ANNUAL REPORT 2022

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

भाकृअनुप
ICAR

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PREFACE

Mountains are home to one tenth of the world's population, and cover one fifth of the world's land mass. To most of us, mountain regions offer landscapes of spectacular scenic beauty – but what we don't see are the lives and struggles of the people who live in the mountains, many of whom are poor and marginal. Going by the global average, one in eight persons is food insecure, but in rural mountain areas this ratio is one out in two. This means that around 300 million mountain people are food insecure, with half of them suffering from chronic hunger. The hill agriculture has its own unique characteristics and that the growth potential of hill agriculture has remained under-exploited. However, hilly states have a lot of potential to accelerate agricultural growth through diversification. Demand for attribute based products that can be produced exclusively in hill ecosystem is rising rapidly. These offer tremendous scope for enhancing the farm income, addressing gender issues and creating job opportunities. 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.

During the last year, the institute worked on various aspects of yield improvement of agricultural and horticultural crops, their production, protection and processing technologies. Two varieties of wheat, three varieties of rice and one variety each of maize, lentil and field pea were notified, and one variety of wheat, three varieties of quality protein maize (QPM) and one variety of garden pea were released/ identified. Three genetic stocks of finger millet and two of barnyard millet were also registered for various traits. To popularize the newly developed varieties, front line demonstrations (FLDs) were conducted in a total of 22.6 ha area across the state. The newly released cultivars of various crops recorded a yield advantage of 19 to 87% over the popular varieties in farmer's field. A total of 379.16 q quality seed of various categories was produced and 366.14 q seed was supplied to government seed production agencies, NGOs, farmers, research organizations and private partners in 24 states across the country.

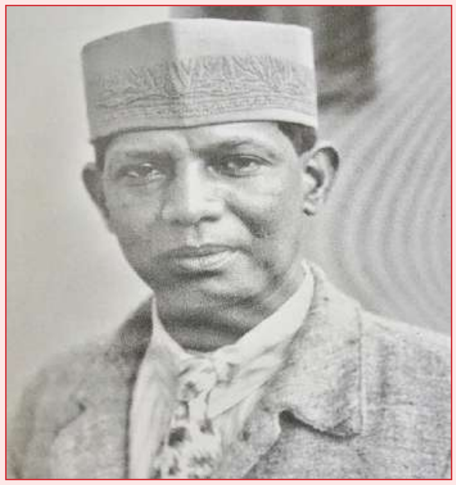
The special population of scheduled tribes and scheduled caste farmers is being served through Tribal Sub Plan (TSP) and Scheduled Caste Sub Plan (SCSP) programs in the unprivileged remote locations. Under these programmes, various physical assets *viz.*, low cost poly houses, poly tanks, portable polyhouses, vegetable seeds, 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 to the far flanged villages in North Eastern Himalayan regions through NEH programme. 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. In addition, 40 advisories were sent to 455 farmers through 21 Whats App groups, 75 phone calls were replied through Help Line service, 6 messages were sent through *m-Kisan* to 92,722 farmers and 40 need based messages were sent to 26,06 farmers. 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.

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 and kind support. I am obliged to the Deputy Director General (Crop Science), Assistant Director General (Seed) for their whole hearted 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: December 2022

(Lakshmi Kant)
Director

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



Padma Bhushan Professor Boshi Sen
01.01.1887 to 31.08.1971

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

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

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

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

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

CONTENT

Executive Summary

During 2022, two varieties of wheat, three varieties of rice and one variety each of maize, lentil and field pea were notified, and one variety of wheat, 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 of rice 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), and two state release varieties of wheat, VL *Gehun* 2028 (2,270 kg/ha) and VL *Gehun* 3010 (5,819 kg/ha), one state release each of maize, VLQPMH 59 (3,327 kg/ha), lentil VL *Masoor* 150 (758 kg/ha) and field pea VL *Matar* 64 (990 kg/ka). VL *Dhan* 69 is notified for cultivation in mid hills of the states of Uttarakhand, Sikkim and UTs of Jammu & Kashmir and Ladakh 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. VL *Gehun* 2028 is notified for timely sown rainfed organic production conditions of Uttarakhand hills and VL *Gehun* 3010 is notified for irrigated late sown production conditions of Uttarakhand plains. Both are highly resistant to yellow and brown rust diseases. Wheat variety VL *Gehun* 2041 (VL cookies) has been identified for Himachal Pradesh, Jammu and Kashmir, Uttarakhand, Manipur and Meghalaya, besides being high yielding (2,960 kg/ha) under rainfed conditions, possesses excellent biscuit quality (spread factor) value of 11.7 (highest in country), and mean grain hardness index of 22.6 placing it in soft wheat category. 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 varieties, 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 (4,100-4,400 kg/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 *opaque2* allele using marker-assisted backcrossing (MAB) method. The lentil variety VL *Masoor* 150 is moderately resistant to wilt, rust, pod damage and aphids and field pea variety VL *Matar* 64 is moderately resistant to wilt and powdery mildew. Both have been identified for timely sown rainfed organic condition of Uttarakhand hills. 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 (11.55 t/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 22.6 ha area across the state. The newly released cultivars of various crops recorded a yield advantage of 19 to 87% over the popular varieties in farmer's field. During this period, 379.16 q quality seed of various categories was produced and 366.14 q seed was supplied to government seed production agencies, NGOs, farmers, research organizations and private partners in 24 states across the country.

Bacterization of wheat (VL *Gehun* 967) seeds with PGP bacteria/consortia showed highest grain yield of 1,737 kg/ha with RDF (75% RDN +25% N by FYM) + consortium. Treatment of finger millet (VL *Mandua* 379) seed with PGP bacteria/consortia 75% RDF (50% RDN +25% N BY FYM) +*Pesudomonas*) recorded highest grain yield of 1,899 kg/ha. Buckwheat variety VL *Ugal* 7 recorded highest grain yield with

N:P:K through calcium nitrate+SSP+MoP (1,554 kg/ha). The nitrogen release pattern from bio-oil coated urea was observed to be better than commercial neem-coated urea. Methanol extracted bhang oil coated urea released 74.6 and 76.4 mg/kg available N on 10 DAT, whereas, neem coated urea (72.7 mg/kg) and uncoated urea (96.4 mg/kg) released maximum nitrogen on 5 DAT. Hexane-extracted pine needle, methanol-extracted *batain* and lantana oil showed higher toxicity against *Meloidogyne* sp. and LD50 value of these bio-oils were 495.1, 530.3 and 576.9 ppm, respectively. Evaluation of cold tolerant *Pseudomonas* sp. PPERs 23 increased grain yield of wheat variety VL *Gehun* 892 by 11.7% over uninoculated control (1,787 kg/ha). Out of 63 isolates collected from rhizospheric region of two lentil varieties (VL *Masoor* 126 and VL *Masoor* 507) at farmer's field, 16 isolates showed best results for three plant growth promoting activities (zinc and phosphate solubilization and siderophore production). VL polytunnel was modified in view of easier transportation and multi-use for farmers. A metering device was attached to VL Line maker which is detachable, adjustable and replaceable in nature as per crop requirement. Fruit based agri-horti system showed the maximum sweet corn (CMVL Sweet Corn 1) cob yield of 11,802 kg/ha under plum trees. The highest green pod yield of 12,256 kg/ha of garden pea (VL *Matar* 12) was recorded under open followed by with lemon, plum and apricot. Nutritional quality of wheat (VL *Gehun* 967) and barley (VL *Jau* 130) under peach based agro-horti system were found better than in open condition. In a study involving five different grass planting systems, the love grass was found to be most effective in controlling surface runoff (37.10%), soil loss (77.7%) and nutrient loss (77%) as compared to control. Wheat-rice rotations in relation to tillage alterations showed higher wheat yield of 5,301 kg/ha under zero tillage in comparison to 4,950 kg/ha under conventional tillage. The average highest wheat yield of 5,979 kg/ha was recorded under FYM mulch followed by 5,491 kg/ha under *Artemisia* mulch and 5,176 kg/ha walnut mulch and lowest of 3,856 kg/ha without mulch. In the long-term fertilization experiment, application of recommended NPK+10 t FYM recorded highest wheat grain yield of 4,588 kg/ha and application of only N recorded lowest grain yield of 1,667 kg/ha. An adjustable framing head structure was developed to maintain adjustable head up to 5m for efficient operation of micro irrigation system. The hydraulic evaluation of gravity based micro-irrigation system was found satisfactory as per the dripper flow variation and distribution uniformity varied in the range of 2.78-9.09% and 94.04-99%, respectively. Soil respiration and dehydrogenase enzyme activity were estimated under different irrigation systems for different crops under open and polyhouse conditions. Maximum microbial activities were found under polyhouse condition (dehydrogenase 45.63-55.70 µg TPF/g soil/h and respiration 26.7-34.8 µg CO2-C/g) as compared to open condition (dehydrogenase 40.16-48.20 µg TPF/g soil/h and respiration 23.2-31.4 µg CO2-C/g).

The use of *T. harzianum* as a biocontrol agent for managing lentil wilt showed the soil application and drenching with *T. harzianum* strains 28 and 202 had the lowest disease severity (9.58%), whereas seed treatment with carbendazim showed the maximum disease reduction (67.58%) compared to the bio-agent combination. Overall, the evaluated *T. harzianum* strains showed effectiveness in suppressing lentil wilt and have potential as a field biocontrol agent. Fifty-eight garden pea germplasm entries were screened for ascochyta blight, with entry VP1925 identified as resistant and nine other entries showing moderate resistance to the disease. An integrated approach for managing powdery mildew of wheat (VL *Gehun* 967) involved evaluating various fungicides and combinations, combination of azoxystrobin and difenoconazole at a concentration of 0.10% along with propiconazole proving effective in reducing disease severity (3.66 average disease score on a 0-9 scale) and also resulting in the highest yield (7,206 kg/ha). The evaluation of different carbon sources (dextrose, sucrose, and fructose) on mycelial biomass of *C. militaris* revealed that dextrose supplementation resulted in the highest mycelial biomass (8.11 g/L) in CDOX medium, followed by sucrose (8.00 g/L) and fructose (7.91 g/L). The role of entomophily (insect-mediated pollination) in enhancing seed yield and quality of lady's-finger (okra) in the mid-Himalayan region revealed up to 42% of cross pollination is facilitated by insects and planned bee pollination can improve both the economic fruit yield and biological parameters. The study also identified 28 insect species, with five predominant species (*Apis cerana indica*, *Apis mellifera*, *Bombus haemorrhodalis*, *Lithurgus atratus*, and *Xylocopa latipes*) acting as important floral visitors for okra. In a study to assess the molecular characterization of three *Ceratina* species native to the Indian Himalayas, phylogenetic analysis and comparison with the NCBI database revealed the presence of *Ceratina sutepensis* and *Ceratina smaragdula* with high identity matches, whereas *Ceratina similima* showed a lower identity match to *Braunsapis mixta*, indicating their distinct evolutionary paths within the *Apidae* family and *Xylocopinae* sub-family. In an effort to develop an eco-friendly pest management strategy against fall armyworm in maize, locally available plant extract *Thuja* leaf and seed extract showed the highest efficacy in reduction in pest infestation, followed by *Artemisia* and *Urtica* leaf extracts. In an effort to address the increasing insect pest problem in tomato cultivation under polyhouse conditions, a multipurpose insect trap was developed and screened for its effectiveness against *Tuta absoluta* and *Trialeurodes vaporariorum*, resulting in significant reductions in pest infestation by 71.25 and 48.45 per cent, respectively, offering a potential eco-friendly pest management strategy for tomato growers. A cost-effective *in-vivo* mass production system was developed for *Heterorhabditis indica* VLEPN01, an entomopathogenic nematode, using *Galleria* larvae, offering a viable method for large-scale production of this biocontrol agent for effective management of soil insect pests. The compatibility of the indigenous entomopathogenic nematode *Heterorhabditis indica* with different insecticides revealed that insecticides such as dichlorovos, carbofuran, and chlorguard were found to be non-compatible and should not be used in combination with EPN for controlling insect pests.

A pilot study on assessing women's empowerment in agriculture was taken up in mid hill region. On an average, women achieve adequacy in 46 per cent of the weighted indicators of women empowerment in agriculture. With respect to the relative contribution of individual indicators that comprise the women empowerment measure, women were most likely to achieve adequacy in asset ownership, access to and decisions on credit, and control over the use of income, and least likely to achieve adequacy in group membership and workload. Another study conducted to explore the nature of communication and information exchange networks prevailing among vegetable growers of Uttarakhand using social network analysis technique revealed that relatives/friends had the highest degree centrality in all the locales, indicating their significance as the most-preferred information source by the respondents, followed by state horticulture department, progressive farmer, friend and neighbour. These were the top five central and influential actors in the network. Relatives had the highest betweenness centrality score which means relatives played the broker/gatekeeper role in the network. It was evident that the factors that affect agriculture network usage among female vegetable growers were education, farming experience, hours dedicated to farming, group membership and contact with extension agency. Group membership has a positive and significant relation with agriculture network usage. Income, land holding, access to mobile, contact with extension agency and frequency of contact were the main factors that affected the agriculture network usage among male vegetable growers.

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 sponsored *Krishi Samridhi* radio programmes. During the period under report, 40 advisories were sent to 455 farmers through 21 Whats App groups, 75 phone calls were replied through Help Line service, 6 messages were sent through *m-Kisan* to 92,722 farmers and 40 need based messages were sent to 26,06 farmers. 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 *Padma Bhushan* 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 99 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 181 high yielding disease resistant varieties of 25 crops have been developed and notified by the institute. However, during last five years, 36 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 *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. VL *Gehun* 2028 is notified for timely sown rainfed organic production conditions of Uttarakhand hills and VL *Gehun* 3010 is notified for irrigated late sown production conditions of Uttarakhand plains. Both are highly resistant to yellow and brown rust diseases. The identified wheat variety VL *Gehun* 2041 (VL cookies), besides being high yielding (29.60 q/ha) under rainfed conditions, possesses excellent biscuit quality (spread factor) value of 11.7 (highest in country), and mean grain hardness index of 22.6 placing it in soft wheat category. 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 varieties, 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 *opaque2* allele using marker-assisted backcrossing (MAB) method. The lentil variety VL *Masoor* 150 is moderately resistant to wilt, rust, pod damage and aphids and field pea variety VL *Matar* 64 is moderately resistant to wilt and powdery mildew. Both have been notified for timely sown rainfed organic condition of Uttarakhand hills. 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 22.6 ha area across the state. The newly released cultivars of various crops recorded a yield advantage of 19 to 87% over the popular varieties in farmer's field. 379.16 q quality seed of various categories was produced and 366.14 q seed was supplied to government seed production agencies, NGOs, farmers, research organizations and private partners in 24 states across the country.

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; angular leaf spot, rust and anthracnose in bean; purple blotch, downy mildew 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 harzianum* 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 100 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 4,500 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 tons 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 tons) 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 laboratories, 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

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)

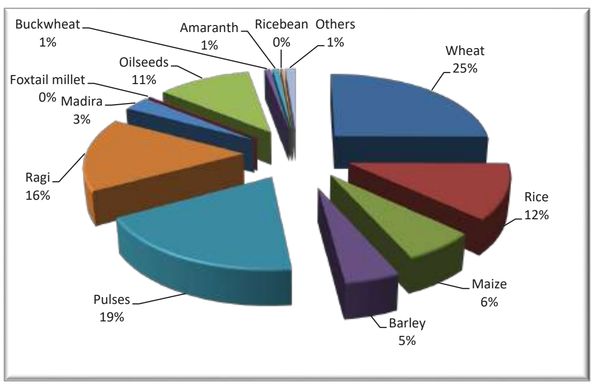
Local Area Network has been set up at the institute consisting of more than 100 nodes with 50 Mbps Internet Lease line connections at Almora and Hawalbagh campuses. AKMU maintains institute website which can be accessed at http://vpkas.icar.gov.in. AKMU also provides toll free Farmers' Helpline Service 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 92,722 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 Doon Trunk House, Lower Mall Road, Almora, Uttarakhand for 4 years. VL *Syahi Hal* is another popular implement developed and its TLA was signed with Dunagiri Swayat Sahkarita, Narsingh Bari, Officers Colony, Near K.G.N Furniture, Almora, Uttarakhand and Navsrijan Bahuuddeshiya Swayatt Sahkarita, Sitlakhet, Hawalbag, Almora for 03 years. Another TLA was signed with Green Tech Solution, Deval Chaur Kham, Manpur West, Haldwani, Nainital, Uttarakhand and M/s Himalayan Hi-Tech Nurseries, 85, Subhash Nagar Bhotia Parao, Haldwani, Nainital, Uttarakhand for the manufacturing and commercialization of VL Small Tool Kit for 3 years.

Gene Bank/ Medium Term Storage (MTS) Module

In the MTS module of ICAR-VPKAS, Almora, presently 17,242 germplasm accessions of more than 25 crops have been maintained. The germplasm comprised land races, obsolete varieties, genetic stocks, promising breeding lines and seed of national and international nurseries. A total 144 germplasm accessions, comprising garden pea (18), radish (60) leafy mustard (48), *Dolichos* bean (17) and horse gram (1) were deposited in the gene bank during 2022 for further utilization in crop improvement programme.



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

Staff

The staff position of the Institute as on December 31, 2022 is given below:

Position	Sanctioned	Filled	Vacant
R.M.P.	1	1	0
Scientific	55	30	25
Technical	44	29	15
Administrative	35	14	21
Supporting	35	27	08
Supporting (CLTS)	0	09	0
Total	**170**	**101**	**69**

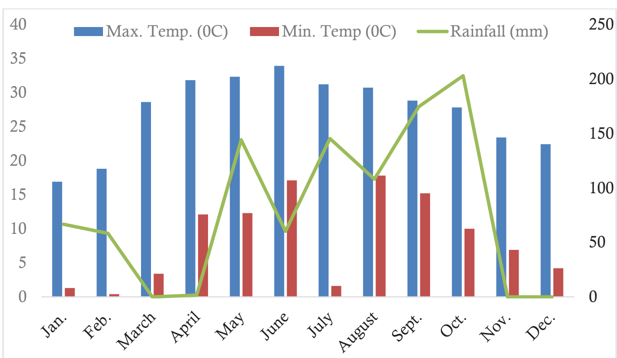
Finance

The budget outlay for January to December 2022 (Rs. in lakhs) is given hereunder:

Item	Allocation	Expenditure
Grant-in-General	500	500

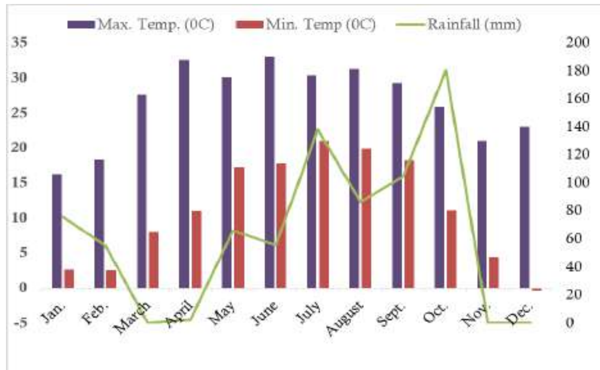
1.5. Weather

The mean maximum temperature ranged from 16.9^0C (January) to 33.9^0C (June) and mean minimum temperature varied from 0.4^0C (February) to 18.6^0C (July) in Almora. During the month of October 202.8 mm rainfall was received.



Meteorological data of ICAR-VPKAS, Almora

At Experimental farm, Hawalbagh, mean maximum temperature ranged from 16.3^0C (January) to 33.1^0C (June) and mean minimum temperature varied from -0.4^0C (December) to 19.9^0C (August). During the month of October 180.5 mm rainfall was received.

