bijarniya	Ergonomical Design Guidelines for Agricultural Tools, Equipment and workplaces (online)	ICAR-CIAE, Bhopal
July 19 to August 01, 2021	Dr. Anuradha Bhartiya	PGR Management and Utilization (online)	ICAR-NBPGR, New Delhi
August 09-13, 2021	Drs. Priyanka Khati and Asha Kumari	Online training program on "Climate Change: Challenge and responsibility" for women scientist	Centre for Disaster Management (CDM), Lal Bahadur Shastri National Academy of Administration (LBSNAA), Mussoorie, Uttarakhand-248179
August 10-12, 2021	Dr. Shyam Nath	Sustainable Technological Interventions for Entrepreneurship Development in Tribal Zone	ICAR-NAARM, Hyderabad
August 16-18, 2021	Dr. J.K. Bisht	Training workshop for vigilance officer of ICAR institutes (online)	ICAR-NAARM, Hyderabad
August 23 to September 01, 2021	Dr. Kushagra Joshi	Advances in Extension Research and Evaluation Methodology	ICAR-NAARM, Hyderabad

Duration	Participant	Topic	Venue
September 1-10, 2021	Dr. Renu Jethi	Effective extension method for upscaling and outscaling of wheat and barley production technologies	Extension Education Institute, Nilokheri, Haryana
September 15-24, 2021	Dr. K.K. Mishra	Training on Biosecurity and biosafety: Policies, diagnostics, phytosanitary treatments and issues	ICAR-NBPGR, New Delhi
September 28-30, 2021	Drs . Rakesh Bhowmick and Sougata Bhattacharjee	Transcriptomic Data Analysis (online)	ICAR-IASRI, New Delhi
October 4-8, 2021	Dr Renu Jethi	Data Analysis in Social Science Research (online)	ICAR-NAARM, Hyderabad
16-17 December, 2021	Drs. K.K. Mishra and N.C. Gathyari	Virtual Training on Wheat Blast and *Fusarium* Head Blight	ICAR-IIWR, Karnal
December 13-24, 2021	Drs . Nirmal Hedau and B.M. Pandey	Management Development Programme on Leadership Development (online)	ICAR-NAARM, Hyderabad
Technical staff			
January 19-23, 2021	Mr. Harish Chandra Joshi	"Market Led Extension" (online)	SAMETI, (GBPUA & T Pantnagar), Uttarakhand
May 3 to 5, 2021	Mr. J.P. Gupta	Inspection and Sampling under Insecticide Act, 1968	NIPHM, Hyderabad
May 18-20, 2021	Mr. Harish Chandra Joshi	Entrepreneurship Development in Mushroom Cultivation	ICAR-Directorate of Mushroom Research, Solan, H.P.
June 07 – 10, 2021	Shri Sanjay Kumar Arya	Public Procurement for Government Officers (online)	Arun Jaitley National Institute of Financial Management (AJNIFM), Faridabad
June 16-18, 2021	Dr. Kamal K. Pande	Vertebrate Pest Management online	NIPHM, Hyderabad
July 14 to 16, 2021	Shri Harish Chandra Joshi	'Non- Insect Pest Management - Mites, Crabs, Snails, Slugs and Avian' (online)	National Institute of Plant Health Management, Hyderabad
August 9-11, 2021	Shri Harish Chandra Joshi	Road map for KVK's to enhance mushroom production and consumption (online)	ICAR-IIHR, Banguluru
October 20-29, 2021	Mr. Ajit Bisht	Experimental Data Analysis for Technical personnel in NARES (online)	ICAR-IASRI, New Delhi
Administrative staff			
06-08 January, 2021	Shri. Sunder Ram	Technical Service Rules for Assistants /AAOs /AOs / SAOs/ Technical staff/other staff of ICAR Institutes dealing with Technical Service Rules (online)	ICAR- NAARM, Hyderabad

Duration	Participant	Topic	Venue
June 28 to July 02, 2021	Shri. Sunder Ram	Establishment Rules-1 & 2 (ER-01-06) (online)	ISTM, New Delhi
July 5-7, 2021	Shri. Sunder Ram	Pay fixation (WPF-24) (online)	ISTM, New Delhi
September 6-8, 2021	Mrs. Radhika Arya	Implications of new labour codes, 2020 for ICAR for Administrative and Finance and other Officers of ICAR (online)	ICAR-NAARM, Hyderabad
October 6-8, 2021	Mr. Naveen Chandra Joshi	Asset Management (online)	ICAR-IARI, New Delhi

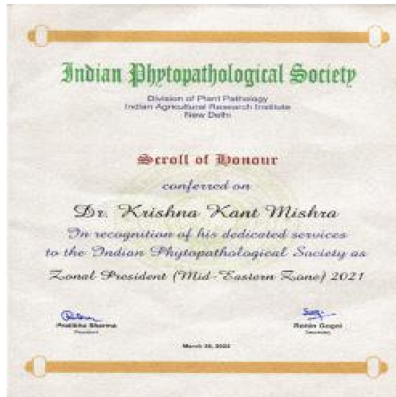
11. Awards & Recognitions

- ICAR-VPKAS, Almora was awarded Best Performance centre (ICAR Institute Category) under ICAR Seed Project for the year 2020-21 during (virtual) Joint Annual Group Meeting of AICRP-NSP (Crops) & ICAR Seed Project held during April 21-22, 2021.

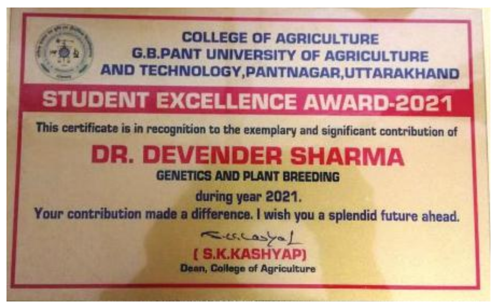
- Dr. Lakshmi Kant, Director, ICAR- VPKAS, Almora has been awarded Dr. MV Rao Memorial Award for the year 2021 announced by the Society for Advancement of Wheat and Barley Research (SAWBAR), Karnal.

- Dr. K. K. Mishra, Principal Scientist (Plant Pathology) received Reviewer Award 2021 by Indian Phytopathological Society, IARI, New Delhi.

- Dr. K. K. Mishra served as Zonal President (Mid-Eastern zone)-2021 of Indian Phytopathological Society, New Delhi.



- Dr. Devender Sharma, Scientist received Student Excellence Award 2021 by G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India.



- Dr. Pankaj Nautiyal, SMS (Horticulture), KVK, Uttarkashi was felicitated as "Corona Worrier" by district administration, Uttarkashi.

- Mr. Jeevan B., Scientist (Plant Pathology) received Elsevier Reviewer Recognition 2021.

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
- SSJ University, Almora, Uttarakhand

12.2. National Institutes and Agricultural Universities

- ICAR-Indian Agricultural Research Institute, New Delhi
- ICAR-Central Rice Research Institute, Cuttack, Odisha
- ICAR- Indian Institute of Wheat & Barley Research, Karnal, Haryana
- ICAR-Indian Institute of Rice Research, Hyderabad, Telangana
- ICAR-Indian Institute of Millet Research, Hyderabad, Telangana
- ICAR-Indian Institute of Maize Research, New Delhi
- ICAR- Indian Institute of Pulses Research, Kanpur, Uttar Pradesh
- ICAR-Indian Institute of Seed Science Mau, Uttara Pradesh
- ICAR-Indian Institute of Soil and Water Conservation, Dehradun, Uttarakhand
- ICAR-Central Institute of Temperate Horticulture, RS Mukteshwar, Uttarakhand
- ICAR-National Bureau of Agriculturally Important Microorganism, Mau, Uttar Pradesh
- ICAR-National Centre for Integrated Pest Management, New Delhi
- ICAR-Central Institute of Post Harvest Engineering and Technology, Ludhiana
- ICAR-Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh
- ICAR-Central Research Institute for Dryland Agriculture, Hyderabad, Telangana
- ICAR-Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh
- ICAR-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
- ICAR-Central Research Institute for Dryland Agriculture, Hyderabad
- ICAR-Central Institute of Post-Harvest Engineering & Technology, Ludhiana

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
- Watershed Management Directorate, Uttarakhand
- NGOs [Syahi Devi Vikas Samiti, Almora; Himalayan Environmental Studies & Conservation Organization (HESCO), Dehradun; Himmotthan, Dehradun etc.]
- Department of Agriculture and Cooperation
- Departments of North Eastern Hill States

13. Important Committees of the Institute

13-1- jktHkk"kk dk;kZo;u lfefr

- डॉ0 लक्ष्मी कान्त – निदेशक, अध्यक्ष
- डॉ0 रेनू जेठी – वरिष्ठ वैज्ञानिक, सदस्या
- डॉ. अमित पश्चापुर – वैज्ञानिक
- वरिष्ठ प्रशासनिक अधिकारी – सदस्य
- वित्त एवं लेखाअधिकारी – सदस्य
- श्रीमती रेनू सनवाल–सहायक मुख्य तकनीकी अधिकारी, सदस्या
- श्रीमती राधिका आर्या –सहायक प्रशासनिक अधिकारी, सदस्या
- ललित मोहन तिवारी– प्रभारी सदस्य सचिव

13.2. Institute Joint Council (IJC)

Chairman – Dr Lakshmi Kant, Director

Members (Official Side) – Drs. N.K. Hedau, Pr. Scientist; Kushagra Joshi, Scientist; Shri R.S. Negi, Senior Administrative Officer; Shri B.C. Pandey, Finance & Accounts Officer; Mrs. Radhika Arya, Assistant Administrative Officer; Shri Lalit Mohan Tiwari, Assistant Administrative Officer

Members (Staff Side) – Mr. Sachin Kumar Pandey, UDC; Shri Vishnu Dutt Pandey, LDC; Mr. Medni Pratap Singh, Farm Manager; Mr. Neeraj Kumar Pandey, Technical Assistant; Mr. Mohan Chandra Bhatt, SSS; Mr. Bhagwan Ballabh Tiwari, SSS

13.3. Research Advisory Committee (RAC) (upto 16.03.2021)

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; Dr. A. Pattanayak, Director, ICAR-VPKAS, Almora, Uttarakhand (upto 17.02.2020), Dr. Lakshmi Kant, Director, ICAR-VPKAS, Almora (*w.e.f.* 18.02.2020); Shri. Nagendra Kumar, farmer member; Shri Sushil Tyagi, farmer member

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

(*w.e.f.* 17.03.2021)

Chairman – Dr. H.S. Gupta, Ex. Director General, Borlaug Institute of South Asia (BISA)

Members – Assistant Director General (Seed), Indian Council of Agricultural Research, Krishi Bhawan, New Delhi; Dr. S.R. Maloo, Ex- Director Research and Associate Director (Seeds & Farms), MPUAT, Udaipur, Dean & Chairman, Faculty of Agriculture Sciences, Pacific University, Udaipur; Dr. C. Chattopadhyay, Principal Scientist (Plant Pathology), IIAB, Ranchi; Dr. H.C. Bhattacharyya, Dean, Daffodil College of Horticulture, DMET, Khetri, Kamrup (Metro); Dr. Mahesh Chandra, Head, Extension Education Division, ICAR-IVRI, Izatnagar-Bareilly; Dr. Anjani Kumar, International Food Policy Research Institute (IFPRI), CG Block, NASC Complex, Pusa, New Delhi; Dr. Lakshmi Kant, Director, ICAR-VPKAS, Almora;

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

13.4. Institute Management Committee (IMC)

Chairman – Director, ICAR-VPKAS, Almora

Members – Assistant Director General (Seeds), ICAR, New Delhi; Joint Director of Agriculture, Govt. of Uttarakhand; Director of Agriculture, Govt. of Jammu & Kashmir; Director, Directorate of Extension Education, GBPUA&T, Pantnagar; Dr Rajnarayan, Station In-Charge, ICAR-IVRI, Mukteshwar; Dr. Mamta Arya, Office In-Charge, NBPGR Regional Station, Bhowali; Dr. J.K. Bisht, ICAR-VPKAS, Almora; Dr. Lakshmi Kant, ICAR-VPKAS, Almora; The Finance & Accounts Officer, IVRI, Bareilly; Shri Nagendra Kumar, Non-Official/ farmer member; Shri Sushil Tyagi, Non-Official/ farmer member

Member Secretary – Sr. Administrative Officer/ Administrative Officer

13.5. Institute Research Council (IRC)

Chairman – Director

Members – All the Scientists of ICAR- VPKAS, Almora

Member Secretary – In-charge (PME Cell)