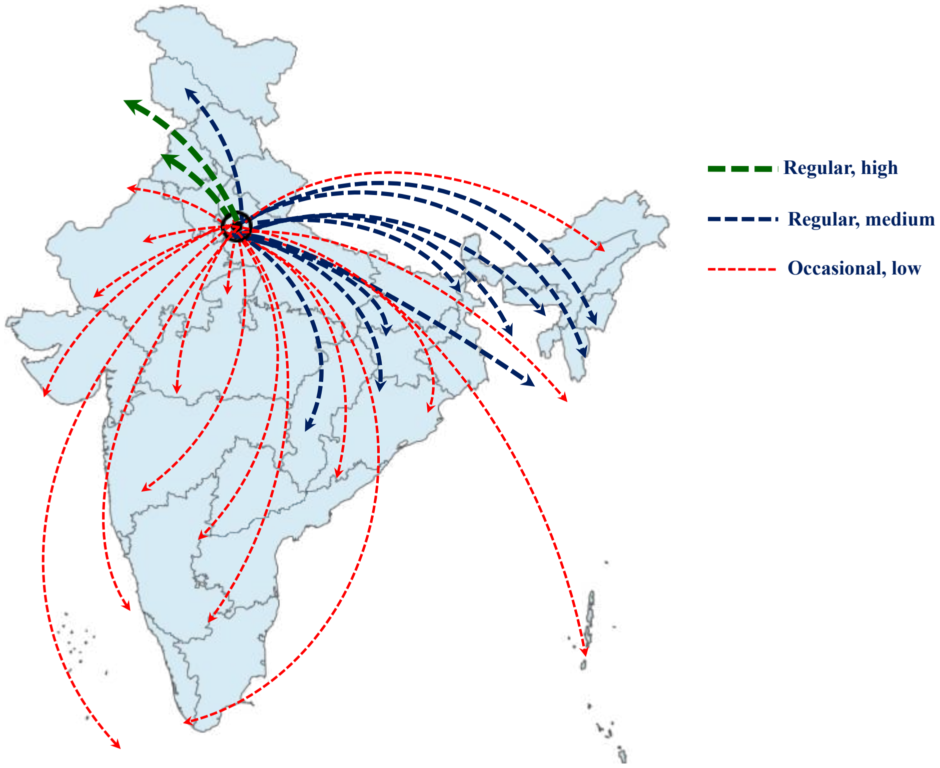


Meteorological data of Experimental Farm, Hawalbagh

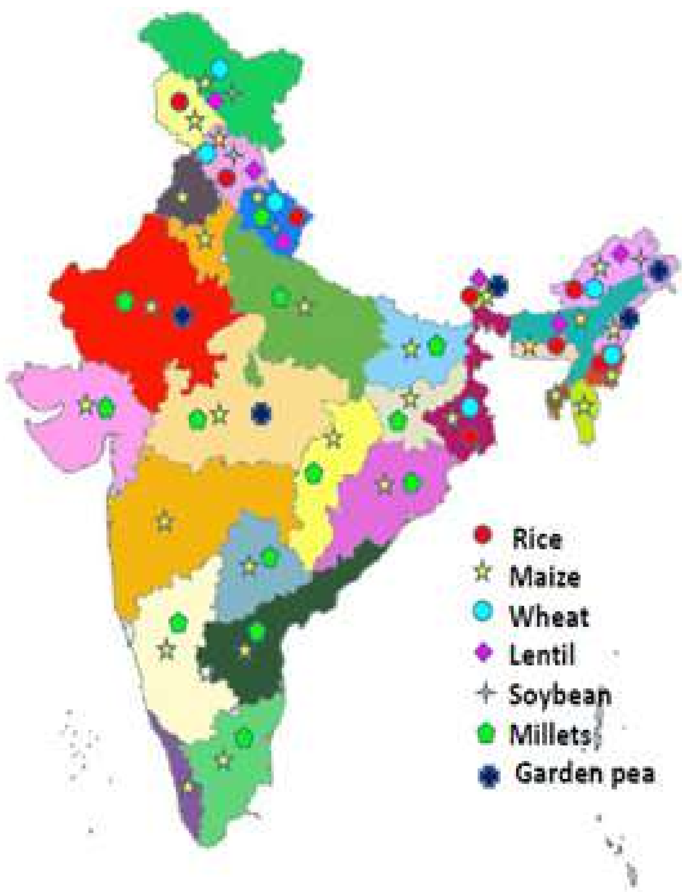
1.6. Recommendation Domain of the Varieties Developed during Last Five Years outside the Mandated Area

Since 2018, 36 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.

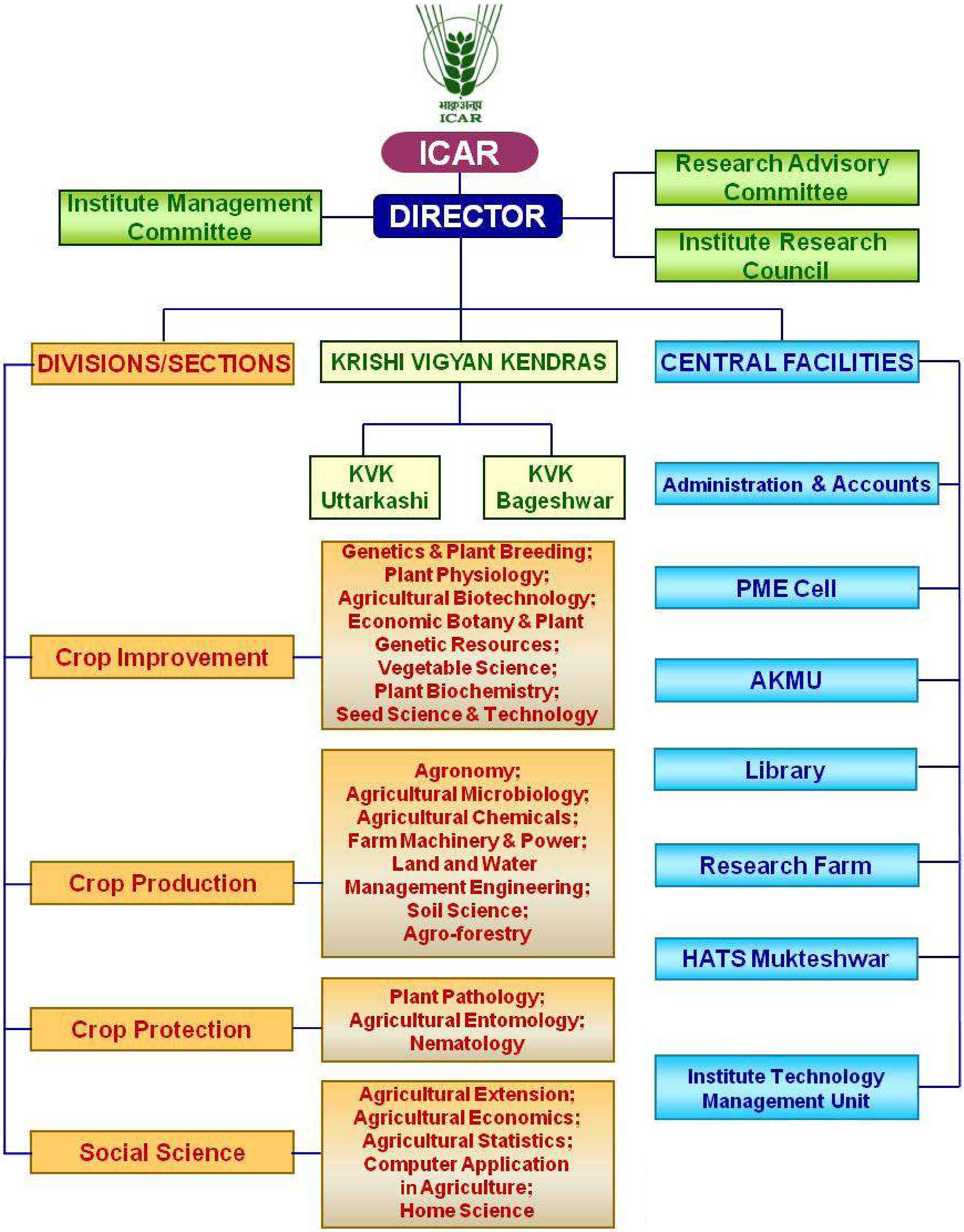
Technology dissemination map



Technology delivery Map



ICAR-VPKAS varieties reach to the states of India



Organizational Setup, ICAR-VPKAS, Almora, Uttarakhand

ACHIEVEMENTS

VL *Dhan* 69

VL *Gehun* 2028

VL *Masoor* 150

Sowing Device for VL Line Maker

Multipurpose Insect Trap

VL Soya 89 at Farmer's Field

2. Enhancement in the Productivity of Major Hill Crops

Research Projects

- Rice Breeding for Escalating Productivity and Resistance to Biotic and Abiotic Stress for Himalayan Region [*Drs. J.P. Aditya, Gaurav Verma, Anuradha Bhartiya, Manoj Parihar (upto December 23, 2022) and R.P. Meena (w.e.f. December 24, 2022)*]
- Enhancement of Wheat and Barley for Productivity, Quality Traits, Biotic and Abiotic Stresses through Conventional and Molecular Tools in Northern Hills Zone [*Drs. Lakshmi Kant (upto October 13, 2022), Navin Chandra Gahtyari, K.K. Mishra and Amit Kumar*]
    - **Sub-project:** Breeding for Reduced Anti-Nutritional Factors and Improved Grain Quality through Integrated Approaches [*Dr. Navin Chandra Gahtyari (PI)*]
- Breeding Maize for Diverse End-Uses Using a Combination of Conventional and Accelerated Breeding Approach [*Drs. R.K. Khulbe, Devender Sharma, Jeevan, B. (upto September 03, 2022), K.K. Mishra (w.e.f. September 04, 2022), R.S. Pal, Rakesh Bhowmick and Amit Kumar*]
    - **Sub-project:** Genetic Enhancement of Maize for Micronutrients and Methionine Using an Integrated Breeding Approach [*Drs. Devender Sharma (PI) and PriyankaKhati (PM)*]
- Genetic Enhancement of Small Millets and Potential Crops to Strengthen Climate Resilience and Nutritional Security in North-West Himalayas [*Drs. D.C. Joshi, M.S. Bhinda, Jeevan, B. (upto September 03, 2022), Dr. Gaurav Verma (w.e.f. September 04, 2022), Manoj Parihar (upto December 23, 2022), R.P. Meena (w.e.f. December 24, 2022) and Amit Umesh Paschapur*]
    - **Sub-project:** Genetic Improvement of Quinoa for High Yield, Nutritional Quality and Tolerance to Biotic Stresses [*Dr. M.S. Bhinda (PI)*]
- Enhancing Pulses and Oilseeds Productivity and Profitability through Improved Varietal Technologies in NW Himalayan Hills [*Drs. AnuradhaBhartiya, J.P. Aditya, R.S. Pal, Jeevan, B. (upto September 03, 2022), Dr. Gaurav Verma (w.e.f. September 04, 2022) and AmitUmeshPaschapur*]
- Genetic Improvement in Vegetable Crops for North West Himalayan Ecosystem through Conventional and Mutagenesis [*Drs. N.K. Hedau, Rahul Dev, B.M. Pandey, K.K. Mishra, Amit Umesh Paschapur and R.S. Pal (PM)*]
    - **Sub-project:** Collection, Evaluation, Identification and Documentation of Underutilized Vegetable Crops for North-West Himalayan Ecosystem [*Dr. Rahul Dev (PI)*]
- Evaluation and Identification of Major Hill Crops for Abiotic Stresses and Quality Traits through Basic Techniques [*Drs. R.S. Pal, Rakesh Bhowmick, Devender Sharma, Rahul Dev and Navin Gahtyari*]
    - **Sub-project:** Identification and Utilization of Important Genes/Alleles/ Markers in Hill Crops [*Dr. Rakesh Bhowmick (PI)*]
- **Flagship project:** Ensuring Food and Nutritional Security in North West Himalayas through Climate Resilient Enhanced Production of Millet and Potential Crops by Post-Harvest Management, Value Addition and Commercialization *(Drs. D.C. Joshi, M.S. Bhinda, Jeevan, B. (upto 03.09.2022), Dr. Gaurav Verma (w.e.f. 04.09.2022), Hitesh Bijarnia, Manoj Parihar (upto December 23, 2022), R.P. Meena (w.e.f. December 24, 2022),Kushagra Joshi)*
- Seed Production Programme [*Drs. Lakshmi Kant (upto October 13, 2022), Rajesh Kumar Khulbe, Devender Sharma*]

2.0 Enhancing Genetic Gain in Important Crops of North-Western Himalayan Region for Productivity, Quality Traits and Multi Stresses Resilience through Pre-Breeding, Conventional and Accelerated Breeding Tools

2.1 Rice Breeding for Escalating Productivity and Resistance to Biotic and Abiotic Stress for Himalayan Region

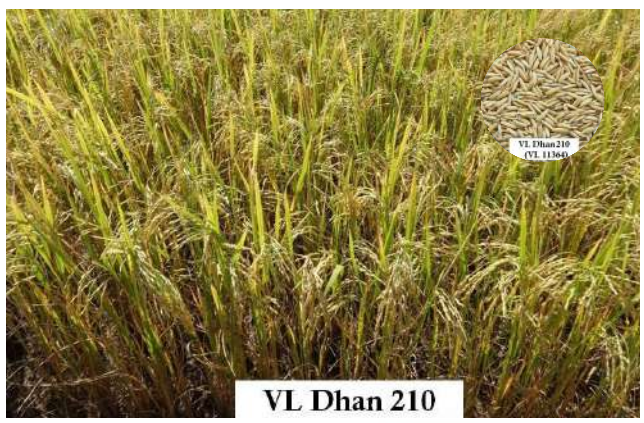
Rice is one of the main *kharif* crops ofNorth Western Himalayan hills, cultivated in an area 0.59 m ha withproduction1.43 mt and 2,435 kg/ha productivity. The union territory of Jammu & Kashmir has the largest acreage of rice(0.26 m ha), while Uttarakhand had the highest production (0.71 mt) and productivity (2,814 kg/ha).In comparison to the national average productivity (2,717kg/ha), the NW Himalayan regions are falling behind. Therefore, location, ecosystem and elevation specific high yielding varieties are needed that are resistant to biotic and abiotic stresses.

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 of 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 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 of VLD 207/VL 30424 and has long slender grain. It has plant height of 90-110 cm and has shown resistance against leaf and neck blast (score 1-3), brown leaf spot (score 3-4), sheath rot (score 1), leaf scald (score 3), false smut (score 0-1), stem borer and leaf folder (score 0-3) 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 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 resistant to leaf and neck blast diseases. It has shown average yield potential of 2,088 kg/ha under organic conditions which was 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) 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 (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).

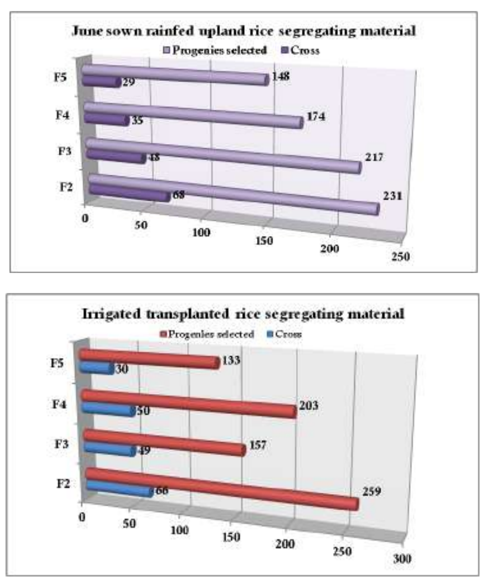


Fig 2.1.1. Segregating material under rainfed upland and irrigated transplanted ecosystem

2.1.1.4. Frontline demonstrations

The front line demonstrations of released variety, VL *Dhan* 68 were conducted under irrigated condition during *kharif* 2021in 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 (33.4q/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, IR-BL-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	2302,2306,2507,2011,2613,2619,2625,2627,2629,2714
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).

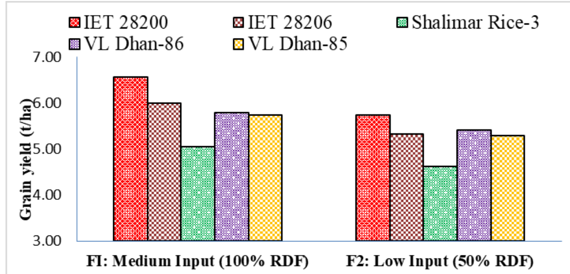


Fig. 2.1.2. Effect of nutrient levels on grain yield of early hill rice cultivars

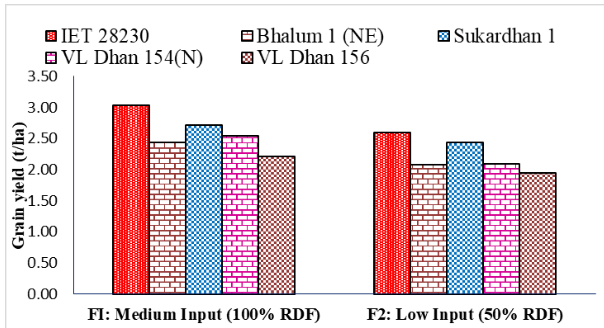


Fig. 2.1.3. Effect of nutrient levels on grain yield of upland rice cultivars

2.2. Enhancement of Wheat and Barley for Productivity, Quality Traits, Biotic and Abiotic Stresses through Conventional and Molecular Tools in Northern Hills Zone

A. Wheat

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

2.2.1. Varietal Improvement

2.2.1.1. Variety Notified

VL *Gehun* 2028 (S.O. 4065 (E) dated 31.08.2022): This new high yielding strain was developed from a cross FRANCOLIN #1*2/MUU. It has been identified for release under timely sown rainfed organic production conditions of Uttarakhand hills. It has an average yield potential of 22.70 q/ha which was 10.55% higher than the best check VL *Gehun* 953 (20.53 q/ha) over three years of testing in Uttarakhand hills. It is also highly resistant to yellow and brown rust diseases.

VL *Gehun* 3010 (S.O. 4065 (E) dated 31.08.2022): This new high yielding strain was developed from a winter x spring wheat cross RAJ 4083/NESSER/SAULES:KU 32. It has been identified for release under irrigated late sown production conditions of Uttarakhandplains. It has an average yield potential of 58.19 q/ha which was 6.16% higher than the best check UP 2526 (54.81 q/ha) over three years of testing in Uttarakhandplains. VL *Gehun* 3010 is also highly resistant to yellow and brown rust diseases.

2.2.1.2. Variety Identified

VL *Gehun* 2041 (VL Cookies): The variety was identified based on its superior grain quality and suitability for biscuit making. It possesses excellent biscuit quality (spread factor) value of 11.7 (highest in country), and mean grain hardness index of 22.6 placing it insoft wheat category. VL *Gehun* 2041 (29.60 q/ha) showed an overall yield superiority of 2.00 %, 5.08 % and 2.01 % over checks HS 507 (29.03 q/ha), VL *Gehun* 907 (28.17 q/ha) and HPW 349 (29.02 q/ha), respectively under rainfed conditions during the three years of testing. This variety has been identified for release in Northern Hills Zone comprising of Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Manipur and Meghalaya.

2.2.1.3. Elite lines under All India Coordinated Wheat Improvement Program

Rainfed conditions

Eight entries were tested in AVT timely sown trial. Test entries VL 2043 (5,030 Kg/ha) and VL 2044 (4,860 Kg/ha) were the top two entries at Almora centre and were significantly superior to best check HS 562 (4,560 Kg/ha). However, at zonal level none of the entry were able to surpass the best check HS 562 (3,610 Kg/ha). Twelve entries were evaluated in the late sown restricted irrigation AVT (pre-sown irrigation only) trial wherein none of the test entry was found statistically superior to best check VL *Gehun* 892 (2,350 Kg/ha). However, on overall basis (zonal mean) only one entry *viz.*, VL 3028 (2,700 kg/ha) yielded statistically superior to the best check VL *Gehun* 892 (2,515 kg/ha) and hence was advanced to the AVT-II trial.

2.2.1.4. Elite lines under state wheat improvement programme

Irrigated organic conditions

Eleven entries were evaluated under the irrigated SVT organic timely sown trial and none was superior to the best check VL *Gehun* 967 (3,998 kg/ha) at Hawalbagh centre. However, based on the pooled data for previous two year across state, VL 2043 (2845 Kg/ha) showed 6.63% yield advantage over the best check VL *Gehun* 967 (2568 Kg/ha) and hence was promoted to the final year of testing in 2022-23.

2.2.1.5. Elite lines under station trials

Under initial station yield evaluation trials, one trial each under rainfed timely sown, irrigated timely sown and restricted irrigation late sown conditions was conducted to assess the adaptability of new wheat strains with respect to grain yield and disease resistance. Under timely sown rainfedtrial,42entries were tested and the test entries VW 2149 (5,590 kg/ha), VW 2113 (4,680 kg/ha) and VW 2106 (4,510 kg/ha)were the top three entries which were significantly superior to the best check HS 562 (3,240 kg/ha).Eighteen entries were evaluated under the late sown restricted irrigation (pre-sown irrigation only) trial, where VW 2145 (2,600 kg/ha) and VW 2149 (2,620 kg/ha)were the top two entries of trial, superior to the best check VL *Gehun* 892 (2,200 kg/ha).Forty-two entries were evaluated under irrigated timely sown trial and entries VW 2108 (7,640 kg/ha), VW 2101 (7,600 kg/ha) and VW 2104 (7,520 kg/ha) were statistically at par with best check HS 562 (7,660 kg/ha) in grain yield.