13.6. Institute Technology Management Committee (ITMC)

Chairman – Dr. Lakshmi Kant, Director

Members – Head, Crop Improvement Division; Head, Crop Production Division; Dr. Arun Kishore, CITH RS, Mukteshwar; Dr. J.K. Bisht, Pr. Scientist, In Charge, PME

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

13.7. 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 (upto 28.10.2021); Finance and Accounts Officer

13.8. Study Leave Committee (SLC)

Chairman –Dr. J.K. Bisht, Head, CPD

Member – Drs. P.K. Mishra, Pr. Scientist, N.K. Hedau, Pr. Scientist

Member Secretary –Mr. R.S. Negi, Sr. Administrative Officer

13.9. PERMISNET/PIMSICAR/HYPM

Nodal Officer – Dr. Renu Jethi, Sr. Scientist

13.10. Committee for Monitoring of Field Experiments

Chairman – Dr. Lakshmi Kant, Director, ICAR-VPKAS, Almora

Members – All the Scientists of ICAR-VPKAS, Almora

Member-Secretary - In-charge, PME Cell

13.11. Vigilance Officer (VO)

Dr. J.K. Bisht, Pr. Scientist

13.12. Grievance Cell (GC)

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

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

13.13. Women Cell (WC)

Chairman - Dr. Renu Jethi, Sr. Scientist

Members - Mrs. Radhika Arya, Assistant Administrative Officer; Mrs. Renu Sanwal, ACTO

Member Secretary - Ms. Usha Birdi, Assistant

13.14. Internal Complaint Committee (ICC)

Chairman - Dr. Kushagra Joshi, Scientist

Members - Dr. Sher Singh, Pr. Scientist (upto 28.10.2021);, Mrs. Renu Sanwal, A.C.T.O.; Ms. Usha Birdi, Assistant; Mrs. Lata Harbola, Programme Coordinator, Chirag

13.15. Purchase Advisory Committee (PAC)

(Upto 12.10.2021)

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

Members – Drs. P.K. Mishra, Pr. Scientist; J.P. Aditya, Sr. Scientist; Rakesh Bhowmick, Scientist, Kushagra Joshi, Scientist; Finance & Accounts Officer

Member Secretary – In-Charge (Purchase & Store)

(*w.e.f.* 13.10.2021)

Chairman – Dr. B.M. Pandey, Pr. Scientist

Members – Drs. K.K. Mishra, Pr. Scientist; Ramesh Singh Pal, Scientist; Manoj Parihar, Scientist; Tilak Mondal, Scientist; Amit Umesh Pashchapur, Scientist; Sr. Administrative Officer; Finance & Accounts Officer

Member Secretary - Administrative Officer (Purchase & Store)

13.16. Standing Purchase Committee (SPC)

(upto 12.10.2021)

Chairman – Dr. S.C. Panday, Pr. Scientist

Members – Drs. Sher Singh, Pr. Scientist (upto 28.10.2021) ; R.P. Yadav, Scientist (upto 12.08.2021); Jitendra Kumar, Scientist; Rakesh Bhowmick, Scientist; Finance & Accounts Officer

Member Secretary - In-Charge (Purchase & Store)

(w.e.f. 13.10.2021)

Chairman – Dr. R.K. Khulbe, Pr. Scientist

Members – Drs. D.C. Joshi, Sr. Scientist ; Amit Kumar, Scientist ; Shri Jeevan B., Scientist ; Sr. Administrative Officer ; Finance & Accounts Officer

Member Secretary - In-Charge (Purchase & Store)

13.17. Technical Vetting/ Screening Committee (TVC)

(Upto 12.10.2021)

Chairman – Dr. B.M. Pandey, Pr. Scientist

Members – Drs. N.K. Hedau, Pr. Scientist; Renu Jethi, Sr. Scientist; Ramesh Singh Pal, Scientist; Jitendra Kumar, Scientist

Member Secretary - In-Charge (Purchase & Store)

(w.e.f. 13.10.2021)

Chairman – Dr. S.C. Panday, Pr. Scientist

Members – Drs. P.K. Mishra, Pr. Scientist ; N.K. Hedau, Pr. Scientist; Er. Shyam Nath, Scientist ; Dr. Rakesh Bhowmick, Scientist ; Finance & Accounts Officer

Member Secretary - In-Charge (Purchase & Store)

13.18. Institute Bio-safety Committee (IBSC)

Chairman – Dr. Lakshmi Kant, 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

13.19. House Allotment Committee (HAC)

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

Members – Dr. N.K. Hedau, Pr. Scientist; Dr. K.K. Mishra, Pr. Scientist, Dr. B.M. Pandey, Pr. Scientist

Member Secretary – Mr. Lalit Mohan Tiwari, Assistant Administrative Officer

13.20. Public Information Cell (PIC)

Public Information Officer – Dr. J.K. Bisht, Pr. Scientist & Head; Dr. N.K. Hedau, Pr. Scientist; Shri R.S. Negi, Sr. Administrative Officer

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

Program Coordinator, KVK, Bageshwar

Program Coordinator, KVK, Uttarkashi

13.22. Strengthening Statistical Computing for NARS

Nodal Officer- Dr. Kushagra Joshi, Scientist

13.23. mKisan

Nodal Officer – Dr. Kushagra Joshi, Scientist

13.24. Institute *Swachhta Abhiyan* Committee (ISAC)

Chairman - Dr. K.K. Mishra, Pr. Scientist

Member – Dr. Kushagra Joshi, Scientist; Mr. Lalit Mohan Tewari, AAO

13.25. Human Resource Development (HRD)

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

13.26. Research Data Management (RDM)

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

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

Members- Drs. Sher Singh, Sr. Scientist (upto 28.10.2021); and K.K. Mishra, Pr. Scientist

13.27. Institute Germplasm Identification Committee (IGIC)

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

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

13.28. Innovation Cell (IC)

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

Members- Dr. Renu Jethi, Sr. Scientist; Dr. ARNS Subbanna, Scientist (upto 12.02.2021); Dr. D.C. Joshi, Sr. Scientist; Sr. Administrative Officer

13.29. Mera Gaon Mera Gaurav (MGMG)

Nodal Officer- Dr. Kushagra Joshi. Scientist

13.30. Social Media Committee

Members- Dr. Renu Jethi, Sr. Scientist and Dr. Kushagra Joshi, Scientist

14. List of Publications

14.1 Scientific Papers Published in Peer Reviewed Journals/Proceedings

Research Papers	NAAS Rating
Sharma, S.K., Gupta, O.P., Pathaw, N., Sharma, D., Maibam, A., Sharma, P., Sanasam, J., Karkute, S.G., Kumar, S. and Bhattacharjee, B. (2021). CRISPR-Cas-Led Revolution in Diagnosis and Management of Emerging Plant Viruses: New Avenues Toward Food and Nutritional Security. *Frontiers in Nutrition*, 8:751512. https://doi.org/10.3389/fnut.2021.751512.	12.58
Das, S.K., Ghosh, G.K., Avasthe, R., Mondal, T., Choudhury, B.U., Roy, A., Mishra, V.K., Kundu, M.C., Lama, A. and Dhakre, D.S. (2021). Organic nutrient sources and biochar technology on microbial biomass carbon and soil enzyme activity in maize-black gram cropping system. *Biomass Conversion and Biorefinery,* https://doi.org/10.1007/s13399-021-01625-4.	10.99
Maity, A., Lamichaney, A., Joshi, D., Bajwa, A., Subramanian, N., Walsh, M. and Bagavathiannan, M. (2021). Seed shattering a trait of major evolutionary importance in plants. *Frontiers in Plant Science,* https://doi.org/10.3389/fpls.2021.657773.	10.40
Roy, C., Gahtyari, N.C., He, X., Mishra, V.K., Chand, R., Joshi, A.K. and Singh, P.K. (2021). Dissecting Quantitative Trait Loci for Spot Blotch Resistance in South Asia Using Two Wheat Recombinant Inbred Line Populations. *Front. Plant Sci.* 12:641324. doi: 10.3389/fpls.2021.641324.	10.40
Singh, P.K., Gahtyari, N.C., Roy, C., Roy, K.K., He, X., Tembo, B., Xu, K., Juliana, P., Sonder, K., Kabir, M.R. and Chawade, A. (2021) Wheat Blast: A Disease Spreading by Intercontinental Jumps and Its Management Strategies. *Front. Plant Sci.* 12:710707. doi: 10.3389/fpls.2021.710707	10.40
Sarkar, D., Sankar, A., Devika, O.S., Singh, S., Parihar, M., Rakshit, A., Sayyed, R.Z., Gafur, A., Ansari, M.J., Danish, S. and Fahad, S. (2021). Optimizing nutrient use efficiency, productivity, energetics, and economics of red cabbage following mineral fertilization and biopriming with compatible rhizosphere microbes. *Scientific reports*, *11*(1), pp.1-14. https://doi.org/10.1038/s41598-021-95092-6	10.38
Katoch, S., Sharma, V., Sharma, D, Salwan, R. and Rana, S. K. (2021). Biology and molecular interactions of *Parastagonospora nodorum* blotch of wheat. *Planta,* 255: 21. https://doi.org/10.1007/s00425-021-03796-w.	9.39
Chaudhary, P., Sharma, A., Chaudhary, A., Khati, P., Gangola, S., Maithani, D. (2021). Illumina based high throughput analysis of microbial diversity of maize rhizosphere treated with nanocompounds and *Bacillus sp*. *Applied Soil Ecology*. 159:103386.	9.19
Samreen, T., Naveed, M., Nazir, M. Z, Asghar, H. N., Khan, M. I., Zahir, Z. A., Kanwal, S., Jeevan, B., Sharma, D., Meena, V. S., Meena, S. K., Sarkar, D., Devika, O. S., Parihar, M and Choudhary, M. (2021). Seed associated bacterial and fungal endophytes: Diversity, life cycle, transmission, and application potential. *Applied Soil ecology,* https://doi.org/10.1016/j.apsoil.2021.104191.	9.19
Parihar, M., Panday, S.C., Meena R. P., Kumar, U., Meena V.S., Choudhary, M., Singh, A.K, Bisht, J.K., Kant, L. and Pattanayak, A. (2021). Long-term organic and inorganic fertilization on economics, energy budgeting and carbon footprint of soybean-wheat cropping system in the Indian mid-Himalayas. *Archives of Agronomy and Soil Science*, pp. 1-5. https://doi.org/10.1080/03650340.2021.1954163	9.09
Gururani, K., Sood, S., Kumar, A., Joshi, D.C., Pandey, D. and Sharma, A. R. (2021). Mainstreaming Barahnaja cultivation for food and nutritional security in the Himalayan region. *Biodiversity and Conservation,* 27; 1-24. Doi: 10.1007/s10531-021-02123-9.	8.94
Chaudhary, P., Khati, P., Chaudhary, A., Maithani, D., Kumar, G., Sharma, A. (2021). Cultivable and metagenomic approach to study the combined impact of nanogypsum and Pseudomonas taiwanensis on maize plant health and its rhizospheric microbiome. *PLoS ONE*. 16(4): e0250574	8.74