Development of new strains/breeding materials

Three hundred and seventy-two fresh crosses [141spring x spring (S×S) and 231winter × spring (W×S) wheat] including direct, back crosses and three-way crosses were successfully made by utilizing diverse donors of winter and spring wheat. Two hundred and two better performing F_1 hybrids, consisting of 110 S×S and 92W×S were identified after evaluation of 332F_1 hybrids. One hundred and sixty-eightF_2's (*i.e.,* 51 S×S and 117W×S) and 465 bulk progenies of 465 crosses (248 W×S and 217 S×S) in F_3 to F_5 generations and 528single plant progenies of 109crosses (61SxS and 48WxS) in F_6 and subsequent generations were planted for evaluation and further selection. The heavy rust infection facilitated the selection and on overall basis, 518bulk and 657individual plant progenies from F_3 generations onward were selected.

2.2.1.6. Breeding for quality wheat

For protein percentage (>12.5%) eight entries *viz.* VL 3004, VL 3019, QLD 102, BNSR6, QLD 118, QLD 120, QLD 121, QLD 122; for biscuit quality, three entries *viz.* HS 490, BN 1143, BN 1129; for sedimentation value, three entries *viz.* DBW 173, QLD 73 and QLD 100; for chapatti quality, four entries *viz.* PBW 757, HD 2967, VL 907 and VL 858; for high iron nine entries *viz.* DBW 107, GW 1339, DBW 107, FLW 10, HD 3237, HI 1621, HD 3298, DBW 252 and HS 562; for high zinc three entries *viz.* WB02, Karan Poshan-1 and Karan Poshan-2; and for low phytic acid one entry *i.e.* IIWBR Phy-1 were used as donors for the respective traits and were crossed with well adapted genotypes. Ninety-four F_1 crosses attempted during the previous season for quality (*rabi* 2020-21) were evaluated during *rabi* 2021-22. Additionally, ninety fresh crosses were attempted during *rabi* 2021-22. Based on the quality assessment for the F_6 bulks, 9 entries having sedimentation value <35 were retained due to their soft wheat quality for further observation and evaluation. Among them, one entry *i.e.* BN 1439 (VL 1003/VW 1472//HD 3075-26) owing to its superior agronomic and yield traits was selected for LS station trial during 2022-23.Similarly, an entry BN 1212 (DBW 50/PBW 707-22) owing to its high Fe content (56.3 ppm) was selected for the timely sown rainfed and irrigated station trials during 2022-23. The quality parameters of promising F_6 bulks are given in Table 2.2.1.

2.2.1.7. Improvement of spring wheat through introgressionfrom winter wheat gene pool

Forty-three winter and facultative wheat selected for their high grain yield, tillering, ear length, grain number per ear and disease resistance were planted in a crossing block at experimental farm, ICAR-VPKAS, Hawalbagh and crossed to spring wheat known for their high yield potential, disease resistance (rust resistance) and adaptation to the major wheat-growing regions of the country. A total of 206 (winter x spring) crosses including 91 direct crosses, 23 back crosses and 923-way crosses were successfully made during *rabi* 2021-22. In addition, 156 F_1s made during *rabi* 2020-21 were planted and 92were retained for growing their F_2 generation during the next crop season (2022-23).A total of 60 F_2's retained during last season (2020-21), were raised during *rabi* 2021-22 and finally, 50 F_2's was bulked. The 50 F_2 bulks were shared with 21 co-operators in five major wheat growing zones of the country through 25[th] Segregating stock nursery (SSN) for evaluation and further selection under different biotic and abiotic stresses. These materials were utilized to the tune of 39.6% by different cooperating centres and a total of 3129 plants were selected.

2.2.1.8. Genetic Resources – Evaluation, Utilization and Maintenance

One national nursery *i.e.*, national genetic stock nursery (NGSN) comprising of 82 entries, one

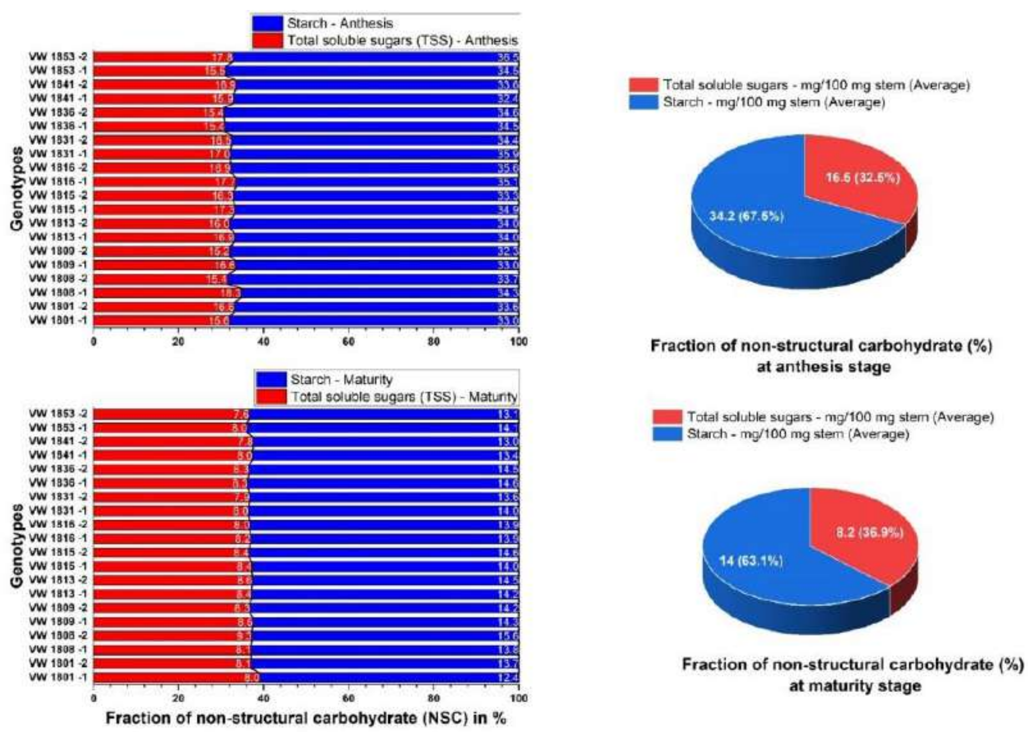
Table 2.2.1. Promising F_6 bulks with desirable quality parameters

Sample No	Iron (Category)	Protein (%)	Carbohydrate (%)	Fat (%)	Moisture (%)	β-carotene (ppm)	Zeleny sedimentation value (ml)	Polyphenols (mg GAEg)
950	Medium	11.2	68.2	3.4	13.8	1.8	15.6	0.31
931	Medium	11.0	68.2	3.4	13.8	1.6	31.3	0.32
1291	High	11.0	66.5	3.3	13.9	1.6	23.4	0.30
933	Medium	11.0	68.4	3.3	13.8	1.8	39.1	0.36
929	Low	11.0	67.2	3.3	13.7	1.6	23.4	0.30
1292	High	10.9	67.9	3.3	13.8	1.7	31.3	0.34
1163	Medium	10.9	67.6	3.3	13.8	1.6	23.4	0.29
1212	Medium	10.9	67.2	3.2	13.8	1.7	15.6	0.32
1213	Medium	10.9	66.8	3.2	13.8	1.6	39.1	0.31
1154	Medium	10.9	68.4	3.4	13.7	1.7	39.1	0.31

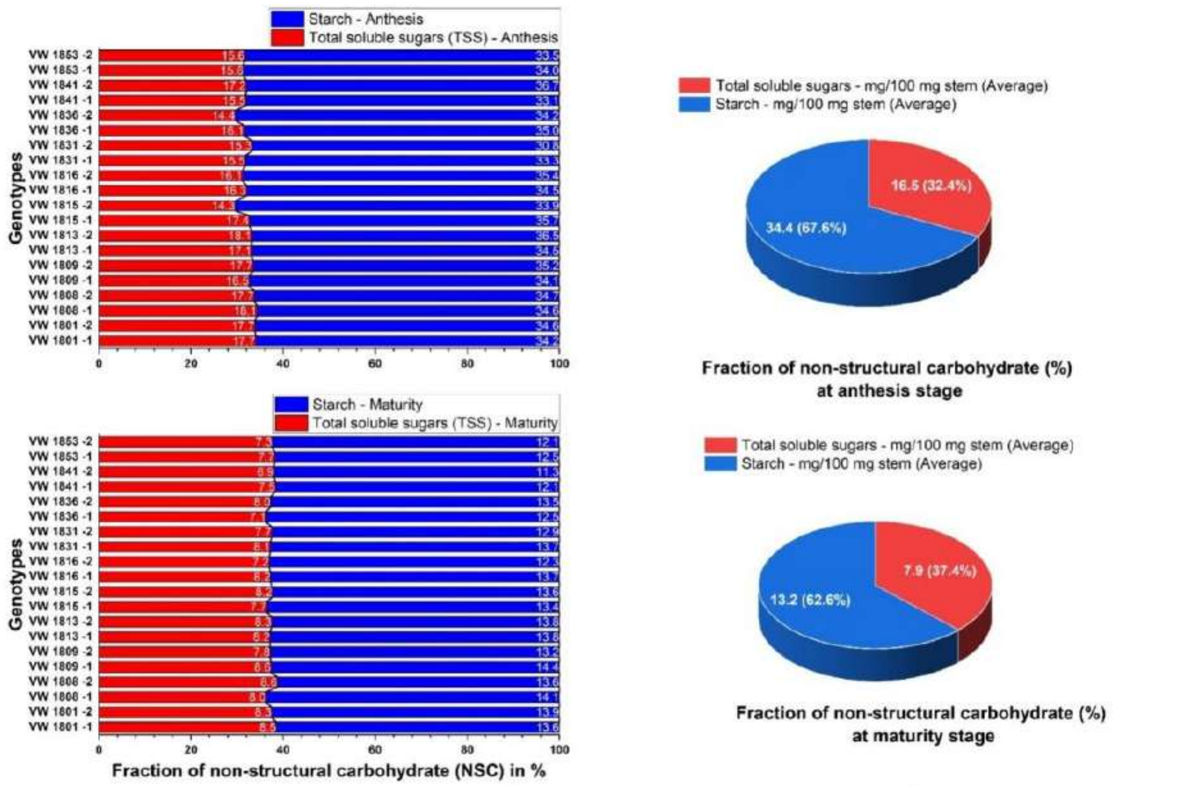
international winter wheat yield trial *i.e.*, 23rd IWWYT–SA, 2021-22of 40 entries, and one facultative and winter wheat observation nursery (29th FAWWON–SA – 2021-22) having 90 entries were evaluated during the season (*rabi* 2021-22). 25 entries from the NGSN were utilized as donors in the hybridization programme. The entries from NGSN were utilized for diverse utilities like for 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), thousand kernel weight (TAW 185), shorter plant height (DM 6, DM7) and disease resistance (DBW 187, PBW 778). Likewise, 11 entries from 23rd IWWYT–IR, 2021-22 and 15 entries from 29th FAWWON–SA–2021-22 were utilized as donors for desired agronomic traits like thousand kernel weight, higher tillering, rust resistance and high grain yield in the hybridization programme.

2.2.1.9. 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 in two different dates of sowing *i.e.*, timely (18th November 2021) and very late (17th January 2022). During timely sown conditions, the average total soluble sugar (TSS) content at anthesis stage was 16.5mg (range–15.2–18.3 mg) which reduced by 50.2% at the physiological maturity stage to reach average value of 8.2 mg (range –7.6 – 9.3 mg). Likewise, starch component of the NSC at anthesis stage had an average value of 34.2 mg (range –32.3–36.5) which reduced to an average value of 14.0 mg (12.4 – 15.6 mg), showing 59.1% reduction from the initial levels at anthesis stage. The NSC composition at anthesis was 32.5% TSS and 67.5% starch, which changed to 36.9% TSS and 63.1% starch at the maturity stage. Compared to timely sown conditions, the same genotypes in late sown conditions showed higher amount of NSC at anthesis stage *i.e.*, average TSS and starch content of 16.5 mg and 34.4 mg respectively, but conversely lower amount of NSC at maturity stage i.e., average TSS and starch content of 7.9 mg and 13.2 mg, respectively.



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 very late sown conditions.

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

A total of 10 test entries having low and high-test weights sourced from the *rabi* 2020-21 timely and late sown trials, respectively were aggregated to constitute a 20-entry trial in two different dates of sowing (timely and very late) during *rabi* 2021-22 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. The single grain weight of superior grain (34.2–54.1 mg) was on an average 7.7% heavier compared to inferior grain (30.2–50.4 mg) in timely sown conditions, which enhanced to 9.4% in the very late sown conditions. Based on overall results for timely and very late sown conditions, the single grain weight difference between superior and inferior grain was highest for genotype 1813-2 (superior grain 12.3–14.3% heavier compared to inferior grain) compared to genotype 1831-1 (superior grain 4.1–6.1% heavier compared to inferior grain) having the minimal differences. In very late sown conditions, the paired t-test for the superior grains showed a significant difference for kernel weight of the same genotype but designated separately attributed to last season's test weight differences with p values <0.001.

2.2.2. Plant Pathological Investigations

More than 2450 wheat and barley entries/lines under different coordinated and station nurseries/trials were screened under artificial epiphytotic conditions. These included Wheat Disease Monitoring Nursery (WDMN), SAARC nursery, Loose Smut Expression Nursery (LSEN), powdery mildew screening nursery (PMSN), hill bunt screening nursery, 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). Following lines of wheat and barley were found promising (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), RNB 1001 (0S), WL1562 (0S) against stripe rust; susceptible check-80S
SAARC	HD 2189 (0S), PBW 660 (0S), Faisalabad 83 (0S), Punjab 85 (0S) against stripe rust; susceptible check-40S
LSEN	VL 2041 (11.1%), DBW 222 (c) (4.2%), DBW 321 (4.7%), UP 3062 (8.8%), Sonalika (47.1%)
PMSN	UAS 478 (d) (2), HD 3392 (2), DBW 359 (2), DBW 353 (2), WH 1124 (2), PBW 343 (c) (7)
HBSN	VL 2047 (3.6%), HPW 481 (3.2%), HPW 488 (5.8%), HPW 483 (4.4%), HPW 484 (3.9%)
EPPSN	HI 1654, DBW 296, HI 8830 (d), WHD 965 (d), HD 3368, HD 3410, PBW 867, DBW 318, UP 3060, HI 8833 (d), HI 8826 (d), HI 8828 (d), HI 8827 (d), PBW 826, HD, 3368, DBW 316, HD 3407, HD 3413, DBW 318, WH 1405, PBW 870, CPIIWBR-121 and CPIIWBR-185 (for all rusts) HI 1655, GW 513, HI 1636, GW 528, CG 1036, HI 1651, UP 3095, UP 3096, CPIIWBR-100, CPIIWBR-153, CPIIWBR-266 (for stem & leaf rusts) PBW 835, UAS 475 (d), PBW 874 and CPIIWBR-144 (for leaf & stripe rusts) UP 3062 (for stem & stripe rusts)
MDSN	HS 679,HS 681,DDK 1058 (dic.),HUW 838,RAJ 4541,HI 8823(d), DDK 1059 (dic.), GW 513,HD 2864,HI 1544,HI 1633,HI 8627(d),HI 8818(d),VL 3024 (resistant to stem and leaf rust)
NBDSN	BH1042, BH1045, BHS352©, K603©, KB2004, KB2013, KB2015, NDB1776, NDB1785, NDB1800, PL936, PL940, RD3034, RD3051, RD3054, RD3055, RD3059, RD3063 and UPB1105 (YR ACI=0); Infector (YR ACI=80)
EBDSN	HUB113 (C), RD2794 (C), RD2899 (C) and RD3039 (YR ACI=0); Infector (YR ACI=82.9)
IBDSN	BD 1935, BD 1938, BD 1940, BD 1944, BD 1946, BD 1947, BD 1948, BD 1951, BD 1958, BH 21-03, BH 21-10, BH 21-38, BBM 902, BBM 923, PKB 2150, PKB 2155, PKB 2160, VB 2110, UPBM 8, UPBM 17, UPBM 18, BL 2016 and BK 2136 (YR ACI=0), Infector (YR ACI=80)

2.2.3. Agronomic investigations

Performance of new wheat genotypes at different irrigation levels under restricted irrigation conditions

The performance of one test genotype VL *Gehun* 2041 was evaluated under restricted irrigation conditions (no irrigation, one irrigation at CRI and two irrigations at CRI and Jointing stages) against four checks (HPW 349, VL *Gehun* 907, HS 562, and HF 507). The study showed that increasing irrigation levels significantly increased the grain yield. The significantly higher grain yield (47.5 q/ha) was obtained with two irrigations as compared with zero and one irrigations levels. All the check varieties were significantly superior to test entry VL *Gehun* 2041. Among check varieties, HS 562(C) produced significantly higher yield (48.4 q/ha) then rest of the tested genotypes. Irrigation level and genotypes interaction was non-significant for grain yield.

Effect of nano urea on increasing N use efficiency and productivity of wheat under irrigated condition

The experiment was conducted to gauge the effects of foliar sprays of IFFCO nano urea, normal urea and water in combination with different fertilizer N doses on yield response of wheat under irrigated ecosystem. In comparison to control, all the treatments caused significant yield improvement of wheat (VL *Gehun* 2014). Among the treatments, the lowest grain yield (25.5 q/ha) was found in control treatment. The recommended N doses + water spray at tillering and jointing recorded significantly highest grain yield of wheat (56.7 q/ha) and was found at par with recommended N doses + one spray of nano urea (0.4%) at tillering, recommended N doses + two spray of nano urea (0.4%) at tillering and jointing and recommended N doses + two spray of urea (5%) at tillering and jointing treatments.

B. BARLEY

Barley is being cultivated to some of the traditional areas of North-Western Hills. It is being cultivated in 20.0 thousand 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

Fifty-fivenew barley strains were evaluated in 4 different trials, to identify high yielding disease resistant genotypes as against the checks in NHZ (HBL 113, BHS 352, BHS 380, BHS 400 and VLB 118) and SVT (VLB 118, VLB 130 and UPB 1008). In AVT timely sown rainfed trial, VLB 177 (3,756 kg/ha) was the topmost entry statistically at par with best check VLB 118 (3,684 kg/ha). On overall basis in NHZ, VLB 175 (2,944 kg/ha) was topmost entry for grain yield and 2ndbest entry for fodder yield (11,610 kg/ha) and thus promoted to AVT-II year. In SVT (organic) timely sown rainfed trial, test entries VLB 177 (1,973 kg/ha) was statistically superior to best check VLB 118 (1,705 kg/ha) at Hawalbagh centre. On overall basis in the state, two test entries *i.e.* VLB 175 (2,001 kg/ha) and VLB 177 (1947 kg/ha) were found significantly superior to best check VLB 118 (1,777 kg/ha) by 12.6% and 9.5%, respectively and were thus promoted for 2nd year of co-ordinated testing.

Development of new strains

To develop high yielding disease resistant genotypes, 136 introduced materialswere evaluated and 30were selected based on their agronomic score, yielding ability and yellow rust resistance (<20S) for their further evaluation during the ensuing season.

2.3. Breeding Maize for Diverse End-Uses Using a Combination of Conventional and Accelerated Breeding Approach

Maize is an important cereal crop of North-Western Himalayas. By and large, maize is cultivated during the *kharif* season under rainfed conditions in the North-Western Hills. The states of Jammu & Kashmir, Himachal Pradesh and Uttarakhand (Hills) with a total area of 595 th ha and production of 1,323 th tonnes account for 6.3 and 4.8% of the national area and production, respectively. The productivity is 2,099 kg/ha compared to national average of 2,995 kg/ha. Considering the short growing period and high cropping intensity in hills, emphasis was laid on the development of early and extra-early duration genotypes, which mature in 85-90 days in hills with high yield potential and resistance to prevailing diseases in general and turcicum leaf blight in particular. Thrust was also placed on the development of specialty corn like sweet corn, popcorn and baby corn varieties, in view of the commercial potential of specialty corn in the region.

2.3.1. Varietal Improvement

2.3.1.1 Notified 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.

2.3.1.2 Identified 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.

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.

2.3.1.3. 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) FPVH 1(7,069 kg/ha)	VMH 53 (7,823) 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)
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		
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)

2.3.1.4. 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 - 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 BC2F3 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.

2.3.1.5. 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
- Nine CIMMYT donor lines [2 low phytate (Lpa 1, Lpa 2), 2 provitamin A (CIMMYT 4,CIMMYT 13), 2 liguleless lines and 3 haploid inducer lines 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.

2.3.1.6. 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)	V335, V345, V341, V346, V373, CM152, CM212, VQL1
ICAR-NBPGR, New Delhi	VBL 17,VQL 398, VQL 390, V 461

2.3.2. 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 (SC-21 K-I-01, SC-21 K-I-02, SC-21 K-I-03, and SC-21 K-I-04) 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 green cob yield of sweet corn. Among genotypes, SC-21 K-I-02 produced significantly higher green cob yield (29.798 t/ha) than others followed by SC-21 K-I-01 (green cob yield 26.045 t/ha).