Research Papers	NAAS Rating
Gahtyari, N.C., Roy, C., He, X., Roy, K.K., Reza, M.M.A., Hakim, M.A., Malaker, P.K., Joshi, A.K., and Singh, P.K. (2021). Identification of QTLs for Spot Blotch Resistance in Two Bi-Parental Mapping Populations of Wheat. *Plants* 10(5):973. https://doi.org/10.3390/plants10050973.	8.76
Roy, C., Juliana, P., Kabir, M.R, Roy, K.K., Gahtyari, N.C., Marza, F., He, X., Singh, G.P., Chawade, A., Joshi, A.K., Singh, P.K. (2021). New Genotypes and Genomic Regions for Resistance to Wheat Blast in South Asian Germplasm. *Plants* 10(12):2693. https://doi.org/10.3390/plants10122693.	8.76
Jinger, D., Dhar, S., Dass, A., Sharma, V.K., Paramesh, V., Parihar, M., Joshi, E., Singhal, V., Gupta, G., Prasad, D. and Vijayakumar, S. (2021). Co-fertilization of Silicon and Phosphorus Influences the Dry Matter Accumulation, Grain Yield, Nutrient Uptake, and Nutrient-Use Efficiencies of Aerobic Rice. *Silicon*, pp.1-15. https://doi.org/10.1007/s12633-021-01239-5	8.67
Kumar, B. Dhar, S. Paul, S. Paramesh, V. Dass, A. Upadhyay, P.K., Kumar, A. Abdelmohsen, S.A.M., Alkallas, F.H., El-Abedin, T.K.Z., Elansary, H.O., Abdelbacki, A.M.M. (2021) Microbial Biomass Carbon, Activity of Soil Enzymes, Nutrient Availability, Root Growth, and Total Biomass Production in Wheat Cultivars under Variable Irrigation and Nutrient Management. Agronomy , 11, 669. https://doi.org/10.3390/agronomy11040669	8.60
Parihar, M., Panday, S.C., Meena R. P., Kumar, U., Meena V.S., Choudhary, M., Singh, A.K, Bisht, J.K., Kant, L. and Pattanayak, A. (2021). Long-term organic and inorganic fertilization on economics, energy budgeting and carbon footprint of soybean-wheat cropping system in the Indian mid-Himalayas, *Archives of Agronomy and Soil Science*, DOI: 10.1080/03650340.2021.1954163.	8.14
Chaudhary, P., Khati, P., Gangola, S., Kumar, A., Kumar, R., Sharma, A. (2021). Impact of nanochitosan and Bacillus spp. on health, productivity and defence response in Zea mays under field condition. 3 Biotech. 11(5):237	7.80
Chaudhary, P., Khati, P., Chaudhary, A., Gangola, S., Kumar, R., Sharma A. (2021). Bioinoculation using indigenous *Bacilus spp*. improves growth and yield of *Zea Mays* under the influence of nanozeolite. *3 Biotech*. 11:1.	7.80
Naga, K., Sundaresha, S., Kumar, R., Tiwari, R., Shivaramu, S., Verma, G., Buckseth, T., Bairwa, A., Sharma, S., Katare, S., Srivastava, R., Bansode, G., Sarkar, A. and Patel, J. (2021). A new record of Asia II 5 genetic group of *Bemisia tabaci* (Gennadius) in the major potato growing areas of India and its relationship with tomato leaf curl New Delhi virus infecting potato. *3Biotech,* 11. 10.1007/s13205-021-02966-7.	7.80
Nataraj, V., Bhartiya, A., Singh, C.P., Devi, H.N., Deshmukh, M.P., Verghese, P., Singh, K., Mehtre, S.P., Kumari, V., Maranna, S., Kumawat, G., Ratnaparkhe, M.B., Satpute, G.K., Rajesh, V., Chandra, S., Ramteke, R., Khandekar, N. and Gupta, S. (2021). WAASB-based stability analysis and simultaneous selection for grain yield and early maturity in soybean. *Agronomy Journal*, 1□ 11. https://doi.org/10.1002/agj2.20750.	7.68
Raigond, B., Pathania, S., Verma, A., Verma, G., Kochhar, T. and Chakrabarti, S. (2021). Recombinase Polymerase Amplification assay for rapid detection of a geminivirus associated with potato apical leaf curl disease. *Journal of Plant Diseases and Protection*. 128. 1-11.	7.53
Kumar, U., Singh, S., Bisht, J. K. and Kant, L. (2021). Use of meteorological data for identification of agricultural drought in Kumaon region of Uttarakhand. *Journal of Earth System Science,* 130 (121),1-13. https://doi.org/10.1007/s12040-021-01622-1.	7.42
Rani, A., Kumar, N., Sinha, N.K. and Kumar, J. (2022). Identification of salt-affected soils using remote sensing data through random forest technique: a case study from India. *Arabian Journal of Geosciences*, 15(5), 1-16.	7.33
Ramesh, G.V., Palanna, K.B., Vinaykumar, H.D., Arunkumar, Koti, P.S., Mahesha, H.S., Nagaraja, T.E., Tonapi, V.A. and Jeevan, B (2021). Occurrence and Characterization of *Bipolaris setariae* Associated with Leaf blight of Browntop Millet (*Brachiaria ramosa*) in India. *Journal of Phytopathology*, 169, 613–622. https://doi.org/10.1111/jph.13032.	7.18

Research Papers	NAAS Rating
Sharma, D., Chhabra, R., Muthusamy, V., Zunjare, R.U. and Hossain, F. (2021). Molecular characterization of elite maize (*Zea mays* L.) inbreds using markers associated with iron and zinc transporter genes. *Genetic Resources and Crop Evolution,* 68, 1545–1556. https://doi.org/10.1007/s10722-020-01084-2.	7.07
Panday S. C., Mishra, D. C., Yadav R. P., Pattanayak, A. 2021. Studies on mechanical, vegetative and roof water harvesting: strategies to enhance recharge of spring and its discharge in Himalaya. *Desalination and Water Treatment*. 244:27-40.	6.85
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14.5 Institute Publications

- ICAR-VPKAS Newsletter Vol. 24 (No. 2)
- ICAR-VPKAS Newsletter Vol. 25 (No. 1)

14.6 Extension Leaflets

- Organic farming of wheat under rainfed condition in hills (127/ 2021)
- Organic farming of rainfed toria in hills (128/ 2021)
- Organic farming of rainfed lentil in hills (129/ 2021)
- Package of practices for rainfed organic grain Amaranth in hills (130/ 2021)
- Organic farming of finger millet under rainfed condition in hills (131/ 2021)
- Organic farming of rainfed black soybean in hills (132/ 2021)
- Organic farming of garden pea in hills (133/ 2021)
- Organic management of french bean in hills (134/ 2021)
- वी.एल.क्यू.पी.एम. हाइब्रिड 59: पर्वतीय क्षेत्रों में पोषण सुरक्षा हेतु उच्च ट्रिप्टोफैन व लाइसीन युक्त मक्का की संकर प्रजाति (135/ 2021)
- वी.एल. मंडुवा 382 में पोषण सुरक्षा हेतु सफेद मंडुवा की प्रथम उन्नत प्रजाति (136/ 2021)
- उत्तर पश्चिमी हिमालयी राज्यों में आलू की उन्नत खेती (137/ 2021)
- उन्नत सब्जी पौधशाला प्रबन्धन (138/ 2021)
- पर्वतीय–क्षेत्रों में सब्जी मटर की वैज्ञानिक खेती (139/ 2021)
- पर्वतीय क्षेत्रों में खाद्य सामग्री हेतु वी.एल. सोलर ड्रायर (सौर शुष्कक) (140/ 2021)
- पर्वतीय क्षेत्रों हेतु सुवाहय (पोर्टेबल) पॉलीहाउस (141/ 2021)

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)]*
  - ❖ **Sub Project** - Identification of Potential Lines and Hybrid Combination for high Fe and Zn content in maize through biochemical and molecular approach *[Dr. Devender Sharma (PI)]*
- Enhancement of Genetic Potency of Rice for Productivity, Biotic and Abiotic Stresses for North West Himalayas *[Dr. J.P. Aditya (PI)]*
- Genetic Improvement of Wheat and Barley for Higher Productivity, Quality Traits, Abiotic and Biotic Stresses. *[Dr. L. Kant (PI)]*
  - ❖ **Sub Project** - Inheritance studies for transgenerational stress memory in wheat induced by late sowing [*Dr. Navin Chander Gahtyari (PI)]*
- Trait Mining and Genetic Improvement of Small Millets and Potential Crops in the Context of Climate Change *[Dr. D.C. Joshi (PI)]*
- Genetic Improvement of Pulses & Oilseeds for Higher Productivity, Quality, Biotic & Abiotic Stresses for North-Western Himalayan Hills *[Dr. Anuradha Bhartiya (PI)]*
- Enhancement of Genetic Potency in Important Vegetables Crops for North Western Himalayan Ecosystem *[Drs. N.K. Hedau (PI)]*
  - ❖ **Sub Project:** Heterosis Breeding in Onion [*Dr. Chaudhari Ganesh V. (PI)]*
  - ❖ **Sub- project:** Capsicum Heterosis Breeding [*Dr. Chaudhari Ganesh V. (PI)]*
  - ❖ **Sub-project:** Collection evaluation, identification and documentation of underutilized vegetable crops for North-West Himalayan Ecosystem [*Dr. Rahul Dev (PI)]*
- Germplasm Evaluation in Major Hill Crops for Nutritional and Physiological Parameters Through Basic Techniques *[Dr. Ramesh Singh Pal (PI)]*
- Seed Production *[Dr. L. Kant (PI)]*

15.1.2. Natural Resource Management for Enhancing the Productivity

- Crop Management for Higher Soil Quality and Sustainability in Indian Himalayas *[Dr. Dibakar Mahanta (PI)]*
- Enhancing Productivity and Profitability of Major Hill Crops through Efficient Resource Utilization *[Dr. Sher Singh (PI)]*
  - ❖ **Sub Project:** Identification of micro watershed (natural spring) using Remote sensing & GIS technique and its runoff estimation for potential water harvesting [*Er. Utkarsh Kumar (PI)]*
- Farm Mechanization and Post-harvest Management for Mountain Regions *[Er. Shyam Nath (PI)]*
- Agro-forestry and Fodder Production Management with Emphasis on Utilization of Marginal Lands in Hills *[Dr. J.K. Bisht (PI)]*
  - ❖ **Sub- Project:** B. Evaluation and Refinement of Suitable Agroforestry Practices for hills [*Dr. R.P. Yadav(PI)]*
- Water Harvesting and Effective Utilization of Water for Enhancing Crop Productivity and Input Use Efficiency *[Dr. S.C. Panday (PI)]*
  - ❖ **Sub Project :** Development of sensor network based automation system for improving water productivity *[Dr Jitendra Kumar (PI)]*

15.1.3. Integrated Management of Diseases and Pests of Hill Crops

- Race profiling, variability and management of major plant pathogens of hill crops [*Dr. Rajashekara, H. (PI)]*

- Bio-intensive management of major polyphagous pests of Uttarakhand hills *[Dr. A.R.N.S. Subbanna (PI)]*
- 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)]*

15.1.4. Socio-economic Studies, Transfer of Technology and Information Technology

- Impact of Constrained and Unconstrained Choices on Adoption of Improved Agricultural Practices by Farmers *[Dr. Renu Jethi (PI)]*
- Technological Interventions for Mitigating Drudgery and Improving Nutritional Status of Hill Farmwomen *[Dr. Kushagra Joshi (PI)]*

15.2. Externally Funded Projects

15.2.1. ICAR-NASF Funded Project

- Utilization and Refinement of Haploid/ Doubled haploid Induction Systems in Rice, Wheat and Maize Using In-Vitro and Molecular Strategies *[Drs. R.K. Khulbe & A. Pattanayak]*

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]*
- ICAR-CRP on Molecular Breeding in Maize *[Drs. R.K. Khulbe, R.S. Pal & Rakesh Bhowmick]*
- CRP on Agrobiodiversity, PGR Management, Component II – Wheat *[Drs. Lakshmi Kant & K.K. Mishra]*
- CRP on Molecular Breeding Wheat *[Drs. Lakshmi Kant, K.K. Mishra & Rakesh Bhowmick]*

15.2.3. UNEP-GEF Project

- Mainstreaming Agricultural Biodiversity Conservation and Utilization in Agricultural Sector to Ensure Ecosystem Services and Reduce Vulnerability *[Drs. A. Bhartiya, Kushagra Joshi & Jitendra Kumar]*

15.2.4. DUS Project

- DUS/GOT trials in kidney bean *[Dr. Anuradha Bhartiya]*

15.2.5. AICRP/ Network Projects

- Post Harvest Technology for Value Addition and Marketing of Agricultural Produce (AICRP on PHET) (*Drs. Shyam Nath* (*PI since 09 Jul 2020*), *Dr. Sher Singh* (*PI upto 08 Jul 2020 & Co-PI since 09 Jul. 2020*), Dr. Kushagra Joshi (Co-PI), *Er. Jitendra Kumar* (Co-PI) & *Dr. J.K. Bisht (Associated Scientist)*
- Use of Plastics in Agriculture Particularly in Protected Cultivation, Water Harvesting and Packaging (AICRP on PET) (*Drs. Jitendra Kumar (PI since 30 May 2020), Sher Singh (PI upto 29 May 2020 & Co-PI since 30 May 2020), Shyam Nath (Co-PI) and Er. Utkarsh Kumar* (*Co-PI since 01 April 2020*)
- All India Network Project on Soil Arthropod Pests *[Drs. A.R.N.S. Subbanna & Amit Paschapur]*
- Network Programme on Organic Farming (NPOF) *[Drs. Dibakar Mahanta, P.K. Mishra, K.K. Mishra, V.S. Meena (upto 26.05.2020), Manoj Parihar & Priyanka Khati]*
- All India Coordinated Research Project on Mushroom (*Dr. K.K. Mishra*)

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 (upto 26.05.2020)]*

15.2.7. NMHS Project

- Strategies to Improve Health and Nutriotional Status of Hill Farm Women through Technological Interventions *[Drs. Renu Jethi, Pankaj Nautiyal & Prathibha Joshi]*

15.2.8. NICRA project under Competitive Grants Component (CGS)

- Design & development of protective structures for high values crops to reduce damage from hail and frost *(Dr. Sher Singh)*

16. Consultancy, Patents & Commercialization of Technology

16.1. Patent IN 373714: A sampling apparatus for *in situ* volatile collection (201611021530)

A sampling apparatus for in situ volatile collection designed and developed by ICAR-VPKAS, Almora was granted a Patent (373714). The Patent was filed on 23.06.2016 and was given registration No. 201611021530. The patent for sampling apparatus was granted on 03.08.2021. The apparatus is adapted for onsite collection of volatiles, which are actively released by biological materials without affecting quality and quantity of the volatiles. It is portable and intended to collect volatiles in situ conditions. The volatiles thus collected are not only used to study the biology and communication pattern of organisms but also in biodiversity monitoring, pest control etc.