Three pre-release maize genotypes (FCE-21K-1-01, FCE-21K-1-02 and FCE-21K-1-03) 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) have improved grain yield of maize by 16.4% over 150-60-60 kg/ha N-P_2O_5-K_2O level. Among genotypes, FCE-21K-1-02 produced significantly higher grain yield (8.16 t/ha) followed by FCE-21K-1-03 (7.64 t/ha).

2.3.3. Plant Pathological Investigations

More than 300 maize entries under different coordinated and station trials were evaluated against turcicum leaf blight (*Exserohilum turcicum*) (Table 2.3.3.1).

Table 2.3.3.1. 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. Genetic Enhancement of Small Millets and Potential Crops to Strengthen Climate Resilience and Nutritional Security in North-West Himalayas

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 149.0 thousand hectares in North-Western Himalayas with maximum area in Uttarakhand (138.0 thousand hectares) and productivity ranging from 260 kg/ha (other small millets in J&K) to 1,459 kg/ha (finger millet in Uttarakhand). Development of short duration, high yielding and disease resistant varieties of small millets is the main activity of the research program.

2.4.1. Varietal Improvement

2.4.1.1. 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

2.4.1.2. 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).

2.4.1.3. 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 (3,603.6 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 (2,804.5 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 *Mandua* 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).

2.4.2. 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 ayield advantage of ~13% and 28% over the best checks VL *Mandua* 376 and GPU 67, respectively.

2.4.3. 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 2.4.1. 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	-	

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

2.5. Enhancing Pulses and Oilseeds Productivity and Profitability through Improved Varietal Technologies in NW 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 113 thousand hectares with 132 thousand tonnes production, whereas the total oilseed production is 67 thousand tonnes from 89.16 thousand hectares in North-Western Himalayas (DAC 2020-21). Development of nutritionally superior high yielding, disease and insect-pest resistant varieties suitable for hill agroecosystem with matching production technology are the thrust areas in research programme for improving pulse and oilseed production in hills.

2.5.1. *Rabi* Pulses

2.5.1.1. Varieties Notified

VL *Masoor* 150 : Small seeded lentil entry VL 150 (841 kg/ha) has shown significant yield superiority of 10.87% over the best check VL *Masoor* 125 (758 kg/ha) in SVT. Its maturity duration is 155-160 days and is moderately resistantto wilt, rust, pod damage and aphids. It has been released for timely sown rainfed organic condition of Uttarakhand hills.

VL *Matar* 64: Field pea entry VL 64 (990 kg/ha) has shown significant yield superiority of 9.93% over the best check Pant P14 (901 kg/ha) in State Varietal trials. It matures in 140-145 days. It is moderately resistantto wilt and powdery mildew. It has been released for timely sown rainfed organic condition of Uttarakhand hills.

2.5.1.2. Elite lines under All India Coordinated Programme

In IVT (Large), lentil entry VL 535 (1,155 kg/ha) and VL 536 (1,107 kg/ha) surpassed the best check VL *Masoor* 514 (1,007 kg/ ha) and were promoted to AVT I (NHZ).

2.5.1.3. Breeding Materials/Development of New Strains

Forty-five 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. Twenty-four cross combinations were advanced to F_2 generation and 117 crosses (F_2 to F_6 generation) with 675 progenies were selected and advanced to subsequent generations following pedigree method. Thirty-three 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.

2.5.1.4. Elite Lines under Station Trials

In Initial station trial (large,) entries, *viz.* VLM-2020-102 (1,159 kg/ha), VLM-2020-107 (1,014 kg/ ha) and VLM-2020-103 (996 kg/ha) were found superior to the best check VL *Masoor* 514 (906 kg/ ha), whereas in Initial station trial (small), entries VLM 2020-9 (1,322 kg/ha), VLM 2020-2 (1,214 kg/ha) and VLM 2020-4 (1,196 kg/ha) were found superior to the best check VL *Masoor*148 (1,069 kg/ ha). In advance station trial (small), entries VLM 2020-10 (1,382 kg/ha) and VLM 2020-7 (1,304 kg/ ha) were found superior to the best check VL *Masoor* 148 (1,121 kg/ha), whereas in advance station trial (large), entries VLM 2018-101 (1,246 kg/ha) and VLM 2018-115 (1,140 kg/ha) were found superior to the best check VL *Masoor* 507 (928 kg/ ha).

2.5.1.5. Elite Lines under International Nurseries

In yield adaptability trial, a total of 36 exotic lines were evaluated in international nurseries LIEN GLO-2021-22 and LIEN SA-2021-22 each for their adaptability and yield performance. In LIEN GLO 2021-22, considerable variability was observed in the exotic lines for days to 50% flowering (95-121), maturity days (141-151), plant height (37-54 cm), 100 seed weight (2.4-3.74 g) and grain yield (399-1,739 kg/ha). Exotic lines *viz.*, GID 26579 (1,739 kg/ ha), GID 26542 (1,703 kg/ha) and GID 26613 (1,703 kg/ha) were found promising based on their yield performance over the best check ILL 4605 (1,522 kg/ha). In LIEN SA-2021-22, wide variability was observed for days to 50% flowering (95-122), maturity days (145-150), plant height (32-54 cm), 100-seed weight (1.54-4.11 g) and grain yield (290-1,775 kg/ha). Exotic lines *viz.*GID 26538 (1,775 kg/ ha) and GID 26535 (1,630 kg/ha} were found promising based on their yield performance over the best check VL *Masoor* 514 (1,558 kg/ha).

2.5.1.6. Mustard Adaptability Trial

In yield adaptability trial of mustard, 5 entries were evaluated along with check Kranti in a Randomized Block Design. Considerable variability was observed in 50% flowering (85-87 days), maturity days (140-146 days), 1000 seed weight (3.4-5.1), plant height (144-171 cm), siliqua per plant (126-153). Grain yield ranged from 444 to 903 kg/ha. The entries PM 33 (903 kg/ha), PM 25 (736 kg/ha) and PM 27 (729 kg/ ha) yielded higher than the check Kranti (444 kg/ha).

2.5.1.7. TaramiraAdaptability Trial

Seven entries of taramira were evaluated in a Randomized Block Design. Variability was observed for50% flowering (83-86 days), maturity days (152-154 days), 1000 seed weight (2.7-4.8g), plant height (81-87 cm), siliqua per plant (71-75) and grain yield (569-722 kg/ha). The top performing entries were RTM-2002 (722 kg/ha), RTM-1624 (681 kg/ha) and RTM-1355 (639 kg/ha).

2.6. Genetic Improvement in Vegetable Crops for North West Himalayan Ecosystem through Conventional and Mutagenesis

Vegetable cultivation, principally off-season and temperate, is recognized as a practicable and lucrative venture due to its 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 below the national productivity of 18.5 t/ha (NHB 2019-20). Development of HYVs specific to quality, market demands and resistant to biotic stresses along with package of practices is an important area of research for the improvement of vegetable scenario of North- Western Himalayas

Rabi vegetables

2.6.1. Garden Pea

2.6.1.1. 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 Leh) at 39thAICRP (VC) Group Meeting held virtually during 07-09 Sept., 2021. VP 1429 has high green pod yield (115.5 g/ha), high shelling percentage (>50%) and 8-9 seeds per pod.

2.6.1.2. Varietal Improvement

Eight field yield evaluation trials were conducted to evaluate 80 entries with suitable checks to identify early maturing/medium maturing/edible pod genotypes with higher yield. 2021/PEVAR-3 (148.9 q/ha), 2019/PEVAR-5 (147.76 q/ha), 2021/PMVAR-3 (118.88 q/ha), 2019/PMVAR-6 (112.01 q/ha), 2021/PEPVAR-3 (122.65q/ha)and2019/PEMPMR-8(76.66 q/ha) recorded maximum green pods yield in varietal (early) IET, varietal (early) AVT- II, varietal (mid) IET, varietal (mid) AVT- II, 2019/PMVAR-6, IET (edible podded) and AVT II (PM), respectively.

2.6.1.3. Development of New Strains

Emphasis was given to develop early/medium duration, edible pod genotypes with high green pod yield with escape/resistance for powdery mildew. Five edible podF_1s and 61 new normal pod F_1s were generated using selected parents (VPsp 2020-101 in edible pod and VLSM 13, VP1801, VP1802, VP1803, VM 12, VLSM 14, HFP-715, Pant-P-200, RFPG-79 and ArkaAjeet in normal pod) to combine different horticultural traits like edible pods, earliness, high green pod yield, high shelling percent, attractive pod colour, resistance to powdery mildew, wilt, rust and ascochyta blight. Selection was practiced in the segregating materials and 258 progenies derived from 35 F_3s, 40 F_4s, 18 F_5s and 54 F_6s and 32 F_7s were advanced. Nineteen new bulks were made based on phenotypic uniformity for further evaluation in early and medium maturity group.

2.6.2. Onion

2.6.2.1. Varietal Improvement

Eight AINRP trials on long day onion were conducted with 53 genotypes to evaluate their yield performance against checks. RVA 21-21(303.35 q/ha), RVB 21-24 (305.72 q/ha), RVC 21-39 (362.96q/ha), RHA 21-31 (29.01 q/ha), RHC 21-60 (274.09 q/ha), WVA 21-37(309.36 q/ha), WVC 21-74 (294.15q/ha), WTC 21-82 (209.31 q/ha) recorded maximum bulb yield in IET-Red, AVT I-Red, AVT II-Red, Hybrid IET (RED), Hybrid AVT-II (RED), IET (White), AVT-II (White) and AVT-II (White) HTSS, respectively.A CMS-based onion hybrid (VLP-68) was evaluated in AINRP-Onion & Garlic for AVT I 2022-23.

2.6.2.2. Maintenance of CMS Lines (VL In. 31-1A & B)

Maintenance of cytoplasmic male sterile line (VL In. 31-1A; Smsms) and maintainer line (VL In. 31-1B; Nmsms) was carried out using acetocarmine dye.

2.6.2.3. Development of New Hybrids

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

2.6.3. Garlic

2.6.3.1. Varietal Improvement

Three AINRP trials on long day garlic were conducted with 25 genotypes to evaluate their yield performance against checks. GN 21-08 (200.01 q/ha) in IET, GN 21-41(189.92 q/ha) in AVT Iand GN 21-75(197.79 q/ha) in AVT II recorded maximum bulb yield with big clove size.

2.6.3.2. Breaking Dormancy of Bulbils of Long Day Garlic (VL *Lahsun* 2)

A trial on breaking dormancy of bulbils of long day garlic (VL *Lahsun* 2) in comparison to normal cloves was conducted. Five treatments (cold and GA_3 combinations) were applied. Among transplanted garlic seedling treatment T4 (water soaked bulbils for 48 h followed by cold treatment (4^0C) for 48h) resulted in maximum faster germination (11.5 days with 97 per cent) and found statistically at par with treatment T5 (bulbils treated with 250 ppm of GA_3 followed by cold treatment (4^0C) for 48h) estimated 11.4 days with 96 per cent.

2.6.3.3. Bulbils as Planting Material in VL *Lahsun* 2

A trial on evaluation of bulbils as planting material in Garlic (VL *Lahsun* 2) in comparison to cloves was conducted. Ten fertilizer (NPK and S combinations) treatments were applied on the transplanted garlic. Among transplanted garlic seedling treatments, T7 (150-50-150+25; N-P-K+S) gave maximum average bulb weight (36.4 g) and bulb yield of 186.7 q/ha and was found statistically at par with treatment T1 (cloves as planting materials) for bulb yield (178.6 q/ha). The average bulb weight in T1 was 36.8 g.

2.6.4. Seed Multiplication of Released and Pre-released Varieties

A total of 2.15 q breeder seed along with 7 q planting materials (bulbs) of VL *Lahsun* 2 and 8 kg seed of VL *Piaz* 3 were produced. In addition, 12.8 q TL seed of garden pea variety VLSM 13 was produced in Farmer Participatory Seed Production mode.

2.6.5. Genetic Resources –Evaluation & Maintenance

Five hundred thirty-one accessions of different vegetable crops (garlic-94, French bean-125, capsicum-63, tomato-115, garden pea-130 and others-04) were maintained during *rabi* 2020-21 and *kharif* 2021.

2.6.6. Underutilized Vegetables

Forty-four accessions of *Raphanus sativus* acquired from different sources (NBPGR, Bhowali; NBPGR, Delhi, ICAR-CITH and local collections) were evaluated at Experimental Farm, Hawalbagh. The performance of the accessions for morphological traits like plant height, days to germination, root weight and days to bolting, and biochemical parameters such as total antioxidants, Vitamin C, total carotenoids and total chlorophyll is depicted in Fig 2.6.1.

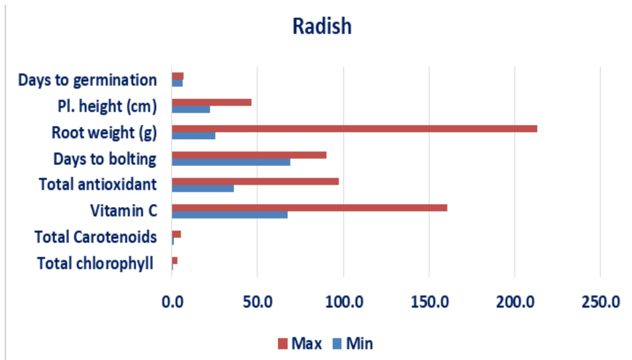


Fig. 2.6.1. Performance of *Raphanus sativus* accessions

2.6.7. Agronomic Investigation

2.6.7.1. Garlic

Response of garlic towards different sources and fertility levels

Garlic variety VL *Lahsun* 2 was evaluated under different nitrogen level *viz*., T1: 50% N (NPK) + 20 Ton FYM, T2: 100% N (NPK) + 20 Ton FYM, T3: 150% N (NPK) + 20 Ton FYM, T4: 50% N (DAP) + 20 Ton FYM, T5: 100% N (DAP) + 20 Ton FYM, T6: 150% N (DAP) + 20 Ton FYM, T7: 50% N (UREA) + 20 Ton FYM, T8: 100% N (UREA) + 20 Ton FYM, T9: 150% N (UREA) + 20 Ton FYM, T10: 20 Ton FYM, T11: 40 Ton FYM, and T12: 60 Ton FYM. The highest clove yield was recorded with T9 (9110 kg/ ha) followed by T2 (8743 kg/ ha) and T 5 (8532 kg/ ha). The lowest yield was recorded with T 10 (5532 kg/ ha).

2.6.7.2. Garden Pea

Response of Garden Pea Varieties to Different Fertility Levels

Six AVT-2 garden pea cultures (VP 1218, VP 1242, VP 1423, VP 1513, VPSP 1332 and VPSP 906-1) were evaluated in comparison with high yielding checks (GS 10, VL *Sabji Matar* 13 and VL *Sabji Matar* 15) for four fertility levels (F_1- 20:40:40 + 10 t FYM/ ha, F_2 - 20:60:40 + 10 t FYM/ ha, F_3 - 20:80:40 + 10 t FYM/ ha, and F_4 - 20 t FYM/ ha) under field conditions. Among fertility levels, the highest pod yields was recorded with F3 (14,909 kg/ha) followed by F2 (14,736 kg/ha). Among cultures, the highest pod yields was recorded with VPSP 1332 (17,400 kg/ha) which was at par with VP 1513 (16,350 kg/ha). Both the cultures were found superior as compared to GS 10, the leading private sector variety of garden pea.

2.6.8. Plant Pathological Investigations

Screening of onion and garlic against purple blotch disease

A total of 55 onion and 25 garlic entries were evaluated against purple blotch disease under artificial inoculated conditions. The promising entries are given in Table 2.6.8.1.

Table 2.6.8.1. Purple blotch disease screening nurseries

Trial	Name	No. of Entries	Resistant entries
Onion Trial	IET (Red)	8	RVA 21-19 (1 score)
	AVT I	8	RVB 21-17 (1 score)
	AVT II	9	RVC 21-41 (1 score)
	IET Hybrid	6	None
	AVT II (Hybrid)	7	None
	IET (W)	5	None
	AVT II (W)	5	WVC 21-76 (2 score)
	AVT II (HTSS)	7	WTC 21-88 (2 score)
Garlic Trial	IET	7	GN 21-08 (1 score)
	AVT I	6	GN 21-48 (2 score)
	AVT II	12	GN 21-75 & GN 21-77 (2 score)

2.7. Evaluation and Identification of Major Hill Crops for Abiotic Stresses and Quality Traits through Basic Techniques

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

2.7.1. Comparison of Nutritional, Anti-nutritional and Health-Promoting Properties of White and Brown Finger Millets

Ten brown-grain genotypes (VL-149, VL-315, VL-352, VL-376, VL-379, VL-391, VL-400, VL-402, VL-406, VL-408) and ten white-grain genotypes (VL-382, VL-384, VL-405, VR-18-12, VR-18-13, VR-18-14, VR-13-8, VR-13-15, VR-15-5, VR-20-34) were used for study. Total protein content was recorded higher in brown finger millet as compared to white finger millet. Total soluble sugars, total lipid and dietary fibre content was recorded higher in white finger millet. Starch content was recorded higher in white finger millet, whereas, amylose content was recorded higher in brown genotypes. Phytic acid content was comparable in both coloured genotypes.Polyphenols were found to be significantly higher in brown finger millet. Oligosaccharides (Mannitol, Raffinose, Stachyose and RFOs) were found significantly higher in brown fingermillet genotypes. PCA analysis revealed strong positive correlation between peak viscosity, final viscosity, break down and amylose content. Strong positive correlation was found between total polyphenols, DPPH, ABTS and FRAP value. Strong negative correlation was found between total soluble sugars, DPPH, ABTS, and total antioxidant activity (Fig. 2.7.1.1).

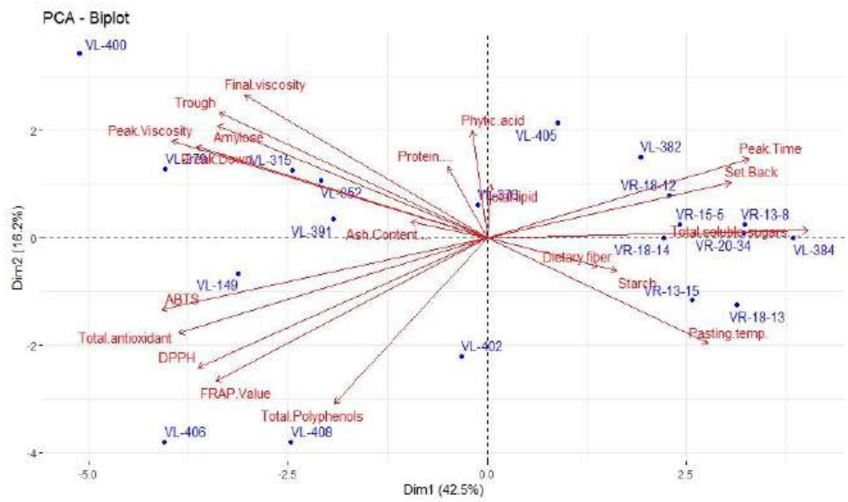


Fig. 2.7.1. PCA analysis of nutritional, anti-nutritional and health-promoting properties of white and brown finger millets

2.7.2. Physicochemical Characterization of Different Cherry Tomato Cultivars

Total five cherry tomato fruits (VL Cherry Tomato 1, Swarnratan, Black Cherry, Bumble Purple and Tomato Nepa) were analyzed for total soluble sugars, pH, Lycopene, β-Carotene, Vita C, polyphenols content and antioxidant activities. Black cherry tomato was found promising for most of traits containing TSS (8.15), β-carotene (7.26), polyphenols (1.84), vita. C (89.67) and for antioxidant activities. However, lycopene content was found highest (7.19mg/100 g FW) in VL Cherry Tomato 1.

2.7.3. Quantifications of Tryptophan in Maize Genotypes through HPLC

Total 57 samples of maize (FLPH, MTC, PQPM-9 DH and MQA populations) were analyzed for tryptophan content through HPLC. Range of tryptophan content was found 0.37 (MTC-8 DH-9-1) to 1.00 (PQPM-9 DH-225-1). Total 8 samples (FLPH-49-2, FLPH-20-1, MTC-4 DH-17, PQPM-9 DH-147-2, PQPM-9 DH-177-1, PQPM-9 DH-225-1, PQPM-9 DH-4 and MQA-14-25-3)were found to have tryptophan content ≥ 0.70% of protein.

2.7.4. Development and Standardizing of Protocol for Estimation of Methionine Content from Maize Grains

A set of 10 inbred lines (VQL1, VQL2, VQL373, VQL398, CQE, VBL1, V400, MCA, MCB and MLA) was used for the standardization of methionine estimation protocol. Two methods *i.e.,* biochemical estimation (titration) and microbiological methods were used to analyze the grains for methionine content. The breeding target/ threshold level for methionine content in the grain is set at 0.5%. The methionine content in the grains was observed in range of 0.20-0.37%.

2.7.5. Biochemical Screening of Maize Grain Samples for Quality Parameters through FTNIR/HPLC

To confirm the protein quality of the QPM hybrid VLQPMH59 in the farmer's field and Hawalbagh farm,self-pollinated grain samples from QPM varieties FQH-148, FQH-165, FQH-140, VLQPMH-9 and VLQPM-9 were collected from Experimental farm, Hawalbagh. The grain samples from the farmers' field Shama VL QPMH 59, Dhanpau VL QPMH 59, Shama Local (Non-QPM) and Dhanpau Local (Non-QPM) were also collected. The protein quality in terms of tryptophan and lysine content in the grain was estimated and the results were compared (Table 2.7.5.1). Very less/ negligible effect on quality was observed in the grain samples obtained from Hawalbagh farm and farmer's field.

Table 2.7.5.1. Protein quality of the QPM hybrid from the farmer's field and Hawalbagh farm

Variety	Tryptophan	Lysine
FQH-148	0.69	3.04
FQH-165	0.67	2.95
FQH-140	0.69	3.04
VLQPM-59	0.66	2.90

VLQPM-9	0.70	3.08
Shama VL QPMH 59	0.64	2.82
Dhanpau VL QPMH 59	0.62	2.73
Shama Local	0.46	2.02
Dhanpau Local	0.42	1.85

2.8. Sub-Project: Identification and Utilization of Important Genes/Alleles/ Markers in Hill Crops

2.8.1. Identification of Cold Tolerance QTLs in Rice

After two years of trial at High Altitude Testing Site, Mukteshwar, two rice germplasms IRCTN91-82 and Hua110 were found to be cold tolerant. In order to identify cold tolerance QTL in these genotypes, crosses of tolerant IRCTN91-82 and Hua110 were made with the cold sensitive cultivar VL *Dhan* 85 for development of a mapping population. In *Kharif* 2022, F_2 seeds were raised at Experimental Farm, Hawalbagh and individual F_2 plant seeds have been harvested for screening during next season.

2.8.2. Molecular Dissection and Mapping of Novel Rust Resistance Genes in Wheat

A recombinant inbred line population segregating for yellow rust disease was developed by crossing resistant genotype IC145297 with susceptible genotype PBW343. The population was screened for the yellow rust in two locations (Hawalbagh and KVK, Kafligair). At Hawalbagh, disease expression was good and 176 Recombinant Inbred Lines (RILs) showed segregation in a near normal distribution. However, at Kafligair location disease expression was not good and bell-shaped segregation pattern

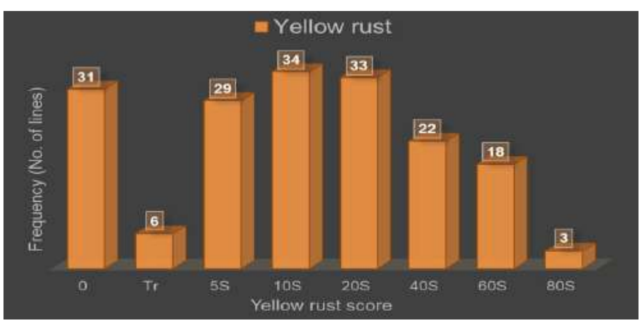


Fig.2.8.2.1.Phenotyping of yellow rust resistance in 176 Recombinant Inbred Lines of wheat (IC145297 X PBW343)

was not found. Parental polymorphism was analysed using 200 SSR markers, of which only 8% were found to be polymorphic between parents. Twenty-eight yellow rust gene linked polymorphic markers were also tested for polymorphism. Xgwm533 (Yr30), WMC175 (yr5) and XGWM413 (Yr15) were found to be polymorphic between the parents (Fig. 2.8.2.1).

2.8.3. Identification of Novel Genic SSR Marker in Barnyard Millet and Their Cross Transferability in Other Species

In this study, RNA sequencing data were assembled *de novo* to constitute 43551 and 35901 unigenes in Japanese barnyard millet (*Echinochloa esculenta*) and Indian barnyard millet (*Echinochloa frumentacea*), respectively. Two hundred and ninety-two orthologous microsatellites were identified between the species, out of which 245 microsatellites were trinucleotide, 39 were dinucleotide and only 3 were tetranucleotide repeat.Out of 50 genic SSR markers which were orthologous between *E. esculenta* and *E. frumentacea*, 20 genic SSR markers showed polymorphism and were used to analyse genetic diversity among twelve barnyard millet genotypes. The SSR genotyping data of 48 barnyard millet genotypes were subjected to cluster analysis (Fig. 2.8.3.1). Cluster I and II mostly consisted of *E. esculenta,* except one *E. frumentacea* genotype (VL 254) in cluster I, whereas cluster III and IV consisted all *E. frumentacea* genotype. VB18-2 (*E. frumentacea*) was the most distant genotype. The analysis showed genic SSR markers can cluster these two species in different groups.

The cross transferability studies of novel *Echinochloa* sp. Genic SSR markers in finger millet and foxtail millet showed that only 16 markers were found to be polymorphic among the 20 genotypes tested. A total of 53 alleles were amplified within these 20 genotypes. PIC value ranged from 0.35 (EeSSR20) to 0.70 (EeSSR33). Polymorphic SSR markers data was subjected to cluster analysis using Nei's genetic distance and UPGMA tree was constructed (Fig. 2.8.3.2). UPGMA tree clustered the genotypes in seven small groups. Finger millet and foxtail millet genotypes were mostly separately clustered.

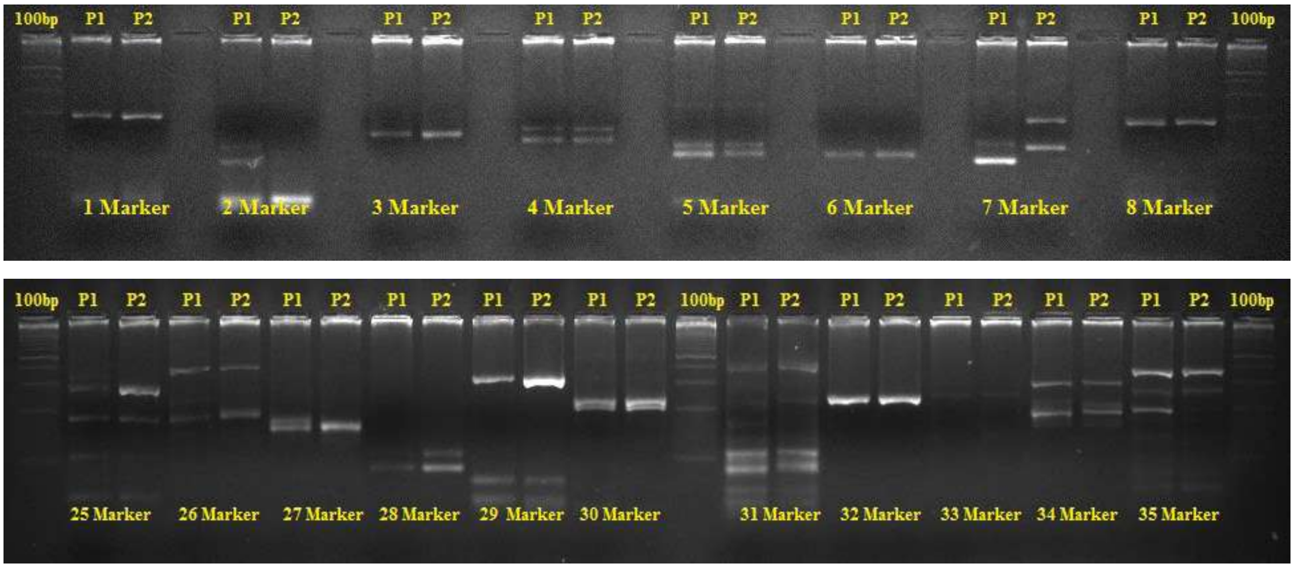


Fig. 2 Parental polymorphism of RIL parents IC145297 (P1) and PBW343 (P2).

Identification of novel Genic SSR marker in Barnyard millet and their cross transferability in other species

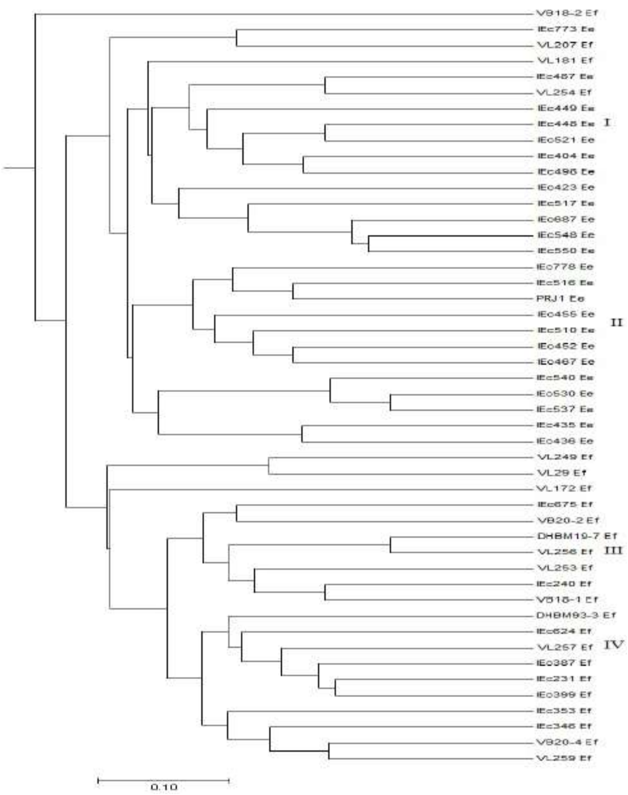


Fig.2.8.3.1. Genetic diversity analysis among 24 *Echinochloa esculenta* and 24 *Echinochloa frumentacea* based on 20 genic SSR markers

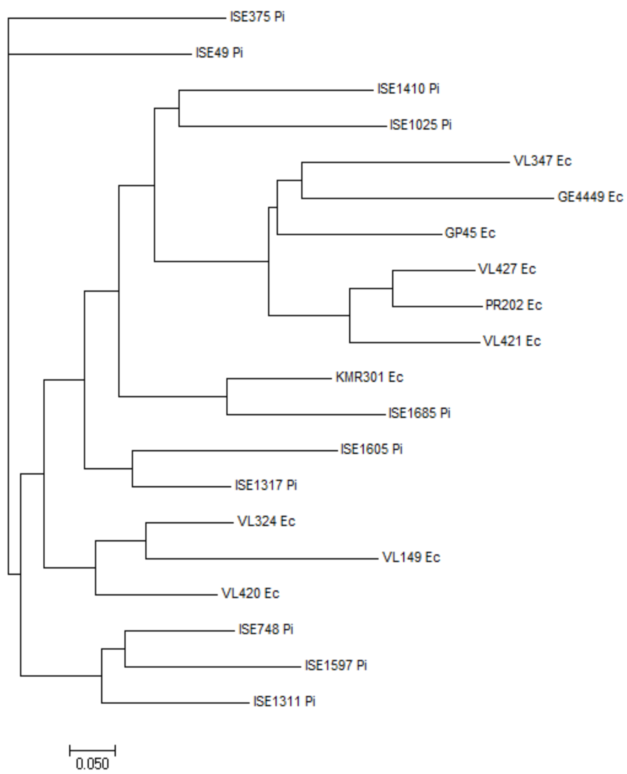


Fig. 2.8.3.2. Cross transferability of barnyard millet genic SSR markers in finger millet and foxtail millet. Dendrogram was constructed using Power marker software.

Fig. 2.9.1.1. Muffins and *laddu* prepared from brown and white ragi

Fig. 2.9.1.2. *Chakli*, *namkeen* and *papad* prepared from brown and white ragi

2.9. Flagship project: Ensuring Food and Nutritional Security in North West Himalayas through Climate Resilient Enhanced Production of Millet and Potential Crops by Post-Harvest Management, Value Addition and Commercialization

2.9.1. Development of value added products from white and brown finger millet

Different value added products of millet were prepared to popularize the millet based food recipes among common people. Nutritionally rich brown and white Ragi recipes were standardized to prepare delicious and healthy food products. Some sweet products of finger millet such as *Laddu* and Muffins (Fig. 2.9.1.1) were developed to meet daily requirement of calcium, folic acid especially for children and women. Laddu from white and brown finger millet were prepared using 100 percentragi flour with ghee and sugar. Similarly, muffins from white and brown *ragi* were prepared using 100 percentragi flour, sugar, refined oil, eggs and baking powder in oven. Different salty snacks were also developed to encourage the millet consumption. *Ragi* based *papad* were prepared using *ragi* flour along with moong dal flour,maize flour (to enhance the nutrients) salt and carrom seeds. White/ brown ragi *chakli* was prepared by using ragi flour, rice flour and wheat flour with spices. Ragi*namkeen* was prepared using ragi flour, besan, pea nut and spices (Fig. 2.9.1.2).

2.9.2. Decadal variation in area, production and productivity of finger millet and small millets in hill districts of Uttarakhand over two decades

The study is based on secondary data pertaining from 2000 to 2019-20 aimed at assessing trends, growth and variability in area, production and yield of finger millet and small millets using Compounded Annual Growth Rate and Cuddy Della Valle Index. Compound annual growth rate (CAGR) for area, production and productivity of finger millet and small millet was analyzed using the exponential growth function. Stability was measured by CDVI (Cuddy and Della Valle, 1978). A low value of this index indicates low instability. It was observed that for finger millet over the time, area and production has been declined while the yield has registered a growth trend. If looked period wise, period I (2000-2009), the area has decreased significantly while the production and yield has increased. In period II (2010-2019), the area, production and yield has shown a significant decline over the decade. For small millets, overall in twenty years time period, the area and production has witnessed a decline but the productivity has registered a positive growth.

Table 2.9.2.1. Variation in area, production and productivity of finger millet and small millets over two decades

Crop	Area (ha)					
	CAGR (%)			CDVI (%)		
	2000-2009	2010-2020	2000-2020	2000-2009	2010-2020	2000-2020
Finger Millet	-1.05*	-2.62*	-1.71	0.022	0.021	0.03
Small millets	-1.69*	-2.68*	-1.56*	0.062	0.030	5.34
	Production (T)					
	CAGR (%)			CDVI (%)		
	2000-2009	2010-2020	2000-2020	2000-2009	2010-2020	2000-2020
Finger Millet	0.49	-2.78*	-0.96	0.091	0.063	0.09
Small millets	-0.92	-1.55*	-0.31	0.096	0.044	7.77
	Yield (T/ha)					
	CAGR (%)			CDVI (%)		
	2000-2009	2010-2020	2000-2020	2000-2009	2010-2020	2000-2020
Finger Millet	1.56	-0.16	0.76	0.084	0.052	0.07
Small millets	0.79	1.16*	1.27*	0.104	0.029	6.89

2.10. 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 institute's mandate. Besides, the institute also produces Truthfully Labelled (TL) and Nucleus seeds of various hill crops.

During the period, 174.53 q breeder seed of 49 released varieties/inbreds of 15 crops were produced. A total of 160.54 q breeder seed was supplied to different seed producing agencies for further multiplication. Around 14.33 q nucleus seed of 40 released varieties of 15 crops were also produced following standard methods of maintaining genetic purity. In addition, 4.01 q Truthfully Labelled seed of 9 varieties of 7 crops were produced. Including the carry-over stock of TL seed; a total of around 2.58 q TL seed was supplied to different stakeholders. Under farmer participatory seed production programme, 181.54 q TL seed of wheat (VL *Gehun* 829, VL *Gehun* 907, VL *Gehun* 953, VL *Gehun* 967, VL *Gehun* 2014), 16.10 q TL seed of garden pea (VL *Sabji Matar* 13), 2.98 q TL seed of soybean (VL Soya 89, VL Soya 201) was produced and out of it a total of 205.74 q TL seed was supplied back to different clientele (Table 2.10.1 & 2.10.2).

Table 2.10.1. Seed Production during *Rabi* 2021-22 and supply in *Rabi* 2022-23

Crop	Variety	Breeder seed (q)		TL Seed (q)		Nucleus Seed Production (q)
		Production	Supply	Production	Supply	
Wheat	VL *Gehun* 967	40.00	44.61	0.00	0.00	1.50
	VL *Gehun* 2015	10.00	6.90	0.00	0.00	1.00
	VL *Gehun* 2014	10.00	2.15	0.00	0.00	1.00
	VL *Gehun* 953	30.00	27.00	0.00	0.00	1.50
	VL *Gehun* 907	20.00	20.02	0.00	0.00	2.00
	VL *Gehun* 829	3.50	2.89	0.00	0.00	0.80
	VL *Gehun* 3004	0.70	0.43	0.00	0.00	0.80
	VL *Gehun* 892	0.00	0.00	0.00	0.00	0.00

	VL *Gehun* 2041	2.80	3.15	0.00	0.00	0.00
	VL *Gehun* 2028	2.80	2.20	0.00	0.00	0.00
	VL *Gehun* 3010	0.96	0.40	0.00	0.00	0.50
Barley	VL *Jau* 118	3.00	3.57	0.00	0.00	0.10
Lentil	VL *Masoor* 148	2.25	1.31	0.00	0.00	0.10
	VL *Masoor* 133	1.25	1.56	0.00	0.00	0.10
	VL *Masoor* 126	1.10	0.02	0.00	0.00	0.00
	VL *Masoor* 507	0.01	0.00	0.00	0.00	0.00
	VL *Masoor* 129	0.00	0.45	0.00	0.00	0.00
Field pea	VL *Matar* 42	0.00	0.12	0.00	0.00	0.10
Garden Pea	VL *Sabji Matar* 13	3.00	2.10	0.00	0.00	0.05
	VL *Sabji Matar* 14	0.20	0.00	0.00	0.00	0.10
	VL *Sabji Matar* 15	0.70	0.23	0.00	0.00	0.01
Piaz	VL *Piaz* 3	0.24	0.18	0.00	0.00	0.50
Garlic	VL *Lahsun* 2	4.00	0.00	0.00	0.00	0.00
Radish	Dunagiri Local	0.00	0.00	0.10	0.08	0.00
Lahi	Hathikaan	0.00	0.00	0.40	0.21	0.00
Methi	PEB 1	0.00	0.00	0.15	0.10	1.50
	Total	**136.51**	**119.17**	**0.65**	**0.38**	**10.16**

Table 2.10.2. Seed Production during *kharif* 2021 and supply in *kharif* 2022

Crop	Variety	Breeder seed (q)		TL Seed (q)		Nucleus Seed Production (q)
		Production	Supply	Production	Supply	
Rice	VL *Dhan157*	1.00	1.01	0.00	0.00	0.40
	VL *Dhan* 68	2.30	3.54	0.00	0.00	0.10
	VL *Dhan* 85	1.50	1.11	0.00	0.00	0.10
	VL *Dhan* 86	0.00	1.22	0.00	0.00	0.00
	VL *Dhan* 158	0.00	1.74	0.00	0.00	0.00
	VL *Dhan* 88	5.50	5.11	0.00	0.00	0.10
Maize	*Vivek Sankul Makka* 35	1.50	0.93	0.00	0.00	0.20
	VL Amber Popcorn	0.00	0.11	0.00	0.00	0.00
	VLS 16 (CMVLSC1 F)	0.08	0.15	0.00	0.00	0.05
	VSL 4 (CMVLSC1 M)	0.10	0.05	0.00	0.00	0.04
	V 390 (VMH 45 M)	0.25	0.00	0.00	0.00	0.08
	VQL 373	1.15	0.19	0.00	0.00	0.00
	V 409 (VMH 53 M)	0.05	0.00	0.00	0.00	0.08
	V 412 (VLMH 57 F)	0.60	0.00	0.00	0.00	0.08
	V 433 (VLMH 57 M)	0.10	0.00	0.00	0.00	0.05
	VSL 26	0.11	0.03	0.00	0.00	0.00
	VSL 27	0.04	0.01	0.00	0.00	0.00
	VQL 1	0.75	0.19	0.00	0.00	0.00
	CMVL Sweet Corn 2	0.00	0.00	0.30	0.12	0.00
	CMVL Baby Corn 2	0.00	0.00	0.55	0.35	0.00