16.2. Trademark Granted

Trademark was granted to ICAR-VPKAS, Almora in respect of "Raw and unprocessed agricultural, aquacultural, horticultural and forestry products; raw and unprocessed grains and seeds; bulbs, seedlings and seeds for planting; Seeds including crop seeds, agricultural seeds, sowing seeds" with Trademark No. 5060460. It was filed on 26.07.2021 and was granted on 31.12.2021.

Form RG - 2

भारत सरकार
Government of India
व्यापार चिन्ह रजिस्ट्री
Trade Marks Registry
व्यापार चिन्ह अधिनियम, 1999
Trade Marks Act, 1999
Certificate of Registration of Trade Mark, Section 23 (2), Rule 56 (1)

Trade Mark No. 5060460 Date 26/07/2021

Certified that Trade Mark / a representation is annexed hereto, has been registered in the name(s) of - ICAR-VIVEKANANDA PARVATIYA KRISHI ANUSANDHAN SANSTHAN, ALMORA

In Class 31 Under No. 5060460 as of the date 26 July 2021 in respect of

Raw and unprocessed agricultural, aquacultural, horticultural and forestry products; raw and unprocessed grains and seeds; bulbs, seedlings and seeds for planting; Seeds including crop seeds, agricultural seeds, sowing seeds

Trade Mark as annexed

Sealed at my direction, this 31st day of December, 2021

व्यापार चिन्ह रजिस्ट्री
Trade Marks Registry MUMBAI

व्यापार चिन्ह रजिस्ट्रार
Registrar of Trademarks

वी एल बीज
VL Seed
कृषक समृद्धि की कुंजी
Key to farmer's prosperity

16.3. Commercialization of Institute Varieties and Machines

Name of Technology	Date of MoA	Date of ending license	Name of company	Revenue earned (Rs.)
VL White Grub Beetle Trap 1	08.01.2021	07.01.2025	Parashar Agrotech Bio Pvt. Ltd., S-15/2-14-4-5, Mohankunj Apartment, Ghausabad, Varanasi - 221002, Uttar Pradesh, India	1.00 Lakh + 18,000 (GST @ 18% of license fee)
	21.09.2021	20.09.2025	G.T. Bio-sciences Pvt. Ltd., 47/48, Prem Sai IV, Shilpa Co-Op. Housing society, Narendra Nagar, Nagpur - 440024, Maharashtra, India	1.00 Lakh+ 18,000 (GST @ 18% of license fee)
VL Paddy Thresher	30.01.2021	29.01.2025	Punjab Agricultural Implements (P) Ltd., Railway road, Saharanpur, UP, India	2.00 Lakh+36,000 (GST @ 18% of license fee)
Vivek QPM-9 An early maturing QPM maize hybrid	05.02.2021	04.02.2026	Jai Shankar Agro Inputs Pvt. Ltd., 65, Indra Market, Old Sabzi Mandi, Delhi - 110007, India	4.00 Lakh+72,000 (GST @ 18% of license fee)
VL Portable Polyhouse-A Greenhouse Effect Creating Apparatus	01.03.2021	29.02.2024	M/s Aerotech Eng. Works Pvt. Ltd., Chaltaberia, Duttapukur, North 24 Parganas - 743248, West Bengal, India.	60,000 + 10,800 (GST @ 18% of license fee)
VL Small tool kit	23.09.2021	22.09.2024	Faith Enterprises, 4435/7 Ansari Road Daryaganj. New Delhi - 110002	90,000 + 16,200 (GST @ 18% of license fees)
VL *Syahi Hal*	22.10.2021	21.10.2024	Green Tech Solution, Deval Chaur Kham, Manpur West, Haldwani, Nainital - 263139, Uttarakhand, India	1.20 Lakh + 21,600 (GST @ 18% of license fee)
	23.02.2022	22.02.2025	Dunagiri Swayat Sahkarita, Narsingh Bari, Officers Colony, Near K.G.N Furniture, Almora - 263601, Uttarakhand, India	1.20 Lakh + 21,600 (GST @ 18% of license fee)
	02.03.2022	01.03.2025	Navsrijan Bahuuddeshiya Swayatt Sahkarita, Sitlakhet, Hawalbag, Almora - 263678, Uttarakhand, India	1.20 Lakh + 21,600 (GST @ 18% of license fee)
VL Maize Sheller	28.12.2021	27.12.2024	Tyaagi Implements and Manufacturer Private Limited, H. No. 04 A, Shri Ram Vihar Colony, Patholi, Agra – 283105, Uttar Pradesh, India	1.00 Lakh + 18,000 (GST @ 18% of license fee)


Handing over the certificate to M/s Aerotech Eng. Works Pvt. Ltd.

TLA signed with Jai Shankar Agro Inputs Pvt. Ltd.

Signing of TLA with Punjab Agricultural Implements (P) Ltd.

17. RAC & IRC Meetings

17.1. Research Advisory Committee (RAC) Meeting

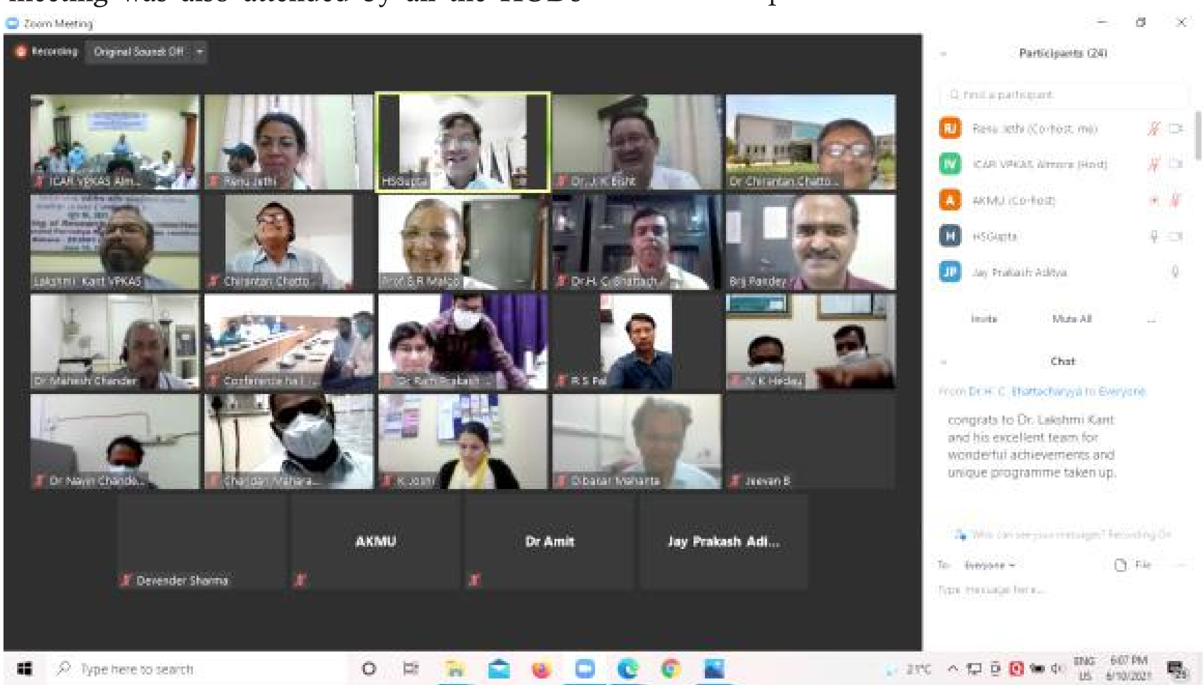
The XXV Research Advisory Committee (RAC) meeting of ICAR-VPKAS, Almora was held through online mode on 10th June, 2021 under the Chairmanship of Dr. H. S. Gupta, Former Director General., Borlaug Institute of South Asia (BISA) and Former Director, ICAR- IARI. New Delhi. The RAC members present in the meeting were Dr. D.K. Yadava, ADG (Seeds), ICAR HQ New Delhi; Dr. Hemendra Chandra Bhattacharyya, Dean Daffodil Collage of Horticulture, DMET, Khetri, Assam; Dr. C. Chattopadhyay, Former Vice Chancellor, UBKV and Principal Scientist, IIAB, Ranchi; Dr. S. R. Maloo, Ex. Director (Research), MPUAT, Udaipur; Dr. Mahesh Chandra, Head, Extension Education Division, ICAR-IVRI, Izatnagar, Bareilly, U.P.; Dr. Anjani Kumar, IFPRI, New Delhi, Dr. L. Kant, Director, ICAR-VPKAS, Almora and Dr. J. K. Bisht, Member Secretory. The meeting was also attended by all the HODs and scientists of the Institute through Video Conferencing.

17.2. Evaluation of Experiments by Field Monitoring Team

The monitoring of field experiments during *Rabi* 2020-21 was carried out on 08 April 2021 and *Kharif* 2021 was carried out on October 1, 2021 at Experimental Farm, Hawalbagh. All the scientist participated and monitored the experiments. The progress was reviewed by the Director, Dr. Lakshmi Kant.

17.3. Institute Research Council (IRC) Meeting

The meeting of Institute Research Council (IRC) was held on May 24-25 & 27, 2021 for *kharif* 2021 and October 26-27, 2021 for *rabi* 2021-22 under the chairmanship of the Director Dr. Lakshmi Kant to discuss *kharif* and *rabi* programmes, respectively. The progress of all research projects was reviewed and new experiments were discussed.



RAC Meeting at ICAR-VPKAS, Almora

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

Name of Scientist (s)	Conference/Seminar/Webinar/Workshop/Symposia/ Meetings
International	
Mr. Amit Paschapur	International Conference on Biological Control of Pest and disease organized by Tamil Nadu Agricultural University, Centre for plant protection studies, Department of plant pathology, Coimbatore during March 11-12, 2021.
Dr. R.S. Pal and Mr. Jeevan B.	International conference on "Current Approaches in Agricultural, Animal Husbandry and Allied Sciences for Successful Entrepreneurship (CIAAAHASSE-2021)" through virtual mode during March 13-15, 2021.
Dr. Anuradha Bhartiya	International webinar on "Exchange of Post PVP Control Measures" on April 08, 2021-PPV&FRA.
Drs. Renu Jethi and Kushagra Joshi	International Conference on Innovative and current advances in agriculture and allied sciences (ICAAAS-2021) organized by Society for Scientific Development in Agriculture and Technology (SSDAT), Meerut, India during July 19-21, 2021.
Dr. Amit Kumar	International Webinar Conference on "Alternate Cropping Systems for Climate Change and Resource Conservation" virtually organized by ICAR-IIFSR, Modipuram during Sept. 29-Oct. 01, 2021.
Dr. Anuradha Bhartiya	2nd International Agrobiodiversity Congress during November 15-18, 2021 through virtual mode.
Dr. Amit Kumar	5th International Agronomy Congress during November 23-27, 2021 held at PJTSAU, Hyderabad, Telangana.
Drs. Anuradha Bhartiya Kushagra Joshi and Priyanka Khati	International Web Conference on Global Research Initiatives for Sustainable Agriculture and Allied Sciences GRISAAS-2021 organized by Astha foundation, Meerut during December 13-15, 2021
Dr. Priyanka Khati	International conference on Vegetable Research and Innovation for Nutrition, Entrepreneurship, and Environment (ICVEG-21) during December 14-16, 2021 through online mode.
Dr. Anuradha Bhartiya	International webinar on "Exchange on Biochemical and Molecular Techniques (BMT) guidelines and implementation of BMT in DUS" during December 16 – 17, 2021 through video conferencing under Indo-German Cooperation on Seed Sector Development.
National	
All Scientist	Review Meeting of Officers & Staff of DARE & ICAR under the Chairmanship of Secy. (DARE) & DG, ICAR.
Dr. Lakshmi Kant	Attended meeting at NASC to confer certificates to elected fellows on 01 January 2021.
Drs. Sher Singh and Shyam Nath	16th Annual workshop of AICRP on PHET (online) during January 08-09, 2021.
Drs. Jitendra Kumar, Sher Singh and Shyam Nath	XVI Annual workshop of AICRP on PEASEM Project on January 08, 2021.
Dr. R.K. Khulbe	Techno – Commercial Assessment and Expert Committee Meeting with Agri-Innovate on January 11, 2021.