Finger Millet	VL *Mandua* 352	2.90	3.18	0.00	0.00	0.05
	VL *Mandua* 347	1.30	1.30	0.00	0.00	0.05
	VL *Mandua* 376	0.15	0.23	0.00	0.00	0.05
	VL *Mandua* 379	0.85	1.14	1.65	1.23	0.05
	VL *Mandua* 380	1.50	1.48	0.00	0.00	0.05
	VL *Mandua* 382	0.35	0.62	0.00	0.00	0.03
Madira	VL *Madira* 207	0.50	0.51	0.00	0.01	0.05
Soybean	VL Soya 89	6.50	9.06	0.49	0.03	1.20
	VL Soya 201	6.50	6.14	0.36	0.39	0.50
	VL Soya 202	1.00	1.00	0.00	0.00	0.50
Horsegram	VL *Gahat* 19	0.65	0.50	0.00	0.02	0.15
Pigeon pea	VL *Arhar* 1	0.50	0.50	0.00	0.00	0.15
Buckwheat	VL *Ugal* 7	0.22	0.21	0.00	0.00	0.05
Amaranth	VL *Chua* 44	0.00	0.05	0.00	0.00	0.00
	VL *Chua* 110	0.07	0.06	0.00	0.00	0.01
Summer squash	Australian Green	0.00	0.00	0.01	0.01	0.00
Okra	VL *Bhindi* 2	0.00	0.00	0.00	0.04	0.00
	Total	**38.02**	**41.37**	**3.36**	**2.20**	**4.17**

Farmer Participatory Seed Production (q)			
Crop	**Variety**	**Production *Kharif* 2021**	**Supply *Kharif* 2022**
Soybean	VL Soya 89	2.50	2.25
	VL Soya 201	0.48	0.47
	Total	**2.98**	**2.72**

Farmer Participatory Seed Production (q)			
Crop	**Variety**	**Production *Rabi* 2021-22**	**Supply *Rabi* 2021-22**
Wheat	VL *Gehun* 967	134.57	133.02
	VL *Gehun* 2014	24.06	19.60
	VL *Gehun* 953	5.08	17.75
	VL *Gehun* 907	450	3.20
	VL *Gehun* 829	13.33	13.00
Garden Pea	VL *SabjiMatar* 13	16.10	16.45
	Total	**197.64**	**203.02**

3. Natural Resource Management for Sustainable Productivity

Research Projects

- Strategies for Improving Productivity of Important Hill Cropping Systems through Efficient Resource Utilization *[Drs. B.M. Pandey, Tilak Mondal, Amit Kumar, J.K. Bisht, P.K. Mishra, Manoj Parihar, (upto December 23, 2022), R.P. Meena (w.e.f. December 24, 2022), Shyam Nath (PM)]*
  - ❖ **Sub-project 1:** Identification of Suitable Botanicals for Inducing/Enhancing Nitrogen Use Efficiency through development of coated urea fertilizer *[Drs. Tilak Mondal, Amit Kumar, Jeevan, B. (upto 03.09.2022), Ashish Kumar Singh]*
  - ❖ **Sub-project 2:** Dynamics of Soil Carbon Pools and its Sequestration Pattern under Different Nutrient Management Options in Hill Cropping System [*Drs. Amit Kumar, Tilak Mondal, Manoj Parihar (upto December 23, 2022), R.P. Meena (w.e.f. December 24, 2022), Priyanka Khati]*
  - ❖ Evaluation of Multifaceted Microbial Inoculants for Improving Soil Health and Yield of Crops in Hilly Areas [*Drs. P.K. Mishra, Priyanka Khati, Manoj Parihar (upto December 23, 2022), R.P. Meena (w.e.f. December 24, 2022), B.M. Pandey, Tilak Mondal]*
  - ❖ **Sub-project 1:** Assessment of Native Arbuscular Mycorrhizal Fungi for the Sustainable Production of Hill Crops [*Drs. Manoj Parihar (PI) (upto December 23, 2022), R.P. Meena (w.e.f. December 24, 2022) (PI)]*
  - ❖ **Sub-project 2:** Development of Nano-Bioformulation to alleviate drought stress in hill crops [*Dr. Priyanka Khati (PI)]*
- Design and Development of Pre and Post-harvest Mechanization Technologies for Hill Agriculture *[Drs. Shyam Nath, Hitesh Bijarniya, Kushagra Joshi, Jitendra Kumar, J.K. Bisht]*
  - ❖ **Sub-project 1:** Development of Post-harvest Processing Machineries for Enhanced Utilization of Traditional Hill Crops *[Dr. Hitesh Bijarniya (PI)]*
  - ❖ **Sub-project 2:** Zero Energy Polyhouse with Retrievable Glazing Mechanism Suitable for all Geographical Location *[Drs. N.K. Hedau, Shyam Nath, Jitendra Kumar, Hitesh Bijarniya, B.M. Pandey]*
- Fodder Production and Agroforestry Management in Hills *[Drs. J.K. Bisht, P.K. Mishra, Tilak Mondal, Shyam Nath, Jitendra Kumra, Manoj Parihar, R.P. Meena]*
- Integrated Development of Water Resources and Management for Optimizing Production and Use Efficiency *[Drs. S.C. Pandey, Shyam Nath, Tilak Mondal, Manoj Parihar, Jitendra Kumat, R.P. Meena, Ashish Kumar Singh, Priyanka Khati]*
  - ❖ **Sub-project 1:** Development of Sensor Network Based Automation System for Improving Water Productivity *[Dr Jitendra Kumar (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. Strategies for Improving Productivity of Important Hill Cropping Systems through Efficient Resource Utilization

Effect of PGP bacteria/consortia on grain yield of wheat

Bacterization of wheat (VL *Gehun* 967) seeds with PGP bacteria/consortia was carried out and T6 (RDF (75% RDN +25% N by FYM) + consortium) recorded highest grain yield (1,737 kg/ha) followed by T15 (75% RDN (25% N by FYM)+*Azotobacter*+*Pesudomonas*) (1,653 kg/ha) over un-inoculated control (T1) and (T12) (1,356 and 1,360 kg/ha, respectively) with RDF and 75% RDF (25% N by FYM). Maximum harvest index was recorded by T15 (47.9) followed by T3 (40.8) (Fig. 3.1.1).

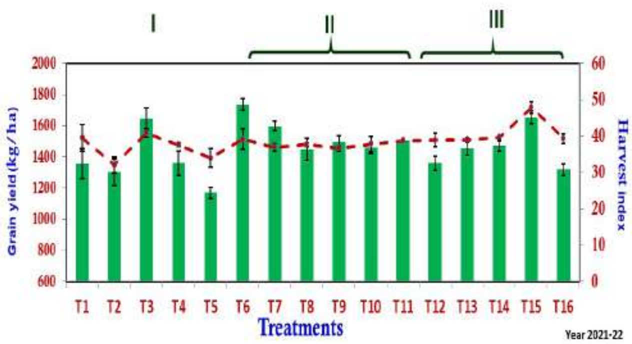


Fig. 3.1.1. Evaluation of PGP bacterial consortium on wheat yield under field conditions

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 nutrients {I set received RDF and RDF (75% RDN+25% N by FYM) + bacteria/ Consortium; II set received 75% RDF and 75% RDF+ bacteria/consortium and third set 75% RDF (25% N by FYM)}. Treatment of finger millet (VL *Mandua* 379) seed with PGP bacteria/ consortia T14 (75% RDF (50% RDN +25% N BY FYM) +*Pesudomonas*) recorded highest grain yield (1,899 kg/ha) followed by T15 {(75% RDF (50% RDN+25% N by FYM)+*Azotobacter*+*Pesudomonas*)} (1,754 kg/ha) over un-inoculated control (T12) (1,543kg/ha) with 75% RDF (50% RDN+25% N by FYM). However, T8 (75% RDF+*Azotobacter*) gave maximum yield of 1,537 kg/ha compared to control (T7) 1,474 kg/ha with 75% RDF. Treatment T6 (RDF (75% RDN+25% N BY FYM +consortium C2) gave at par grain yield of 2,011 kg/ha as compared to un-inoculated control (T1) (2,077 kg/ha) with RDF. Maximum harvest index was recorded by T10 (33.0) followed by T15 (31.8) (Fig. 3.1.2).

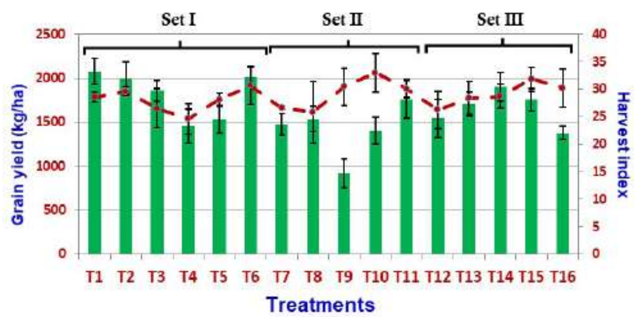


Fig. 3.1.2. Effect of PGP bacteria/consortia on grain yield of finger millet VL *Manuda* 379

Evaluation of buckwheat in different 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 in different cropping system as well as for contingency planning. The highest grain yield of buckwheat was obtained when sown on March 10 (1532 kg/ ha) followed by sown on July 30 (773 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, 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 60 kg N per ha recorded the maximum grain yield (3,332 kg/ ha) which was at par with 80 kg N/ha (3,200 kg/ha). The highest grain yield was recorded with three different split (3,306 kg/ha) which was at par with three equal split (3,193 kg/ha).

Response of different nutrient sources in 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 highest grain yield was recorded with N:P:K through calcium nitrate+SSP+MoP (1,554 kg/ha). However, the lowest yield was obtained with Urea+SSP+MoP (1,135 kg/ha) and 10 kg P through FYM (1,177 kg/ha).

Sub-project 1: Identification of Suitable Botanicals for Inducing/Enhancing Nitrogen Use Efficiency through Development of Coated Urea Fertilizer

Extraction of essential oils from different locally available botanicals

Soxhlet extraction method was used for extraction of essential oils from different botanicals (batain, pine, *Lantana*, bichughash, bhang and *Parthenium*). Three organic solvents (hexane, acetone and methanol) were used for oil extractions. The yield of essential oils varied from 2.1% to 12.8% on dry weight basis. The order of essential oils yield getting from soxhlet extraction process was methanol extracted oil > hexane extracted oil > acetone extracted oil.

Preparation of bio-oil coated urea fertilizer and to evaluate the release pattern of available nitrogen (NH_4 + NO_3) under lab condition

Bio-oil coated slow release urea fertilizer was prepared with two doses (0.5 and 1.0 per cent) by applying different extracted oils using sprayer and dried at room temperature under shade and further used. The available nitrogen release pattern from bio oil coated urea was better as compared to commercial neem coated urea. (Table 3.1.1).

Table 3.1.1. Release pattern of available nitrogen from different oil coated urea fertilizer under lab condition

Botanicals	Extracted oil coated urea	Available Nitrogen (Kg/ha)					
		1 Days	3 Days	5 Days	10 Days	15 Days	30 Days
Batain	Hexane	7.2	24.6	65.8	34.6	13.4	2.17
	Acetone	6.4	26.6	47.3	61.4	22.1	1.12
	Methanol	5.7	18.6	33.3	68.4	27.1	1.64
Pine	Hexane	5.2	18.2	33.3	55.4	32.4	2.5
	Acetone	3.2	17.4	35.8	52.8	29.1	1.6
	Methanol	4.1	21.2	37.3	58.4	29.1	2.7
Lantana	Hexane	8.6	37.8	76.8	56.7	29.4	2.9
	Acetone	4.7	26.2	78.3	51.4	19.4	1.51
	Methanol	3.8	37.4	54.7	66.8	39.4	4.8
Bhang	Hexane	6.4	26.6	47.3	61.4	16.1	2.12
	Acetone	7.2	24.6	45.8	64.6	23.4	5.17
	Methanol	5.7	28.6	36.3	76.4	30.1	6.64
Bichu ghas	Hexane	9.2	17.4	38.8	57.8	32.1	2.6
	Acetone	4.1	24.2	41.3	62.4	29.1	3.7
	Methanol	5.8	22.4	44.7	68.8	30.4	4.3
Parthenium	Hexane	5.2	28.2	58.3	45.4	12.4	2.5
	Acetone	4.7	26.2	78.3	35.4	14.4	1.51
	Methanol	11.6	37.8	77.8	32.7	18.4	1.29
Neem coated		12.2	34.4	72.7	38.2	13.8	0.82
Uncoated		19.7	58.2	96.4	8.85	1.43	0.09

Table 3.1.2. Effects of prepared bio-oil coated urea on soil microbial properties

Botanicals	Extractant	MBC (µg/gm)		Respiration (µg CO_2-C/g soil)		Dehydrogenase (µg TPF/g soil/24 hr.)	
		0.50%	1.00%	0.50%	1.00%	0.50%	1.00%
Batain	Hexane	506.4	492.8	26.3	23.4	41.2	39.3
	Acetone	514.8	502.5	31.5	26.6	41.8	39.5
	Methanol	532.6	515.5	36.6	30.4	44.4	42.2
Pine	Hexane	462.6	428.2	21.9	17.4	31.6	28.4
	Acetone	480.8	446.2	26.3	24.0	33.7	30.6
	Methanol	490.7	452.6	28.5	25.9	34.2	32.4
Lantana	Hexane	528.6	494.2	32.8	27.4	40.8	39.6
	Acetone	512.8	464.4	34.1	31.9	44.3	42.8
	Methanol	552.2	521.6	41.8	36.0	48.2	44.6
Bhang	Hexane	512.5	510.5	32.6	31.8	41.4	40.6
	Acetone	534.6	528.5	39.6	35.7	46.6	43.9
	Methanol	544.2	536.4	44.8	42.1	50.2	47.3
Bichughas	Hexane	514.8	511.5	32.5	31.6	40.8	36.2
	Acetone	528.6	524.8	35.1	34.3	43.8	42.6
	Methanol	532.6	530.4	40.2	36.2	47.5	45.5
Parthenium	Hexane	508.4	506.4	32.6	31.7	41.2	40.4
	Acetone	514.2	512.8	34.2	33.2	43.4	42.8
	Methanol	522.6	524.4	35.8	34.4	45.6	43.5
Neem coated Urea		514.2	502.2	30.8	33.8	42.4	42.4
Uncoated		506.8	478.2	34.6	30.8	40.8	38.6
Initial		496.4	496.4	32.8	32.6	38.6	40.8

Methanol extracted oil coated urea released maximum available nitrogen (6.64 to 74.6 mg/kg) followed by hexane (2.17 to 76.8 mg/kg) and acetone oil coated urea (1.12 to 78.3 mg/kg). Among the oil coated urea, methanol extracted bhang oil coated urea released 74.6 and 76.4 mg/kg available N, followed by methanol extracted batain oil coated urea (68.4 and 74.6 mg/kg) at 10 DAT, whereas, neem coated urea (72.7 mg/kg) and uncoated urea (96.4 mg/kg) released maximum nitrogen on 5 DAT at both treatment doses, respectively.

Effects of prepared bio-oil coated urea on soil microbial properties

Soil microbial properties of oil coated urea treated soil showed positive effects (MBC 492.8 to 552.2 µg/g, respiration 23.4 to 41.4 µg CO_2-C/g soil, and dehydrogenase 39.3 to 48.2 µg TPF/g soil/24 h) as compared to their initial soil status (MBC 496.4 µg/gm, respiration 32.8 µg CO_2-C/g soil and dehydrogenage 38.6 µg TPF/g soil/24 h) except pine oil coated urea whereas neem coated urea treated soil showed MBC 514.2 µg/gm, respiration 30.8 µg CO_2-C/g soil and dehydrogenase 42.4 µg TPF/g soil/24 h. Maximum soil microbial activities (MBC 521.6 µg/gm, respiration 36.0 µg CO_2-C/g soil and dihydrogenage 48.2 µg TPF/g soil/24 h) were observed in methanol extracted lantana oil coated urea (Table 3.1.2).

Evaluation of antifungal activity of extracted bio oils against soil-borne pathogen Fusarium oxyporum

It was observed that most of the extracting bio oils exhibited moderate to very good growth inhibition. The growth inhibition varied from 3.3 to 100 per cent at various concentrations. Among the treated bio oil, methanol extracted pine oil showed highest growth inhibition (38.9 to 100 per cent) followed by methanol extracted batain oil (31.5 to 97.8 per cent) and acetone extracted pine oil (30.0 to 96.7 per cent), respectively. The ED_{50} values of different bio oils varied from 334.8 to 1994.9 µg/mL.

Evaluation of nematicidal activity of extracted bio oils against root knot nematode (Meloidogyne sp.)

Most of the oils showed moderate to good nematicidal activity (mortality 56.7 to 90 per cent) except pathenium and bhang extracting oils. The promising bio oils showing more than 75 per cent mortality were further tested for their nematicidal activity at lower doses up to 500 ppm. The results indicated that hexane extracted pine needle, methanol extracted batain and lantana oil had the higher toxicity against *Meloidogyne* sp. and LD_{50} value of these bio oils were 495.1, 530.3 and 576.9 ppm respectively.

Sub-project 2: Dynamics of Soil Carbon Pools and its Sequestration Pattern under Different Nutrient Management Options in Hill Cropping System

Ten nutrient management options {(T_1: Control, T_2: 100% RDN (FYM) basal, T_3: 100% RDN (VC) basal, T_4: 50% RDN (FYM) basal + 50% RDN (VC) at 20-25 DAS, T_5: 50% RDN (FYM) + 50 % RDN (VC) both basal, T_6: 150% RDN (FYM) basal, T_7: 150% RDN (VC) basal, T_8: Integrated practice (50% RDN through FYM + 50% RDN through chemical fertilizers), T_9: Inorganic practice (100% RDF through chemical fertilizers) and T_{10}: 100% RDN (Nitrogen only)} were examined in rainfed finger millet-wheat cropping system. The results revealed that highest system yield (finger millet equivalent) was recorded under inorganic nutrient management (15.78% higher as compared to control) which was found on par with T10, T8, and T7. Soil samples were analyzed for different soil organic carbon fractions. The results revealed significant differences in soil microbial biomass carbon (MBC) and inorganic carbon levels. The highest MBC (2359 µg/g soil) was recorded in T_7 which was found on par with T_5 and T_6. Average across the treatments, partitioning of total P and total K uptake was also estimated and it was found that out of total P uptake around 25% goes to grain and 75% remain in straw of finger millet. Likewise, out of total K uptake, only 10.2% goes into grain part and around 89.8% was remained in the straw. This clearly showed higher grain mobility of P as compared to K in the finger millet.

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

Evaluation of cold tolerant Pseudomonas sp. PPERs 23 on yield of wheat

Based on three-year performance, the selected elite cold tolerant *Pseudomonas* sp. PPERs 23 was evaluated under larger area (82.8 m²). Inoculation with cold tolerant *Pseudomonas* sp. PPERs23 enhanced wheat variety VL *Gehun* 892 grain yield by 11.7% over uninoculated control (1,787 kg/ha) (Fig. 3.2.1).

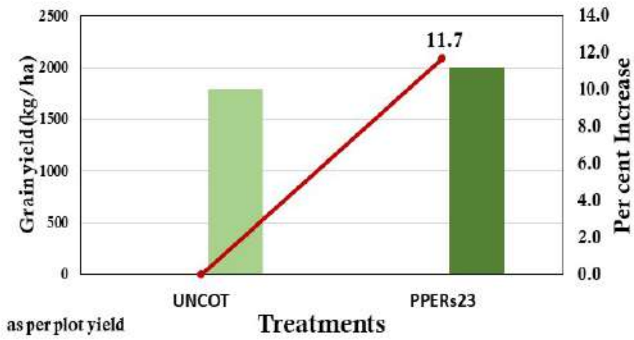


Fig.3.2.1. Evaluation of *Pseudomonas* sp. PPERs 23 on wheat grain yield

Large field demonstration of cold tolerant 'P' solubilizing bacterial consortium C2 (VL PSB consortium C2) on yield of wheat

Based on three-year performance, the selected elite cold tolerant 'P' solubilizing bacterial consortium C2 was evaluated under large field (59.5 m²). Bacterization with cold tolerant 'P' solubilizing bacterial consortium C2 (*Pseudomonas* sp. strains PB2RP1(2)+NS12RH2(1)+CS11RP1) enhanced wheat (VL *Gehun* 892) grain yield by 8.9%, compared to uninoculated control (2,557 kg/ha).

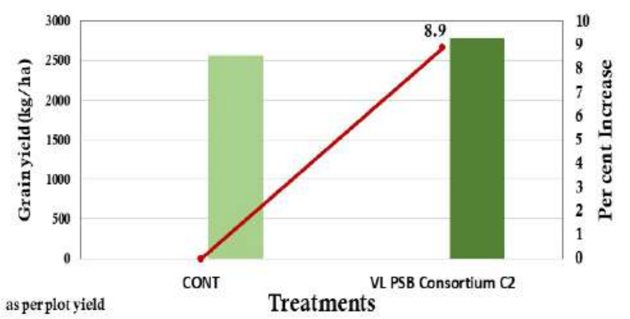


Fig.3.2.2. Evaluation of 'P' solubilising bacterial consortium C2 on wheat yield

Large field demonstration of cold tolerant PGP bacterial consortium C2 (VL PGP consortium C2) on yield of wheat

The selected elite cold tolerant 'P' solubilizing bacterial consortium C2 was evaluated under large field (91.6 m²). Bacterization with cold tolerant PGP bacterial consortium C2 (*Pseudomonas* sp. strain PGRs4+PPERs23+PCRs4) enhanced wheat (VL *Gehun* 892) grain yield by 9.85% compared to uninoculated control (1,420 kg/ha).

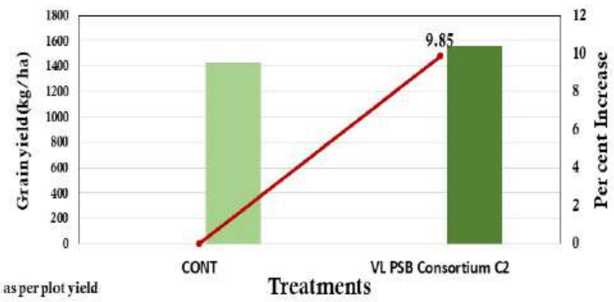


Fig.3.2.3. Evaluation of PGP bacterial consortium C2 on wheat yield

Sub-project 1: Assessment of Native Arbuscular Mycorrhizal Fungi for the Sustainable Production of Hill Crops

Molecular characterization of arbuscular mycorrhizal fungi isolated from diverse cropping system of Uttarakhand Himalayas

The healthy and morphological diverse mycorrhizal spores were isolated from various collected soil samples and used for molecular analysis. Total 24 sequences were obtained from molecular study but finally 13 sequences were used due to low similarity percentage of remaining sequences in NCBI database. The most similar sequences were obtained from the sequence database in NCBI using BLAST and the sequences were grouped into six species in four genera. Most of clades in the phylogram were consistent with morpho-anatomical study. Two species from genus *Gigaspora* and *Dentiscutata* were not able to be identified using morphological characteristics but in molecular study the most similar sequence for these morpho-types were *Gigaspora margarita* (KF378668.1) and *Dentiscutata savannicola* (NR168412.1), respectively and positioned on same clade. Sequences of other morphological identified species such as *Funneliformis caledonium, Funneliformis coronatum, Rhizophagus intraradices* and uncultured *Funneliformis* were also recovered from molecular analysis and their phylogenetic relationship showed the presence of these mentioned species at sampling sites (Fig. 3.2.4).

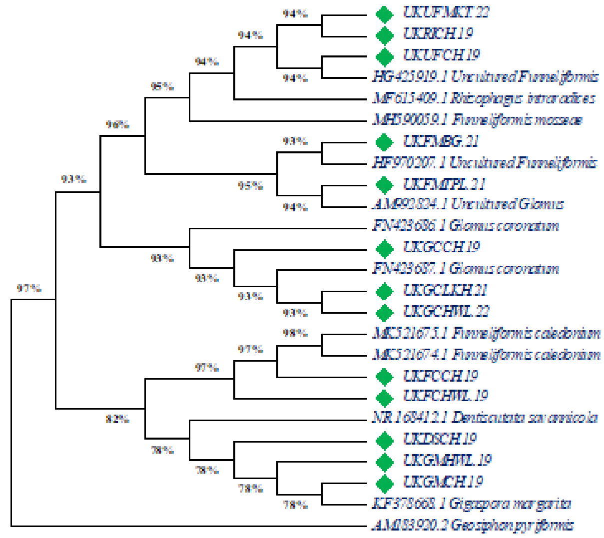


Fig.3.2.4. Phylogenetic tree of arbuscular mycorrhizal fungi (AMF) obtained by analysis of ITS1 and ITS2 sequences using maximum likelihood method

Sub-project 2: Development of Nano-bio formulations to Alleviate Drought Stress in Hill Crops

Isolation of rhizospheric bacterial isolates from farmer's filed under lentil cultivation

Five soil samples were collected from rhizospheric region of two lentil varieties (VL *Massor* 126 and VL *Massor* 507) at farmer's field, village Lakhni, district Bageshwar. A total of 63 isolates were recovered from the rhizospheric region.

Qualitative plant growth promotory tests

Out of 63 isolates, 16 isolates (*L S 4, L PVK 4, L-Kb-1, L KB 3, L NA 2, L S 6, L Zn 4, L NA 10, Endo 2, Endo 10, Endo 12, Endo 13, Endo 5, Endo 7, Endo 8* and *Endo 4*) showed best results for three plant growth promoting activities (zinc and phosphate solubilization and siderophore production). Highest siderophore production was observed in *Endo 13, L S*

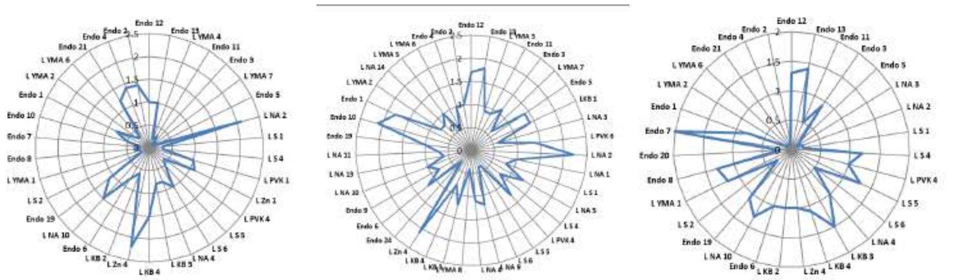


Fig 3.2.5. Qualitative PGPR results on the basis of zone of solubilisation in (a) siderophore (b) p solubilisation and (c) zinc solubilisation

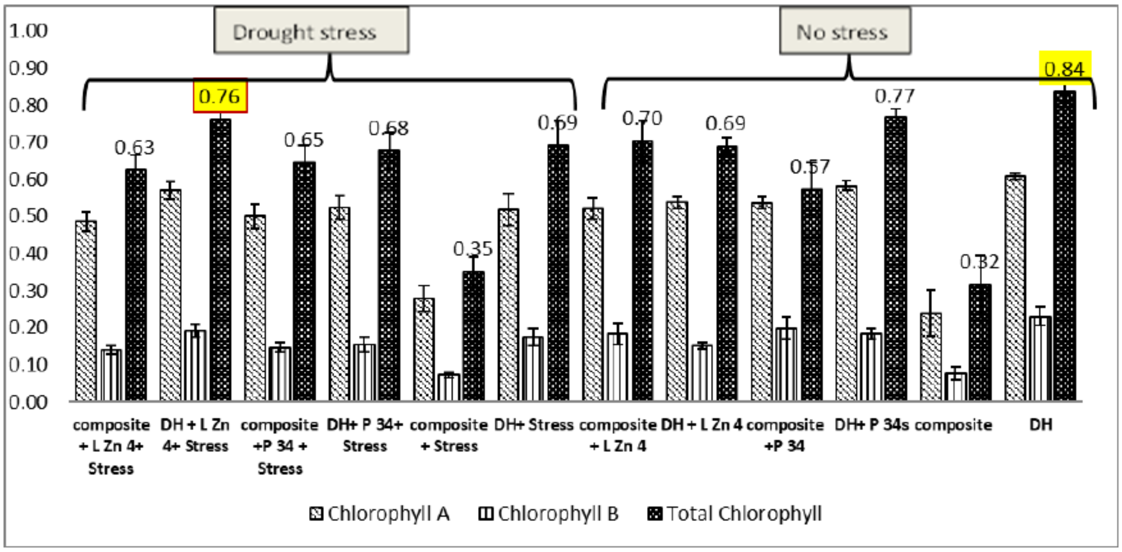


Fig. 3.2.6. Chlorophyll content in *Zea mays* seeds under drought stress condition

4, L PVK 4, L KB 3, L NA 10, Endo 8 and *Endo 7* with a zone of solubilization more than 1 cm. Similarly, in case of P solubilization *Endo 4, Endo 2, L NA 2, L Zn 4 and LNA 10* showed a zone of solubilisation more than 1 cm. Zinc solubilization was maximally found in *Endo 10, Endo 12, Endo 13, Endo 5, L-Kb-1, L-NA 2 and L-Zn-4* with zone of solubilisation equal to and more than 1.5cm (Fig. 3.2.5).

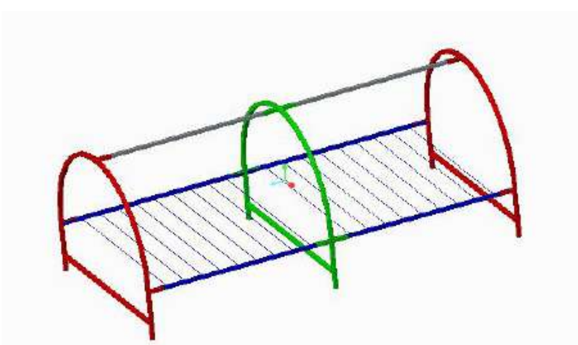
Response of drought tolerant PGP bacterial isolates on drought stress tolerance of Zea mays under controlled condition

The plant height was observed to be higher in case of plants without any stress, but the performance in stressed plants when treated with bacterial inoculants was satisfactorily good. DH line seeds treated bacterial inoculant L-Zn-4 showed better growth in drought stress in comparison to stressed counterparts. Chlorophyll content is the indicator of plant growth and performance in case of any stress or non-stressed condition. The performance of *Zea mays* seeds treated with bacterial inoculants was better in comparison to non-treated seeds.

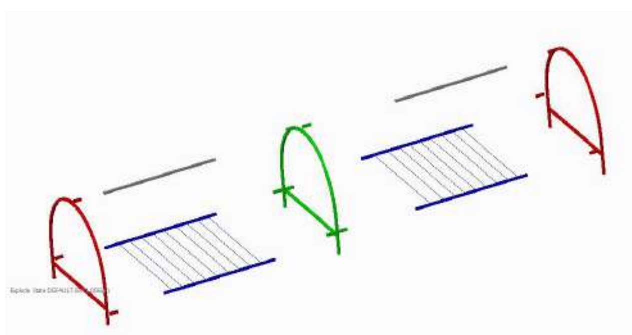
3.3. Design and Development of Pre and Post-harvest Mechanization Technologies for Hill Agriculture

ModifiedVL poly-tunnel

The VL polytunnel is made of steel pipes, GI pipes and GI wires of semi-circular shape (2.0 m length x 1.0 m width x 0.75 m center height) covering ground area of 2 sq m and total available area is 4 sq m. This is made of steel pipes and UV polythene and its price is Rs. 6,000.00. In addition to its primary use in winter for nursery raising, the farmers can also use it for drying and covering their farm produce during rainy season. This polytunnel is very easy for transportation as its maximum parts are detachable in nature and one polytunnel will require only (105x25x80 cm^3) volume for safe transportation.



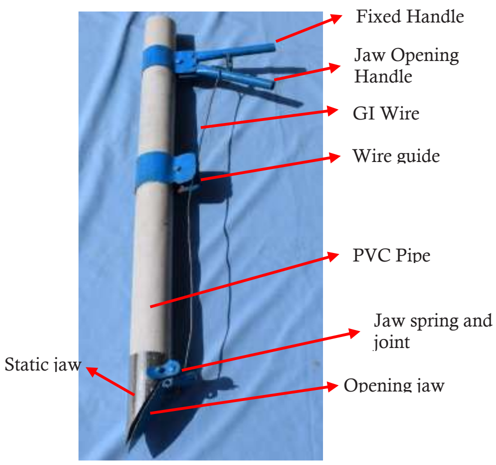
Conceptual design of VL polytunnel



Detachable nature of VL polytunnel

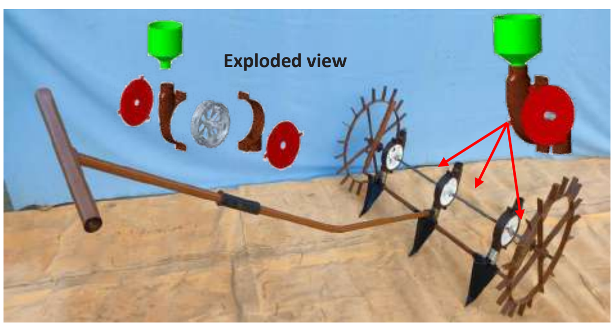
Manual operated seedling transplanter

A hand operated seedling transplanter has been developed using 6.3 cm diameter PVC pipe. Height and weight of the transplanter is 90 cm and 1.3 kg, respectively.



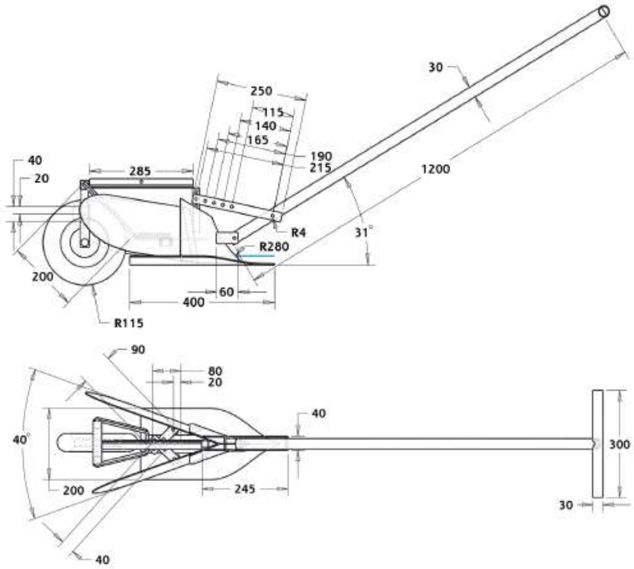
Sowing device for line maker

Metering device was developed using the CAD software (Creo Paraemtric 4.0), printed using 3D printer (Make3D.in) and assembled in the VL line maker. This sowing device is detachable and adjustable and replaceable in nature as per crop requirement and also easy to fix and use. Seed quantity is visible during sowing operation. Seed dropping is very close (5 cm) to soil which is desirable quality of seed drill. Weight of implement is approx. 7.5 kg



Manual operated earthing-up device for maize crop

The manual operated earthing-up device for maize crop was designed using CAD Software (Creo Parametric 4.0). During design three possible adjustments were tried to be incorporated. After that the design was fabricated and tried in the field condition. During operation, it was found that draft requirement was 20 kg and field capacity was 468 sq. m/h.



Conceptual design of earthing-up device using CAD Software (Creo Parametric 4.0)

Earthing-up device

Field operation of device

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

Evaluation of cultivated fodder

Oat: In advance varietal trial on multi cut oat, entry IVTO MC-7 produced significantly higher green fodder (22,450 kg/ha) and entry IVTO MC-7 produced significantly higher dry matter (4,916 kg/ha).

Berseem: Out of eight entries in advance varietal trial, CAVTB-1 & 2-8 produced significantly higher green fodder (17,044 kg/ha) and dry fodder (4,107 kg/ha).

Maize: Out of nine entries of advance varietal trial, significantly higher green forage (18,422 Kg/ha) was obtained by AVTM-1, however, entry AVTM-1-4 produced the highest dry fodder (4,104 kg/ha).

Evaluation of grasses

Tall Fescue: In VT tall fescue, entry VTFF-4 produced the highest green fodder (11,505 kg/ha) along with 2,877 kg/ha dry fodder.

Orchard Grass: Entry VTO-5 produced the highest green forage (11,330 kg/ha) along with significantly higher dry fodder (3,465 kg/ha).

Investigation on fodder trees

In case of kachnar field terrace plantation, the highest green forage (5.20 kg/tree) was recorded from lopping of tree twice in a year followed by local practice, whereas, in case of wayside plantation of kachnar, lopping leaves and tender twigs twice in a year produced highest green forage (8.00 kg/tree).

Agroforestry

Agri-horti system

Fruit-based

During *kharif* season, the maximum sweetcorn (CMVL Sweetcorn 1) cob yield (11,802 kg/ha) was obtained under plum. The maximum green pod yield (12,256 kg/ha) of garden pea (VL *Matar* 12) was recorded under open followed by with lemon (*Citrus limon*), plum (*Prunus domestica*) and apricot (*Prunus armeniaca*).

Peach-based

Four cropping system namely, finger millet-wheat, okra-wheat, okra-barley and finger millet-barley were evaluated. Wheat grain yield reduced by 47% under peach than without peach (open). In case of cropping system, higher wheat equivalent grain yield was recorded from finger millet-wheat (31,120 kg/ha) followed by okra-wheat, finger millet-barley and okra-barley systems.

Grain quality of wheat (VL Gehun 967) and barley (VL Jau 130) under peach based agro-horti system

It was observed that, nutritional quality were better under tree condition than in open condition (Table 3.4.1). Crude protein content were varied from 13.8-14.2 per cent for wheat and 12.1-12.4 per cent for barley, crude fat varied from 3.1-3.4% (wheat) & 1.8-2.2% (barley), crude fiber 6.2-6.5% (wheat) & 5.4-5.7% (barley) and crude ash content varied between 3.3-3.5% (wheat) and 2.5-2.8% (barley). Micronutrient contents also varied.

Soil microbial activities under peach based agro-horti system

The soil microbial activities were significantly higher in okra crop than finger millet crop field under peach trees and value drastically decreases with soil depth under both conditions (Fig 3.4.1). Maximum dehydrogenase activity (44.7 µg TPF/g

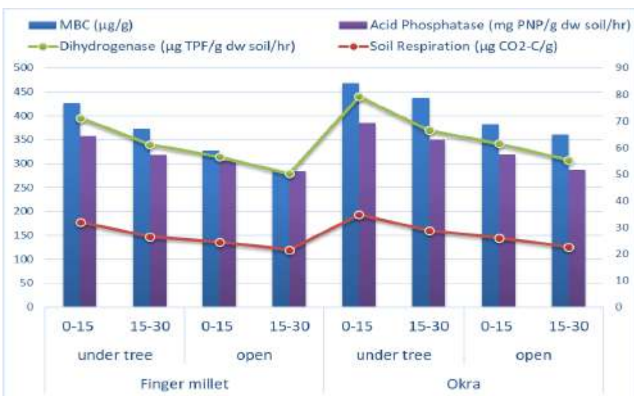


Fig 3.4.1. Soil microbial activities in finger millet-okra crop field soil under peach based agro-horti system

Table 3.4.1. Nutrient content of wheat and barley crop under peach based agro-horti system

Nutrient	Under Tree		Open	
	Wheat	Barley	Wheat	Barley
Moisture (%)	15.4	13.7	14.9	13.3
Dry Matter (%)	84.6	86.3	85.1	86.7
Crude Protein (%)	14.2	12.4	13.8	12.1
Crude Ash (%)	3.5	2.8	3.3	2.5
Crude Fiber (%)	6.5	5.7	6.2	5.4
Crude Fat (%)	3.4	2.2	3.1	1.8
Carbohydrate (%)	63.5	68.9	64.9	66.7
Starch (%)	57.0	63.2	58.7	64.9
Fe (ppm)	48.2	39.5	45.6	36.9
Mn (ppm)	17.5	16.5	17.2	16.2
Zn (ppm)	33.5	23.5	31.2	22.1
Cu (ppm)	1.9	1.5	1.86	1.32

dw soil/h), acid phosphatase activity (384.6 mg PNP/g dw soil/h), microbial biomass carbon content (468.5 µg/g) and soil respiration process (34.8 µg CO_2-C/g) were recorded from okra field soil sample under peach trees at 0-15 cm soil depth.

Silvi-horti system

Oak-based

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 than others. The maximum turmeric yield was recorded with pollarding at 3 m (88.09 q/ha) and least in sole turmeric cropping (61.13 q/ha). However, under oak 31.17% significantly higher turmeric rhizome yield was obtained as compared to sole turmeric cropping. *Swarna* yielded 1.61 % higher than *Pant pithab*.

Soil enzymes activity under oak based silvi-horti system

Among various cutting management options urease, dehydrogenase, acid phosphatase and β-glucosidase ranged from 281-290 µg urea hydrolysed g^{-1} soil h^{-1}, 86-239 µg TPF g^{-1} soil 24 h^{-1}, 310-381 and 10-21 µg p-NP produced g^{-1} soil h^{-1}, respectively. The data revealed that varietal effect was non-significant while other than acid phosphatase various pollarding options influenced soil enzymes activity significantly ($p<0.05$). Among various management practices, cutting from 3 m provided highest soil enzymes activity and improved acid phosphatase, β-glucosidase and dehydrogenase activity by ~3, 76 and 161% than open condition (Fig. 3.4.2).

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 2 m height and pollarding at 3 m height with *Setaria kazungula* under these trees were tested under silvi-pastoral system. During rainy season, the highest green fodder yield (66,560 kg/ha) was recorded under *Bhimal* followed by batain, however, in case of cutting management pollarding at 1 m height produced the highest green fodder yield (62,580 kg/ha).