Name of Scientist (s)	Conference/Seminar/Webinar/Workshop/Symposia/ Meetings
Dr. R.K. Khulbe	NASF DH Maize project partners meeting (virtual) on Jan. 13, 2021 and NASF DH Maize project Advisory Committee meeting (virtual) on Jan. 14, 2021.
Dr. Lakshmi Kant	Role of ICAR-NAARM in Promoting Agri Startups in BIRAC BIG Grant on 18th January 2021 through virtual mode.
Dr. J.K. Bisht	Online meeting related to the action point of the Director's conference on January 22, 2021.
Dr. Lakshmi Kant	92nd AGM of the ICAR Society through VC on 27 January, 2021.
Dr. K.K. Mishra	Virtual conference on "Bio-control of plant diseases under current scenario of restricted pesticide use" (Mid-Eastern Zone) from Jan.27-28, 2021 organized by AMU, Aligarh, and IPS, New Delhi.
Dr. R.K. Khulbe	NASF DH Maize project Annual Review meeting (virtual) on Jan. 28, 2021.
Drs. Sher Singh, Shyam Nath and Kushagra Joshi	36th Annual Workshop of AICRP on Post-harvest Engineering & Technology (online) during Feb. 3-5, 2021.
Dr. J.K. Bisht	Online workshop on farm mechanization and input distribution under NEH KVK Kamroop, Assam on Feb. 12, 2021.
Dr. J.K. Bisht	Meeting with GM NABRD, Dehradun regarding FPO at Bhagartola on Feb. 15, 2021.
Dr. Lakshmi Kant	PJTSAU- 6th National Youth Convention on "Innovation and Agricultural Reforms for Farmers Prosperity" to be jointly organized by AIASA, ICAR and PJTSAU, Hyderabad through virtual mode on 20-21 Feb; 2021.
Dr. J.P. Aditya and Mr. Chandan Maharana	Hill Rice Workshop i.e. 8th Rice Research Group Meeting for Hill region held during February 24-25, 2021 organized by IIRR, Hyderabad through virtual mode.
Dr. Anuradha Bhartiya	Pre-workshop on AICRP on soybean on March 01, 2021.
Dr. R.K. Khulbe	NASF Empowered Committee Meeting (virtual) on March 04, 2021.
Drs. Sher Singh, Anuradha Bhartiya and Jeevan B.	51st Annual Group Meeting of Soybean (online) during March 12-13, 2021.
Mr. Amit Paschapur	Attended annual group meeting of AINP on White grubs and Soil Arthropod pests on March 15, 2021.
Drs. Lakshmi Kant, J.K. Bisht, N.K. Hedau, K.K. Mishra, Sher Singh, Renu Jethi, Jitendra Kumar, and Shyam Nath	"*Kisan Gosthi*-cum-interaction meeting" under SCSP programme in Lakhani village, Bageshwar on March 17, 2021.
All Scientists	National Webinar on "Sustainable Livelihood and Nutritional Security under Changing Climate in the North Western Himalayan Region: Issues, Challenges and Strategies" during March 19-20, 2021 through virtual mode.
Drs. Sher Singh and Jitendra Kumar	Kisan Gosthi cum Input/Farm tools distribution programme at Sunkiya Village of Nainital District under SCSP programme on March 20, 2021.
Dr. J.K. Bisht	Meeting with Director and Deputy Director Agriculture, Govt. of Meghalaya under NEH Programme at Directorate of Agriculture, Shillong on March 25, 2021.
Dr. Amit Kumar	Workshop on Gross environment products organized by HESCO, UPES, and USERC on March 25, 2021 at the University of Petroleum and Energy Studies, Dehradun.
Dr. K.K. Mishra	National e-conference on Plant health and food security: challenges and opportunities during March 25-27, 2021 organized by Indian Phytopathological Society, New Delhi.
Dr. Anuradha Bhartiya	Online meeting regarding nucleus seed availability with ADG seed organized by ICAR-IISR, Indore on March 26, 2021.
Dr. J.K. Bisht	Meeting with Director ATARI Zone VI & VII, Guwahati, Assam, regarding joint NEH Programme on March 27, 2021.

Name of Scientist (s)	Conference/Seminar/Webinar/Workshop/Symposia/ Meetings
Drs Lakshmi Kant, J.K. Bisht, B.M. Pandey and K.K. Mishra	Meeting for signing MoU between GBPUAT, Pantnagar and ICAR-VPKAS, Almora on April 06, 2021.
Mr. Chandan Maharana	Plant Pathology group meeting for AICRIP Rice through virtual mode on April 9, 2021 organized by IIRR, Hyderabad.
Dr. K.K. Mishra	National web conference on Mushroom Biology: Opportunities and Challenges organized by Mushroom Society of India and ICAR-Directorate of Mushroom Research, Solan during April 15-17, 2021.
Drs. Lakshmi Kant, K.K. Mishra, Amit Kumar, and Navin Chander Gahtyari	Online zonal monitoring of AICRP trials of wheat and barley on April 17, 2021.
Mr. Chandan Maharana	56th Annual Rice Group meeting of AICRP Rice held during April 19-20, 2021 through virtual mode.
Dr. R.K. Khulbe	Online discussion on frontline demonstrations of biofortified Maize varieties co-ordinated by IIMR and Coromandel International Ltd. during April 21-22, 2021.
Dr. K.K. Mishra	Executive Body Meeting of Indian Phytopathological Society on May 10, 2021 through virtual mode.
Dr. J.K. Bisht	AICRP on forage meeting with PC on May 12, 2021.
Drs. R.K. Khulbe and Anuradha Bhartiya	*Kharif* SVT Workshop (Virtual) on May 12, 2021.
Dr. R.K. Khulbe	63rd Annual Maize Workshop (virtual) during May 17-19, 2021.
Dr. Anuradha Bhartiya	GEF technical porgramme finalization meeting on May 20, 2021.
Dr. J.K. Bisht	AICRP, forage crop pre-group meeting on May 31, 2021.
Dr. J.K. Bisht	AICRP on forage crop National group meeting during June 1-2, 2021.
Drs. Lakshmi Kant, J.K. Bisht, B.M. Pandey and K. K. Mishra	EFC presentation meeting with DG, ICAR, New Delhi on June 05, 2021.
Dr. Anuradha Bhartiya	Meeting of BSP finalization of soybean with ADG seed organized by IISR Indore on June 07, 2021.
Dr. Anuradha Bhartiya	DUS review meeting on June 17, 2021 through virtual mode.
Dr. Lakshmi Kant	Preliminary meeting of ICAR Institutes located in Uttarakhand State through virtual mode on June 19, 2021.
Dr. J.K. Bisht	SAC Meeting of KVK, Kafligair, Bageshwar on June 21, 2021.
Dr. Lakshmi Kant	Attended virtual National Dialogue on Innovative Food for Hospitality Industry on June 22, 2021.
Dr. Lakshmi Kant	Virtual meeting of ICAR- ATARI, Zone- VII for distribution of Implements allocated by ICAR-VPKAS, Almora for KVKs of Mizoram on June 29, 2021.
Dr. Lakshmi Kant	Director's Conference July 02, 2021 through virtual mode.
All Scientist	Started Boshi Sen memorial lecture series on the Foundation day of the institute on the name of Prof Boshi Sen the founder of the institute. The 1st Lecture was delivered by Secretary DARE & DG, ICAR, Dr T. Mohapatra Sir on 04.07.2021.
Dr. R.K. Khulbe	CRP Biofortification project meeting (virtual) during July 05-06, 2021.
Dr. Lakshmi Kant	ICAR 93rd Foundation Day and Award Ceremony through virtual mode on July 16, 2021
Dr. Renu Jethi	Interactive meeting of Nodal officers of Krishikosh related to Krishi Portal with IASRI, New Delhi on July 17, 2021.
Dr. Lakshmi Kant	Mid Term Review Meeting of Regional Committee V on July 27, 2021 through Virtual mode.

Name of Scientist (s)	Conference/Seminar/Webinar/Workshop/Symposia/ Meetings
Dr. Priyanka Khati	ILSI India symposium on "Safety and Benefits of Nanotechnology Focus on: Agriculture, Water Safety, Food and Food Safety, Nutrition, Packaging" on July 26, 2021.
Dr. Renu Jethi	Webinar on "Ecosystem for Sustainable Farmers Producer Organization" on July 30, 2021.
Dr. K.K. Mishra	Brainstorming session on Pesticide Management Bill 2020 on July 31, 2021.
Drs. J.K. Bisht, P.K. Mishra, K.K. Mishra, Amit Kumar and Er Hitesh Bijarniya	Regional Mass Awareness Campaign organized by ICAR-IIFSR, Modipuram and ICAR-VPKAS, Almora on August 02, 2021.
Dr. K.K. Mishra	AICRP wheat and barley pre group meeting of Crop Protection on August 05, 2021.
Er. Hitesh Bijarniya	Workshop on "Challenges of Intellectual Property Rights (IPR) for Innovations in Agricultural Machinery" organized by AICRP on FIM and MPUAT, Udaipur on Aug. 6, 2021.
Drs. Navin Chander Gahtyari and Lakshmi Kant	Work plan meeting for wheat and barley coordinated trials and quality on upcoming *rabi* 2021-22 season in virtual mode on August 5 and 7, 2021.
Dr. K.K. Mishra	XXIII Annual Virtual Workshop of AICRP-Mushroom organized by ICAR-DMR during August 06-07, 2021.
Dr. K.K. Mishra	Virtual Executive body meeting of Indian Phytopathological Society on August 07, 2021.
Dr. R.K. Khulbe	Participated in *Rabi* Seed Meeting at Directorate of Agriculture, Dehradun on August 10, 2021.
Dr. S.C. Pandey	Annual Scientist meet of AICRP-IWM workshop (virtual mode) during August 11-13, 2021.
Dr. Priyanka Khati	National webinar "Entrepreneurial Opportunities in Food Processing Sector" organized by the School of Agricultural Sciences & Technology (SAST), Narsee Monjee Institute of Management Studies (NMIMS) deemed to be University on August 13, 2020.
Dr. Anuradha Bhartiya	Virtual workshop AICRP on MULLaRP crops during August 16-17, 2021.
Drs. Lakshmi Kant, K.K. Mishra, Amit Kumar, and Navin Chander Gahtyari	60th AICRP Wheat and Barley Research workers virtual meet organized by ICAR-IIWBR, Karnal during August 23-24, 2021.
Dr. J.K. Bisht	26th regional committee meeting of zone IV on August 25, 2021.
Dr. Priyanka Khati	National Seminar (hybrid mode) on "Rice-fallow management in Eastern India" organized by the ICAR-Research Complex for Eastern Region, Patna, Bihar on August 26, 2021.
Dr. Priyanka Khati	National Webinar on Abiotic Stress in Agriculture: Geospatial Characterization and Management Options organized by ICAR-National Institute of Abiotic Stress Management, Baramati, India on August 27, 2020.
Drs. Lakshmi Kant and R.K. Khulbe	Webinar on "Institute Industry Interface on Maize Hybrids and Technologies" on August 31, 2021.
Dr. M.S. Bhinda	National webinar on "Nutritional Security in India: Issues and Way Forward" on September 04, 2021 organized by ICAR-RCER, Patna through virtual mode.
Drs. B.M. Pandey and N.K. Hedau	39th Annual Group Meeting of AICRP (VC) held from September 07-09, 2021 through virtual mode.
Dr. Lakshmi Kant	Attended webinar on "Towards Accelerating Sustainable Development in Uttarakhand: Achievements, Challenges and Policy Options" organized by Doon University Dehradun on September 08, 2021 and delivered lecture through virtual mode on "Hill Agriculture Problems and Prospects".