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

Five different grass planting systems namely kudzu vine, bajra napier, hybrid napier, love grass and lemon grass were studied on runoff and soil loss in the slopping land. The soil of the experimental area was well-drained sandy loam comprising of

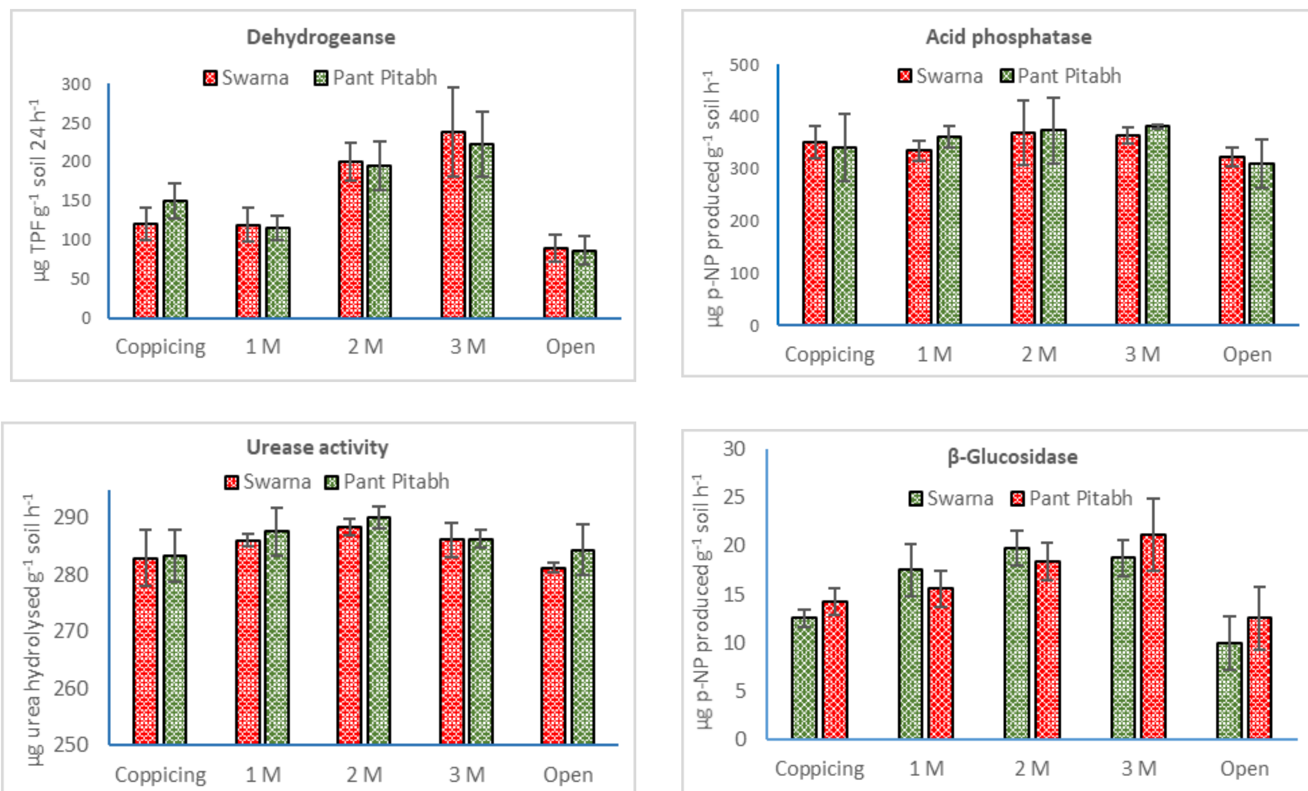


Fig. 3.4.2. Effect of various cutting management option on soil enzymes activity under oak based agri-horti syste

74.01% sand, 15.15% silt and 10.84% clay. The runoff and soil loss were significantly reduced under the different grass systems as compared with control treatment. On the basis of four years of field experiment, love grass followed by hybrid napier and bajra napier were found to be most effective in controlling surface runoff and soil loss management. The love grass was found to be the most effective to control surface runoff (37.10%), soil loss (77.7%) and nutrient loss (77%) as compared to control. The highest soil water conservation efficiency *i.e.* 58.39% and 55.34% was found in love grass and hybrid napier, respectively under different grassland system (Fig 3.4.3).

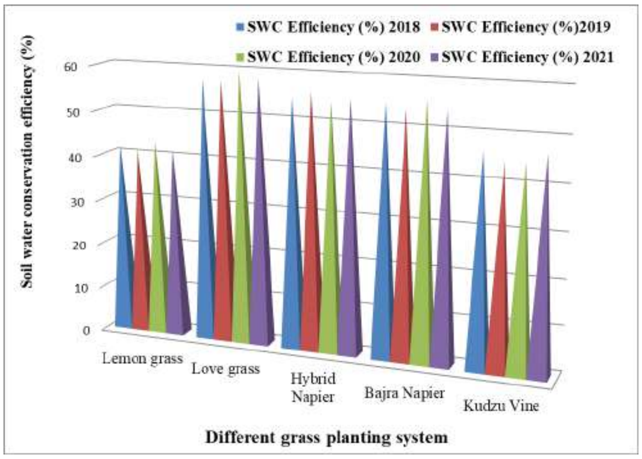


Fig. 3.4.3. Effect of different grass planting system on soil water conservation efficiency

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

Sub-project 1: Development of sensor network based automation system for improving water productivity

Development of adjustable framing head structure for efficient operation of micro irrigation system

The developed device helped to maintain adjustable head up to 5m for efficient operation of micro irrigation system. The hydraulic evaluation of gravity based micro irrigation system was found satisfactory as per the dripper flow variation and distribution uniformity varies in the range of 2.78-9.09% and 94.04-99%, respectively. The water saving was 33.06% and 31.40% in gravity based drip irrigation system as compared to micro sprinkler system at 3.6 m and 5.7 m head, respectively. The emitter flow rate varied from 1.23-2.13 l/h and maximum variation 0-42% were recorded from 1.75 m to 6 m head, respectively. The discharge variation in micro sprinkler were found 0-8.53% from 3.6 m to 5.7 m head, respectively (Table 3.5.1).

Assessment of solar energy based operation of micro irrigation system under different head condition

It was recorded that irradiation varied at site from 2.75 to 5.42 kWh/m^2/day during August

Table 3.5.1. Performance evaluation of system under different head condition

Terrace No.	Lateral / Replication	Average dripper Discharge (l h^{-1})	Average nozzle (Micro sprinkler) discharge (l h^{-1})	Variation in dripper flow rate (%)	Variation in micro sprinkler flow rate (%)	Drip system distribution uniformity (%)	Micro sprinkler system Distribution uniformity (%)
1st Terrace (1.75 m)	R1	1.27	Did not operate due to lower pressure head (<0.2 kg/cm^2)	9.09	Did not operate due to lower pressure head (<0.2 kg/cm^2)	94.74	Did not operate due to lower pressure head (<0.2 kg/cm^2)
	R2	1.2		9.09		97.56	
	R3	1.21		4.76		98.90	
2nd Terrace (3.6 m)	R1	1.84	10.60	6.25	5.93	97.82	94.04
	R2	1.82	10.90	3.22	4.91	98.90	95.09
	R3	1.78	11.28	3.33	3.48	97.75	96.52
3rd Terrace (5.7 m)	R1	2.12	12.06	2.78	1.65	99.05	98.35
	R2	2.02	11.78	5.71	3.77	98.02	96.23
	R3	2.02	12.02	3.03	1.0	98.99	99

to December. A 0.25 HP solar pump has been selected to conduct the experiment and lift water from polylined tank (capacity 135 m^3). Solar energy (0.25 HP) based drip irrigation system was operated satisfactorily as per dripper flow variation and distribution uniformity varied in the range of 3.03-9.89% and 91.74-94.7%, respectively with coverage area 290 m^2 at 5m head and 220 m^2 at 10m head condition. Similarly, in case of hydraulic evaluation of micro sprinkler system, satisfactory operation variation of nozzle flow rate 3.12-9.09% and distribution uniformity 83.40-90.65% having seven sprinkler set with coverage area 198 m^2 at 5m head and 137 m^2 at 10 m head condition was observed.

Effect of different soil biological parameters under different irrigation system in open and polyhouse condition

Soil respiration and dehydrogenase enzyme activity were estimated under drip and sprinkler irrigation system in tomato and capsicum crops in open and polyhouse conditions. The maximum microbial activities were found under polyhouse condition (dehydrogenase 45.63-55.70 µg TPF/g soil/h and respiration 26.7-34.8 µg CO_2-C/g) as compared to open condition (dehydrogenase 40.16-48.20 µg TPF/g soil/h and respiration 23.2-31.4 µg CO_2-C/g). Soil respiration and dehydrogenase activities were better in tomato crop (dehydrogenase 44.28-55.70 µg TPF/g soil/h and respiration 28.9-34.8 µg CO_2-C/g) than capsicum crop (dehydrogenase 42.6-51.8 µg TPF/g soil/h and respiration 26.3-31.4 µg CO_2-C/g) under both conditions. Among the irrigation system, sprinkler system (dehydrogenase 45.63-53.8 µg TPF/g soil/h and respiration 26.7-33.4 µg CO_2-C/g) provided better microbial activities than drip irrigation system (dehydrogenase 40.16-52.6 µg TPF/g soil/h and respiration 23.2-30.6 µg CO_2-C/g) under both conditions.

4. Integrated Pest Management

Research Projects

- Race distribution Pattern, diversity and eco-friendly management of economically important diseases of hill crops {*Drs. Gaurav Verma, Jeevan, B. (upto 03.09.2022) and K. K. Mishra*}
- A high value medicinal fungus (*Cordyceps militaris*): Characterization & commercial exploitation {*Drs. K. K. Mishra, Gaurav Verma, Ashish Kumar Singh, and Ramesh Singh Pal*}
- Crop pollination through *Apis* and non-*Apis* bee pollinators *(Mr. Amit Paschapur)*
- Management of insect pests of hill crops through integrated approach {*Mr. Amit Paschapur, Dr. Ashish Kumar Singh and Dr. Gaurav Verma*}
- Comprehensive assessment of diversity of agriculturally important nematode and their management under hill agriculture *(Dr. Ashish Kumar Singh and Mr. Amit Paschapur)*
- Exploring potential bio-inoculants and host resistance for management of blast disease {*(Drs. Jeevan B (upto 03.09.2022), Gaurav Verma and Priyanka Khati*}

4. Integrated Management of Diseases and Pests of Hill Crops

Crop protection measures play a vital role in reducing the crop yield losses due to diseases and insect-pests. Integrated methods of management are environmentally safe and important in hill ecosystem. Thus, emphasis have been given on 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, stripe rust severity was high (upto 80S) whereas leaf rust severity was medium (upto 40S) at Experimental farm, Hawalbagh. In most of the experimental lines at Hawalbagh, medium-high severity of powdery mildew was observed (5-7 score on 0-9 scale). In garden pea, low-moderate severity of purple blotch (20-50%) and low severity of stemphylium blight (10-15%) in onion and garlic were noticed. In lentil, wilt incidence was low (<10%). Medium severity of turcicum leaf bight (3-5 score on 1-9 scale) was observed in maize. Frog eye leaf spot was moderate (3-5 score on 0-9 scale) in soybean. The infestation of shoot fly, aphid and thrips was observed in wheat and barley at a very low severity (<10%), whereas 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 paddy, the leaf roller and grass hopper damage was noticed with moderate severity (10-20%). Whereas, the infestation of grassy stunt virus and white backed plant hopper damage was recorded with very high severity (30-40%) in *Kharif* season. In maize, the infestation of fall army worm was reduced and the per cent damage of 15-20% was recorded in both vegetative and reproductive stage. In millets, infestation of grasshoppers was recorded with moderate severity (10-20%), whereas, damage of ear head caterpillars and aphids was very low with only 5-10% severity. In case of soybean, the damage of *Platypria* spp. was observed with moderate severity (15-20%) in vegetative stage of the crop. The damage of aphids was recorded in both vegetative and reproductive stages in *Toria*, garden pea, Capsicum and cruciferous crops with medium to high severity (10-30%). In the year 2022, the damage of *Tuta absoluta* in tomato was recorded with up to 30% severity and russet mite infestation increased rapidly in cherry tomato as compare to previous years and the severity of up to 40% was recorded under polyhouse conditions at experimental farm, Hawalbagh. Furthermore, in 2022 the damage of polyphagous black cut worm (*Agrotis segetum*) spread to cereal crops like maize and finger millet with 15-20% damage, in pulses like soybean with 10-15% damage and in vegetables like crucifers, capsicum, chilli and cucurbits with per cent damage ranging between 10-40% in various regions of Almora, Bageshwar, Nainital and Chamoli districts.

The incidence of Southern Rice Black-Streaked Dwarf Virus (SRBSDV), belonging to the genus Fijivirus is reported in rice at Experimental farm, Hawalbagh. The affected plants showed a severely stunted appearance and the roots were poorly developed and turned brownish. It is transmitted by a white-backed plant hopper (WBPH) (Figure 4.1). In general, the pest incidence in all the crops varied between medium to high severity (15-30%).

Fig 4.1 (a) SRBSDV infested rice samples (b) White-backed plant hopper (WBPH)

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

4.2.1. Evaluation of promising Trichoderma harzianum strains for management of lentil wilt

The use of *T. harzianum* as a biocontrol agent for lentil wilt management has been investigated. Out of eight treatments, the promising effect of bio-agent with lowest disease severity (9.58%) was recorded with soil application of *T. harzianum* strain 28 and strain 202 (10g/kg FYM) and drenching (10g/lit) at the time of disease appearance as compared with control (27.97%) (Figure 4.2). However, the maximum disease reduction over control (67.58 %) was observed in seed treatment with carbendazim (2g/kg seed) and drenching at the time of disease appearance as compared to promising combination of bio-agents (64.75%) (Figure 4.2). Overall, the evaluated promising *T. harzianum* strains for management of lentil wilt are effective in suppressing lentil wilt and have the potential to be used as a biocontrol agent in the field conditions.

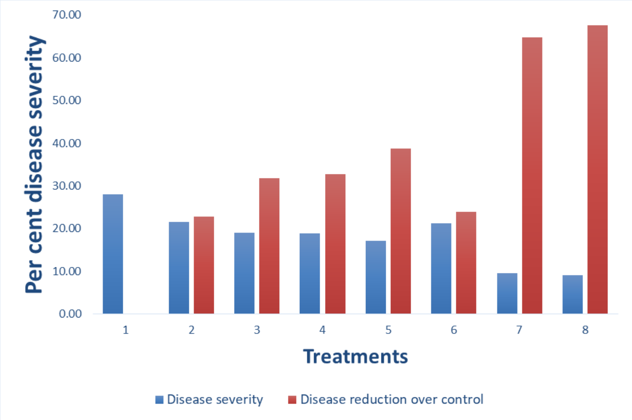


Fig. 4.2. Effect of *Trichoderma harzianum* strains for management of lentil wilt

4.2.2. Field screening of lentil germplasm accessions against Fusarium oxysporum f.sp. lentis

Based on two year field data, forty seven (47) entries of lentil were found resistant against lentil wilt with disease severity upto 10% (Table 4.1). By using standardized approach, resistant germplasm accessions have been identified that can be use in breeding program for the management of lentil wilt.

Table 4.1. Identified lentil germplasm accessions against *Fusarium oxysporum* f.sp. *lentis*

Disease Severity	Entries
Resistant (up to 10%)	IC98400, IC145286, IC145313, ILWL118, IC145277, IC201531, IC201557, IC201521, IC201563, IC201549, IC201528, IC201723, IC201573, IC201545, IC201580, IC201709, IC392634, IC406532, IC201681, ILWS 118-1, IC24090, IC553072, IC201534, IC201527, IC201569, IC281830, IC282894, IC145310, IC201554, IC145305, IC553082, IC201740, IC553099, IC392637, IC406706, IC201541, IC393181, IC406527, IC201559, IC345628, IC201553, IC393196, IC406727, IC282892, IC383379, IC201741 & IC338763 **(47 nos.)**
Susceptible check	L-9-12 (24%)

4.2.3. Screening of garden pea germplasm against ascochyta blight (Ascochyta pisi)

Fifty-eight entries were evaluated under field conditions. The plants are scored for disease severity on a regular basis using a standardized rating scale. Out of 58 tested entries, entry VP1925 was found resistant and 9 entries namely VP1902, VP1909, VP1910, VP1911, VP1228, VP1802, VP1912, VP1928 & HIM PAMALAM were found moderately resistant to ascochyta blight disease (Table 4.2).

Table 4.2. Identified garden pea entries against ascochyta leaf blight disease

Disease Severity	Entries
Resistant (1-10%)	VP1925
Moderately Resistant (11-20%)	VP1902, VP1909, VP1910, VP1911, VP1228, VP1802, VP1912, VP1928 & HIM PAMALAM

4.2.4. Management of powdery mildew of wheat using integrated approach

Out of different fungicides/combinations evaluated against powdery mildew of wheat, azoxystrobin 18.2% w/w+ difenoconazole 11.4% w/w SC @ 0.10% along with propiconazole was found effective (3.66 average disease score on 0-9 scale). However, azoxystrobin 18.2% w/w+ difenoconazole 11.4%

Table 4.3. Management of powdery mildew of wheat using different fungicides

Detail	Dose (%)	Disease score	Yield (q/ha)	% Yield gain
Azoxystrobin 18.2% w/w+ Cyproconazole 7.3% w/w SC	0.10%	4.33	69.15	11.75
Azoxystrobin 18.2% w/w+ Difenoconazole 11.4% w/w SC	0.10%	3.66	72.06	16.45
Azoxystrobin 11%w/w + Tebuconazole 18.3% w/w SC	0.10%	5.33	66.03	6.71
Propiconazole	0.10%	3.66	68.32	10.41
Tebuconazole	0.10%	5.00	64.49	4.21
Control	--	8.33	61.88	--
CD at 5%		1.98	5.56	

w/w SC @ 0.10% resulted in maximum yield (72.06 q/ha) (Table 4.3).

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

4.3.1. Evaluation of different carbon sources on mycelial biomass of *C. militaris*

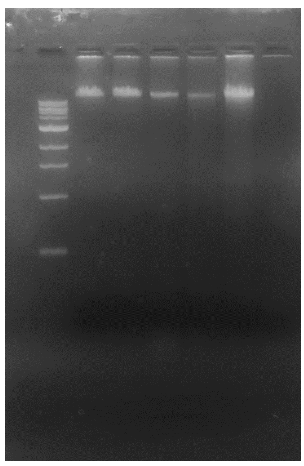
Estimation of mycelial biomass on different carbon sources (dextrose, sucrose and fructose) in CDOX and PDA medium was carried out. The maximum mycelial biomass in CDOX medium was recorded when supplemented with dextrose (8.11 gL^{-1}) followed by sucrose (8.00 gL^{-1}) and fructose (7.91 gL^{-1}) (Table 4.4).

Table 4.4. Evaluation of different carbon sources on mycelial biomass of *C. militaris*

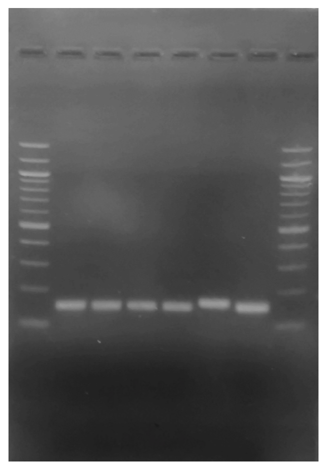
Medium used	C sources used @ 10g L^{-1}	Mycelial biomass (gL^{-1})
CDOX (7.76)	Dextrose	8.11
	Fructose	7.91
	Sucrose	8.00
PDA (6.92)	Dextrose	7.76
	Fructose	7.20
	Sucrose	7.35
CD at 5%		0.08

4.3.2. Molecular based identification of *C. militaris* isolates

Molecular-based identification of *Cordyceps militaris* isolates involves the use of specific diagnostic markers to differentiate between different strains of the fungus. Extraction of DNA from the *C. militaris* isolates was done using modified CTAB method. The Polymerase chain reaction (PCR) was performed using specific primers designed to amplify 167 base pairs (bp) DNA region of the fungus. For *C. militaris*, the internal transcribed spacer (ITS) region of the ribosomal DNA (rDNA) is commonly used as a genetic marker for identification, however, we have target gene specific region of the fungus in order to discriminate among the common isolates for studying the phylogeny of the isolates. The amplified PCR product was run on agarose gel and visualize the DNA fragments. The amplified region of *C. militaris* produces a band of around 167 base pairs.



DNA Extraction: CTAB



PCR Amplification

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

4.4.1. Role of entomophily in enhancing the seed yield and quality of lady's-finger (*Abelmoschus esculentus*) in mid-Himalayan region