Name of Scientist (s)	Conference/Seminar/Webinar/Workshop/Symposia/ Meetings
Drs. K.K. Mishra, R. K. Khulbe, Kushagra Joshi and Er Hitesh Bijarniya	*Kisan Goshthi*/Scientist-farmer interaction at Patiya-Kotyura villages under MGMG program on September 09, 2021.
Dr. Lakshmi Kant	National Project Steering Committee meeting of UN Environment implemented GEF project through online mode on September 10, 2021.
Dr. Anuradha Bhartiya	NPSC meeting of the UN Environment-GEF project held on Sept. 10, 2021.
Dr. Lakshmi Kant	XXVII meeting of ICAR RC meeting No. VII through virtual mode on Sept. 14, 2021.
Dr. Lakshmi Kant	Attended virtual Preliminary Meeting of the Task Force Committee constituted for ACZ-1 (Western Himalayas) as Per the PM Review on 16 Sept. 16, 2021 under the Chairmanship of Dr. Tej Partap, VC, GBPUA&T, Pantnagar.
Dr. Renu Jethi	Webinar on Role of Nutri-Gardens in Nutritional Security of Hill Community organized by KVK-Chinyalisaur on September 17, 2021.
Drs. Anuradha Bhartiya, Kushagra Joshi and Jitendra Kumar	Organized a field day on the importance of traditional crops/millets at Galli basyura village of Almora district under GEF Project on September 20, 2021.
Dr. J.K. Bisht	Virtual Brain Storming Workshop on District Agricultural Contingency Plan for 13 Districts of Uttarakhand at GBPUA&T, Pantnagar on September 22, 2021.
Dr. Lakshmi Kant	Attended Swachta Abhiyan under AKAM at Cant Almora on Sept. 24, 2021.
Dr. Lakshmi Kant	Attended virtual brainstorming meeting on "*Intensification and Sustenance of Pulses in North Hill Zone of India*" organized by ICAR- IIPR, Kanpur on 24 Sep; 2021.
Dr. J.K. Bisht	Participated in Foundation day of ICAR-DCWF, Bhimtal on September 24, 2021.
Dr. Anuradha Bhartiya	Brainstorming on Intensification and Sustenance of Pulses in North Hill Zone of India on Sept. 24, 2021.
Dr. R.K. Khulbe	Monitoring of AICRP Maize trials *Kharif* 2021 of Pantnagar centre on Sept. 27, 2021.
Dr. Lakshmi Kant	Attended *Kisan Mitra* webinar and delivered a lecture on "Agri-technologies for Small and Marginal Farmers of Hills" through virtual mode on Oct. 04, 2021.
Dr. R.K. Khulbe	NITI Aayog Meeting in Dehradun on Oct. 09, 2021.
Dr. Anuradha Bhartiya	GEF technical programme finalization meeting on Oct. 20, 2021.
Dr. M.S. Bhinda	Webinar on "Implementation and use of Agricultural Research Management System (ARMS)" organized by the ICT Unit, ICAR on October 20, 2021.
Dr. Lakshmi Kant	Review of Swachchata Abhiyan Activities through VC on Oct. 21, 2021 under the Chairmanship of Hon'ble DDG (CS), ICAR.
Dr. Lakshmi Kant	Attended National consultation on Plant Based Local Food Systems for Health and Nutrition through VC on 22 Oct. 22, 2021
Dr. Lakshmi Kant	Review meeting on special campaign by MoS on 25 Oct. 25, 2021 through virtual mode.
Drs. Lakshmi Kant, J.K. Bisht, B.M. Pandey, N.K. Hedau, K.K. Mishra, Kushagra Joshi and Priyanka Khati	3rd Meeting of Hill consortium of ICAR institutes on November 10, 2021.
Dr. M.S. Bhinda	"Global Conference on Green Development of Seed Industries" organized by FAO through virtual mode during November 04-05, 2021.
Dr. J.K. Bisht	Meeting with Agri-innovate regarding the commercialization of Institute technology on November 11, 2021.

Name of Scientist (s)	Conference/Seminar/Webinar/Workshop/Symposia/ Meetings
Drs. Renu Jethi, Navin Chander Gahtyari, and Devender Sharma	*Kisan gosthi* in two villages involved in FPSP regarding the recommended dose of seed and fertilizers and other good practices for quality wheat seed production on November 12, 2021.
Dr. J.K. Bisht	Online meeting of AICRP on forage crop on November 20, 2021.
Dr. Lakshmi Kant	Attended XV Agricultural Science Congress at BHU, Varanasi during Nov. 13-16, 2021.
Dr. Lakshmi Kant and Sh. L M Tiwari	Attended *Akhil Bhartiya Rajbhasha Sammelan* at Varanasi on November 13-14, 2021.
Dr. Lakshmi Kant	Attended Summit on *Atma Nirbhar* Uttarakhand @25 at Dehradun on November 27, 2021.
Drs. R.K. Khulbe and Kushagra Joshi	National Workshop on `Farmer's Income and Research Impact Assessment' organized by NIAP on November 29, 2021.
Drs. Amit Kumar and Priyanka Khati	Attended XVI Annual Group Meeting of All India Network Programme on Organic Farming (AINP-OF) during December 03-04, 2021.
Dr. R.K. Khulbe	Virtual review meeting of the CRP Molecular Breeding Maize project on Dec. 08, 2021.
Drs. Renu Jethi, Navin Chander Gahtyari and Devender Sharma	Farmer's *gosthi* in Jhankat and Nakulia villages on Dec. 10, 2021.
Drs. J.K. Bisht, Anuradha Bhartiya, Kushagra Joshi, M.S. Bhinda and Hitesh Bijarniya	Virtual webinar on "Agro-biodiversity conservation and use for climate resilience and livelihood improvement of smallholder farmers under UN Environment-GEF Project on December 23, 2021.
Er Hitesh Bijarniya, Drs. D.C. Joshi, J.P. Aditya and M.S. Bhinda	"International Millet Festival" at Dehradun from December 27-28, 2021.

19. Trainings, Workshops, Seminars, Farmers' Days Organized

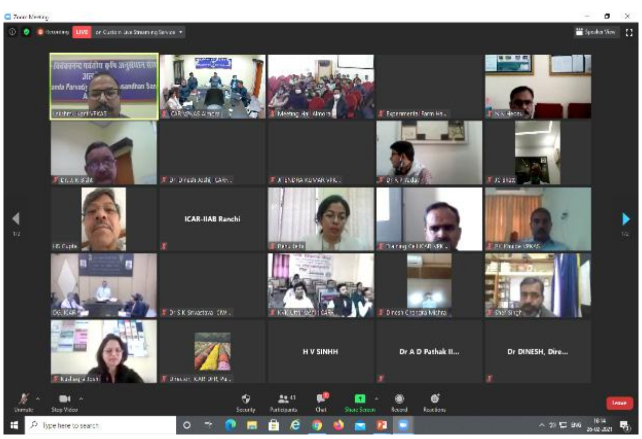
Hon'ble Chief Minister, Uttarakhand, Shri Trivendra Singh Rawat ji visited ICAR-VPKAS, Almora on January 28 2021. He appreciated the research work done by the institute in the field of mountain agriculture and described the efforts of the institute as important to ensure food security in the hilly region. On this occasion, an exhibition stall of the technologies developed by the institute was also put. The director of the institute, Dr. Lakshmi Kant appraised about the various varieties and techniques developed by the ICAR-VPKAS. On this occasion, Chief Minister also launched two improved varieties VL *Bhat* 202 and VL *Safed Mandua* 382 of the institute and extension leaflets, 'Integrated management of bitter gourd in Rajma crop' and 'Integrated management of fall army worm in maize crop' were released. A district level meeting was also organized by the district administration on this occasion. Shri Raghunath Singh Chauhan, Deputy Speaker, Smt. Rekha Arya, Minister of State, Ministry of Women and Child Development, Uttarakhand, Shri Ajay Tamta, MP, Almora, Pithoragarh Parliamentary Constituency, Shri Mahesh Negi, MLA Dwarahat, Shri Nitin Bhadauria, District Magistrate, Almora and other senior officers were also present.

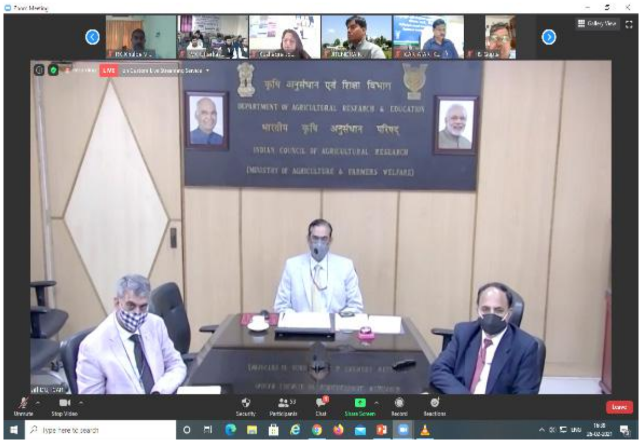
Online training programme on Diseases and Pests of Major *Rabi* Crops and their Management

One-day virtual online training program on "Diseases and Pests of Major Rabi Crops and their Management" was conducted on January 27, 2021. More than 35 participants including state officials, SMSs from KVKs of Uttarakhand and North Eastern Himalayan States have joined the program through Zoom app. Insert photo

Foundation stone of Administration cum Laboratory building of ICAR-VPKAS

Foundation stone of Administration cum Laboratory building of ICAR-VPKAS, Hawalbagh, Almora was laid by Dr. Trilochan Mohapatra, hon'ble Secretary, DARE & Director General ICAR, New Delhi on February 26, 2021. Dr Lakshmi Kant elaborated about the facilities that will be available for research and administration staff after





completion of the building. In his address, Chief guest of the programme, Dr. Trilochan Mohapatra highlighted the role of the institute towards development of hill agriculture. He suggested that institute may organize brain storming programmes on climate change and hill agriculture for the benefit of researchers and students.

Organization of National Science Day

Remembering the discovery of Raman Effect by Nobel Laureate and eminent physicist Sir C.V. Raman, National Science Day was organized on February 28, 2021 at the ICAR-VPKAS, Almora at Hawalbagh Farm. It was attended by 43 students of class 11 and 12 of Inter College, Hawalbagh.

Hon'ble MP, Almora Shri Ajay Tamta ji was the chief guest and informed the students about various schemes and start-ups started by the Government of India, so that students can take advantage of them in future.

Observation of International Women's Day

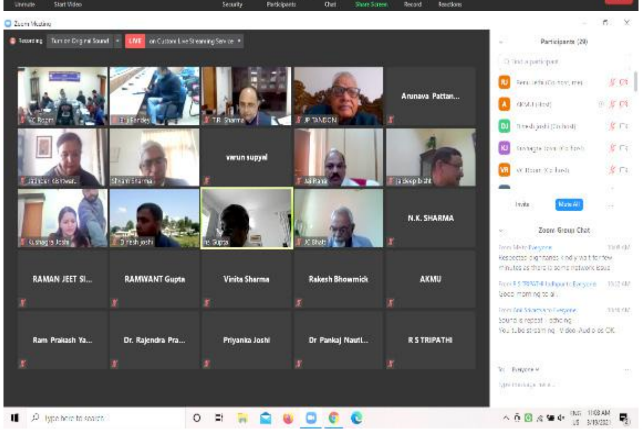
Institute observed International Women's Day in both campuses at Almora (offline) and Hawalbagh (through online mode). At Almora campus, a meeting was held in which women employees of the institute and women from Almora city known for their exemplary contributions in their respective fields participated. Dr. Diva Bhatt, Ex-Professor, SSJ Campus and Dr. Kusum Lata, Senior Radiologist from District Hospital, Almora were the two eminent speakers for the day. The theme given for the year 2021 "Women Leadership in Agriculture: Entrepreneurship, Equity and Empowerment" was elucidated. Four women farmers namely Mrs. Leela Devi, Mrs. Kamla Kaira, Mrs. Kalawati Devi and Mrs. Manju Devi were awarded for their important contribution in the field of hill agriculture.

Review meeting of UN Environment GEF project

Mid-term review meeting of UN Environment GEF project "Mainstreaming agricultural biodiversity conservation and utilization in agriculture sector to ensure ecosystem services and reduced vulnerability" was held under the Chairmanship of Dr. H. S. Gupta, Former DG, BISA on March 16, 2021. Dr. J.C. Rana, National Coordinator, UN Environment GEF project and Country Representative, India Office of Alliance of Biodiversity International & CIAT, New Delhi and other project partners from Uttarakhand also attended the meeting and presented their programme.

Webinar on Sustainable Livelihood and Nutritional Security under Changing Climate in the North Western Himalayan Region: Issues, Challenges and Strategies

The institute organized the national webinar on Sustainable Livelihood and Nutritional Security under Changing Climate in the North Western Himalayan Region: Issues, Challenges and Strategies on 19-20th March 2021 through virtual mode. Dr. T. R. Sharma, Deputy Director General (DDG), Crop Science, Indian Council of Agricultural Research, New Delhi was the chief guest. A total of 452 participants including students, faculty members from state agricultural universities, scientists, entrepreneurs and progressive farmers registered and attended the webinar.



Celebration of World Water Day

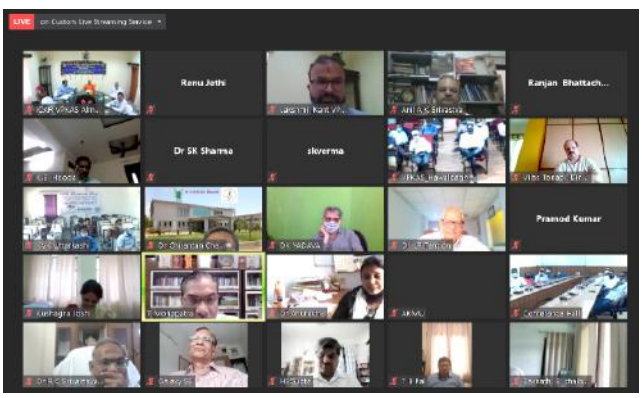
World water day was celebrated on March 22, 2021 at ICAR-VPKAS, Almora focussing the theme of "Valuing water" and highlighting the importance of available fresh water. The programme was carried out by organising a interaction meeting with farmers and students. To commemorate the occasion drawing, extempore and quiz competition was also organised for the class IX students. More than 150 participants including farmers, scientists, subject matter specialist/ extension officials and 35 students of Government Inter College, Hawalbagh, Almora were participated. 11 Nos of State officers/ SMS from North eastern region were attended the programme also.

MoU between ICAR-VPKAS, Almora and GBPUA&T, Pantnagar

ICAR-VPKAS, Almora and Govind Ballabh Pant University of Agriculture and Technology, Pantnagar on April 07, 2021 signed a Memorandum of Understanding in the presence of Hon'ble Vice Chancellor, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar Dr. Tej Pratap.

Celebration of 98th Foundation Day

98th Foundation Day of ICAR-VPKAS, Almora was celebrated through video conferencing on July 04, 2021. Chief Guest of the occasion, Dr. Trilochan Mohapatra, Hon'ble Secretary, DARE & Director General, ICAR, New Delhi, delivered 1st Padma Bhusan Prof. Boshi Sen Memorial Lecture. Emphasizing on the contribution of Prof. Boshi Sen, he paid tribute to him for the establishment of the institute and appreciated the contribution of the former directors. He stressed on the need to solve the new challenges of agriculture in collaboration with ICAR and other institutions. Highlighting the importance of consumer preferences, he advised on nutritional research and product branding to promote them globally.



Virtual online training programmes on Fall Armyworm: Symptoms, Identification & Management"

Two one-day virtual online training programmes on "Fall Armyworm: Symptoms, Identification & Management" were organized during July 05-06, 2021. More than 50 officials from ICAR Institutes, state departments and KVKs of NEH and NWH states (Meghalaya, Manipur, Mizoram, Assam, Arunanchal Pradesh, Sikkim, Tripura and Uttarakhand) attended the training programme.

Organization of Parthenium Awareness Week

ICAR-VPKAS, Almora, organized "16th Parthenium Awareness Week" during 16-22 August 2021. The Institute made aware the farmers and general public about the ill effects of *Parthenium* and its management through All India Radio, Newspapers, Institute website, Krishi Vigyan Kendras.

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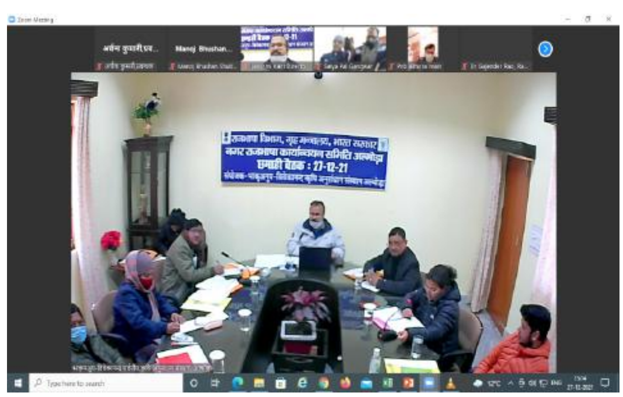
संस्थान में राजभाषा हिन्दी के प्रगामी प्रयोग सरकार की राजभाषा नीति के कार्यान्वयन, नियमों उपबन्धों एवं सर्वाधिक उपबन्धों के उचित अनुपालन एवं इनकी समीक्षा हेतु संस्थान राजभाषा कार्यान्वयन समिति का गठन किया गया है जो निम्नवत है :–

- डॉ0 लक्ष्मी कान्त– निदेशक, अध्यक्ष
- डॉ0 रेनू जेठी– वरिष्ठ वैज्ञानिक, सदस्या
- डॉ. अमित पश्चापुर– वैज्ञानिक
- वरिष्ठ प्रशासनिक अधिकारी– सदस्य
- वित्त एवं लेखाअधिकारी– सदस्य
- श्रीमती रेनू सनवाल– सहायक मुख्य तकनीकी अधिकारी, सदस्या
- श्रीमती राधिका आर्या– सहायक प्रशासनिक अधिकारी, सदस्या
- ललित मोहन तिवारी– प्रभारी सदस्य सचिव

समिति की प्रत्येक तिमाही में बैठक की जाती है। वर्ष 2021 के दौरान समिति की बैठकें क्रमशः 31.03.2021, 28.06.2021, 15.09.2021 एवं 20.12.2021 को आयोजित की गयी। राजभाषा वार्षिक कार्यक्रम की विभिन्न मदों में 'क' एवं 'ख' क्षेत्र के साथ हिन्दी पत्राचार के लिए 100 प्रतिशत का लक्ष्य रखा गया है तथा 'ग' क्षेत्र के साथ 65 प्रतिशत का लक्ष्य रखा गया है। संस्थान द्वारा 'क' क्षेत्र के साथ लगभग 80–82 प्रतिशत 'ख' क्षेत्र साथ 70–72 प्रतिशत तथा 'ग' क्षेत्र के साथ 65–70 प्रतिशत पत्र व्यवहार किया जा रहा है। राजभाषा अधिनियम की धारा 3(3) का अनुपालन सुनिष्चित 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 हैं।

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 2021 से 30 सितम्बर 2021 तक 'हिन्दी चेतना मास' का आयोजन किया गया। चेतना मास के दौरान अनेक कार्यक्रम हिन्दी टिप्पण एवं प्रारूप लेखन प्रतियोगिता, हिन्दी निबंध प्रतियोगिता, कम्प्यूटर पर यूनिकोड में हिन्दी टाइपिंग प्रतियोगिता, आशुभाषण प्रतियोगिता एवं हिन्दी काव्य पाठ प्रतियोगिता आदि का आयोजन किया गया। चेतना मास के दौरान दिनांक 14.09.2021 को हिन्दी दिवस समारोह एवं 30.09.2021 को हिन्दी संगोष्ठी 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 2021 के दौरान ये बैठकें 23.07.2021 एवं 27.12.2021 को आयोजित की गयी। वर्तमान में समिति के सदस्य कार्यालयों की संख्या 32 है जिसमें केन्द्रीय सरकार के शोध संस्थान, विभाग, राष्ट्रीयकृत बैंक, उपक्रम, सशस्त्र बल आदि सम्मिलित है। संस्थान द्वारा राजभाषा विभाग द्वारा मांगी गयी सूचनाएं निर्धारित समय पर भेजी जाती हैं तथा राजभाषा सूचना प्रबन्धन प्रणाली के अन्तर्गत सभी सूचनाएं आन लाइन प्रेषित की जाती हैं। संस्थान नराकास के सभी सदस्य कार्यालयों के बीच हिन्दी को आगे बढ़ाने के लिए सामंजस्य स्थापित करने का निरन्तर प्रयास कर रहा है।



21. Distinguished Visitors

- Hon'ble Chief Minister, Uttarakhand, Shri Trivendra Singh Rawat ji visited ICAR-VPKAS, Almora on January 28, 2021.

- Shri Ajay Tamta, Hon'ble MP, Almora & Pithoragarh; Shri Raghunath Singh Chauhan, Hon'ble Deputy Speaker, Uttarakhand Assembly & MLA, Almora; Dr. P.K. Pandey, Director, ICAR-DCFR, Bhimtal, Shri Pratul Joshi, Director, All India Radio, Almora visited Experimental Farm, Hawalbagh on October 09, 2021.
- Shri Girish Bhatt, Director (Crop Science), ICAR, New Delhi visited institute on October 16, 2021.
- Dr. H. S. Gupta, Former DG, BISA and Dr. J.C. Rana, National Coordinator, UN Environment GEF project and Country Representative, India Office of Alliance of Biodiversity International & CIAT, New Delhi visited institute on March 16, 2021.
- Dr. Diva Bhatt, Ex-Professor, SSJ Campus, Almora and Dr. Kusum Lata, Senior Radiologist from District Hospital, Almora visited Almora campus on March 08, 2021.
- Dr. S.P. Ahlawat, Scientist & Acting Head, ICAR-NBPGR, New Delhi visited on March 15, 2021.
- Dr. Sonal Dsouza, Sr. Project Officer, Biodiversity International, New Delhi visited on March 15, 2021.
- Dr. R.K. Singh, PC, AICRP on PEASEM, ICAR-CIPHET, Ludhiana visited on August 02, 2021.
- Dr. K. Srinivas, ADG(I/c), IPTM, ICAR, New Delhi visited on August 08, 2021.
- Dr. Narendra S Jadon, Dean, GBPUA&T, Pantnagar; Dr. Pawan Kumar, Pr. Scientist, ICAR-NBPGR, New Delhi, and Dr. Badal Singh, Pr. Scientist, ICAR-NBPGR, New Delhi visited on August 24, 2021.
- Dr. H.L. Kushwaha, Agri. Engineer, ICAR-Indian Agricultural Research Institute, New Delhi visited ICAR-VPKAS, Almora on September 17, 2021.
- Dr. P. R. Chaudhary, ICAR (Head Quarter), Crop Science Division, New Delhi; Dr. H.L. Kushwaha, Pr. Scientist (Agricultural Engineering), ICAR-Indian Agricultural Research Institute, New Delhi; Dr. S. K. Verma, Professor Department of Genetics and Plant Breeding, GBPUA&T, Pantnagar; Dr. Sneh Narwal, Principal Scientist, ICAR-IARI, New Delhi; Dr. Dinesh Kumar, Principal Scientist, ICAR-IIWBR, Karnal; Dr. Chunni Lal, Principal Scientist, ICAR-IIWBR, Karnal; Dr. Sukhvir Singh, Pr. Scientist, ICAR-IISR, Lucknow; Dr. O.P.S. Bana, Retired Professor, Agronomy & Agro. Forestry; Dr. Rajesh Kaushal, Pr. Scientist, ICAR-IISWC, Dehradun; Dr. Akhilesh Kumar, Head, Department of Soil & Water Conservation Engineering, GBPUA&T, Pantnagar; Dr. P.K. Singh, Professor, Department of Irrigation & Drainage Engineering, GBPUA&T, Pantnagar visited ICAR-VPKAS, Almora on September 17, 2021.

22. Institute Personnel

Dr. Lakshmi Kant, Director

Crop Improvement Division

Dr. N.K. Hedau, Principal Scientist (Horticulture-Vegetable Science) & I/c Head

Dr. R.K. Khulbe, Principal Scientist (Plant Breeding)

Dr. Jay Prakash Aditya, Sr. Scientist (Plant Breeding)

Dr. Anuradha Bhartiya, Sr. Scientist (Plant Breeding)

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

Dr. Ramesh Singh Pal, Sr. Scientist (Biochemistry)

Dr. Rahul Dev, Scientist (Economic Botany & Plant Genetic Resources)

Dr. Rakesh Bhowmick, Scientist (Agriculture Biotechnology)

Dr. Chaudhari G. Vasudeo, Scientist (Vegetable Science) (upto 12.02.2021)

Dr. Navin Chander Gahtyari, Scientist (Genetic & Plant Breeding)

Dr. Devender Sharma, Scientist (Genetic & Plant Breeding)

Dr. Asha Kumari, Scientist (Plant Physiology) (upto 18.10.2021)

Dr. Sougata Bhattacharjee, Scientist (Agri. Biotechnology) (upto 18.10.2021)

Mr. Mahendra Singh Bhinda, Scientist (Genetics & Plant Breeding)

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) (upto 28.10.2021)

Dr. Ram Prakash Yadav, Scientist (Agroforestry) (upto 12.08.2021)

Dr. Tilak Mondal, Scientist (Agricultural Chemistry)

Dr. Vijay Singh Meena, Scientist (Soil Science) (On deputation *w.e.f* 26.05.2020)

Dr. Mahipal Chaudhary, Scientist (Soil Science) (upto 10.02.2021)

Er. Shyam Nath, Scientist (Farm Machinery & Power)

Dr. Jitendra Kumar (Soil and Water Conservation Engineering)

Dr. Manoj Parihar (Soil Science)

Mr. Rajendra Prasad Meena, Scientist (Agronomy) (*On study leave*)

Er. Utkarsh Kumar, Scientist (Land & Water Management Engineering) (*On study leave*)

Dr. Priyanka Khati, Scientist (Agricultural Microbiology)

Mr. Hitesh Bijarniya, Scientist (Farm Machinery & Power) (*w.e.f.* 13.01.2021)

Dr. Amit Kumar, Scientist (Agronomy) (*w.e.f.* 10.02.2021)

Crop Protection Division

Dr. K.K. Mishra, Principal Scientist (Plant Pathology) & I/c Head

Dr. A.R.N.S. Subbanna, Sr. Scientist (Agricultural Entomology) (upto 12.02.2021)

Dr. Rajashekara, H., Scientist (Plant Pathology) (upto 12.02.2021)

Dr. Amit Umesh Paschapur, Scientist (Agricultural Entomology)

Mr. Ashish Kumar Singh, Scientist (Nematology)

Mr. Jeevan B., Scientist (Plant Pathology)

Mr. Chandan Maharana, Scientist (Plant Pathology) (upto 18.10.2021)

Dr. Gaurav Verma, Scientist (Plant Pathology) (*w.e.f.* 04.10.2021)

Social Science Section

Dr. B.M. Pandey, Principal Scientist (Agronomy) & I/c Head

Dr. Renu Jethi, Scientist (Home Science Extension)

Dr. Kushagra Joshi, Scientist (Home Science/ FRM)

Coordinators/ In-charge

Library

Dr. P.K. Mishra

AKMU

Dr. Renu Jethi

PME Cell

Dr. J.K. Bisht, In-charge

Farm

Dr. N.K. Hedau

Drs. N.K. Hedau & Sher Singh (Mukteshwar) (up to 28.10.2021)

Vehicle

Mr. Lalit Mohan Tewari, Asstt. Administrative Officer

Guest House

Dr. N.K. Hedau

Shri Sanjay Kumar Arya, ACTO

Maintenance

Mr. Lalit Mohan Tewari, Asstt. Administrative Officer

Krishi Samridhi Radio Programme

Dr. Kushagra Joshi

Technical Officers

Smt. Renu Sanwal, ACTO

Shri. S.K. Arya, ACTO

Shri. D.C. Mishra, ACTO

Dr. G.S. Bisht, ACTO

Shri. M.C. Pant, ACTO

Shri. D.S. Gosai, STO

Shri. N.K. Pathak, STO

Shri. D.S. Panchpal, STO

Shri. Daya Shankar, STO

Shri. O.P. Vidhyarthi, TO

Shri. C.S. Kanwal, TO

Shri. J.K. Arya, TO

Shri Ramesh Singh Kanwal, TO

Shri. Narayan Ram, TO

Shri Krishna Lal, TO (Driver)

Shri Vijay Pal Singh, TO (Pump Operator)

Administration and Finance

Senior Administrative Officer

Mr. R.S. Negi

Assistant Administrative Officers

Mrs. Radhika Arya

Mr. Lalit Mohan Tewari

Finance & Accounts Officer

Mr. B.C. Pandey, FAO

Store

Shri Sanjay Kumar Arya

Managerial Staff at KVK, Chinyalisaur

Dr. Chitrangad Singh Raghav, Pr. Scientist-cum-Head

Dr. Pankaj Nautiyal, CTO/ T-, Horticulture

Ms. Manisha, ACTO, Home Science (on study leave)

Dr. Gaurav Papnai, ACTO, Agril. Extension (upto 08.10.2021)

Managerial Staff at KVK, Bageshwar

Dr. Kamal Kumar Pandey, CTO/ T-9, Horticulture

Dr. N.K. Singh, ACTO, Veterinary Science (on study leave)

Dr. H.C. Joshi, ACTO, Plant Protection

Shri. Medni Pratap Singh, Farm Manager/T-6

Smt. Nidhi Singh, Prog. Asst. (Lab Technician) T-6

New Colleagues

Mr. Hitesh Bijarniya, Scientist (Farm Machinery & Power) -13.01.2021

Dr. Chitrangad Singh Raghav, Sr. Scientist-cum-Head - 23.01.2021

Dr. Amit Kumar, Scientist (Agronomy) -10.02.2021

Dr. Gaurav Verma, Scientist (Plant Pathology)-04.10.2021

Retirement

Sh. Bachi Ram, Skilled Supporting Staff - 31.05.2021

Sh. Tej Singh, Skilled Supporting Staff -30.06.2021

Sh. Sher Singh, Skilled Supporting Staff- 31.07.2021

Sh. Gopal Ram, Skilled Supporting Staff-31.07.2021

Sh. Bhupesh Chandra Pandey, FAO - 31.12.2021

Smt. Narayani Devi, Skilled Supporting Staff - 31.12.2021

Smt. Janki Mehta, Lower Division Clerk - 31.12.2021

Obituary

Sh. Puran Singh Kirola, CLTS - 08.03.2021

Regularization

1. Sh. Anand Singh Kholiya, Skilled Supporting Staff- 19.08.2021
2. Sh. Madan Singh Bhakuni, Skilled Supporting Staff- 19.08.2021
3. Sh. Kailash Prasad, Skilled Supporting Staff- 19.08.2021
4. Sh. Rajendra Singh Kanwal, Skilled Supporting Staff- 19.08.2021
5. Sh. Bhupal Ram, Skilled Supporting Staff- 19.08.2021
6. Sh. Pratap Singh (Bimola), Skilled Supporting Staff- 19.11.2021
7. Sh. Mohan Singh Bhojak, Skilled Supporting Staff- 19.11.2021
8. Sh. Vijendra Kumar, Skilled Supporting Staff- 19.11.2021
9. Sh. Govind Lal, Skilled Supporting Staff- 19.11.2021

Transfer

- Mr. Mahipal Choudhary to ICAR-CAZRI, Jodhpur- 10.02.2021
- Dr. ARNS Subbanna to ICAR-IIOPR, Pedavegi- 12.02.2021
- Dr. Rajashekara H. to ICAR-DCR Dakshina Kannada- 12.02.2021
- Dr. Chaudhari Ganesh Vasudeo to ICAR-CCARI, North Goa- 12.02.2021
- Dr. Omvir Singh to ICAR-IIWBR, Karnal- 23.10.2021
- Dr. Sher Singh to ICAR-IVRI, Bareilly- 28.10.2021
- Mr. Sougata Bhattacharjee to ICAR-IARI, Jharkhand- 18.10.2021
- Dr. Asha Kumari to ICAR-IARI, Jharkhand- 18.10.2021
- Mr. Chandan Maharana to ICAR-CPRI, Shimla- 18.10.2021
- Dr. Gaurav Papnai to KVK (ICAR-IARI), Shikohpur, Haryana- 08.10.2021

Selection

- Dr. Ram Prakash Yadav, Scientist as Associate Professor (Forestry), College of Horticulture & Forestry at RLBCAU, Jhansi (UP)- 12.08.2021

Promotion

- Mr. Anirban Mukherjee, Scientist (Research Level -11) *w.e.f.* 01.07.2018
- Dr. Tilak Mondal, Scientist (Research Level - 11) *w.e.f.* 01.01.2018
- Dr. Dinesh Chandra Joshi, Senior Scientist *w.e.f.* 15.12.2018
- Dr. Raghu B. R., Scientist (Research Level - 11) *w.e.f.* 27.04.2017
- Dr. Chaudhari Ganesh Vasudeo, Scientist (Research Level - 11) *w.e.f.* 01.01.2019
- Dr. ARNS Subbanna, Senior Scientist *w.e.f.* 21.04.2019

- Dr. Rakesh Bhowmick, Scientist (Research Level 11) *w.e.f.* 01.01.2021
- Dr. Anuradha Bhartiya, Senior Scientist *w.e.f.* 21.04.2020
- Dr. Ram Prakash Yadav, Senior Scientist *w.e.f.* 11.05.2020
- Dr. Ramesh Singh Pal, Senior Scientist *w.e.f.* 11.05.2020
- Er. Shyam Nath, Scientist (Research Level 11) *w.e.f.* 01.01.2021
- Dr. Jitendra Kumar, Scientist (Research Level 11) *w.e.f.* 05.01.2021
- Smt. Renu Sanwal, Senior Technical Officer/T-6 *w.e.f.* 12.03.2011
- Smt. Renu Sanwal, ACTO/T-7-8 *w.e.f.* 12.03.2016
- Sh. Prahlad Singh Nikhurpa, Senior Technician/T-2 *w.e.f.* 10.11.2020
- Sh. Rajendra Prasad, Senior Technician/T-2 *w.e.f.* 10.11.2020
- Sh. Vijay Pal Singh, Technical Officer/T-5 (Pump Operator) *w.e.f.* 29.06.2021
- Sh. Krishan Lal, Technical Officer/T-5 (Driver) *w.e.f.* 29.06.2021
- Sh. Neeraj Kumar Pandey, Senior Technical Assistant/T-4 (Generator Operator) *w.e.f.* 29.06.2018
- Sh. Salim, Senior Technical Assistant/T-4 (Driver) *w.e.f.* 02.01.2021

Study Leave

- Ms. Manisha, ACTO, Home Science
- Dr. N.K. Singh, ACTO, Veterinary Science
- Mr. Utkarsh Kumar, Scientist, Land & Water Management Engineering
- Mr. R.P. Meena, Scientist, Agronomy

23. Human Resource Development (HRD)

for

ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora-263601 Uttarakhand, India

(2021)

A. Physical targets and achievements

Category	Total No. of Employees	No. of trainings planned for 2021 as per ATP	No. of employees undergone training during Jan-June 2021	No. of employees undergone training during July to December 2021	Total no. of employees undergone training during January to December 2021	% realization of trainings planned during 2021
1	1	3	4	5	6 (4 + 5)	Col. 6*100/ Col. 3 = 7
Scientist	38	06	03	16	19	316.7
Technical	27	04	05	03	08	200.0
Administrative & Finance	18	04	02	03	05	125.0
SSS	35	0	0	0	0	0.0
Total	**118**	**14**	**10**	**22**	**32**	**228.6**

B. Financial targets and achievements (All employees)

RE 2021 for HRD (Rs.)	Actual Expenditure up to December 31, 2021 for HRD (Rs.)	% Utilization of allotted budget
1	2	2*100/1=3
1,75,000.0	**1,75,000.0**	**100.0**

C. Number of trainings organized for various categories of ICAR employees including winter/summer schools and short-term trainings

Category	No. of trainings organized during January to June 2021	No. of trainings organized during July to December 2021	Total no. of trainings organized during January to December 2021	No. of participants (Only ICAR employees)		
				Organizing Institute	Other ICAR Institutes	Total
1	2	3	Col. 2+3=4	5	6	5+6=7
Scientist	0	0	0	0	0	0
Technical	0	0	0	0	0	0
Administrative & Finance	0	0	0	0	0	0
SSS	0	0	0	0	0	0
Total	0	0	0	0	0	0

आज़ादी का
अमृत महोत्सव

भाकृअनुप
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch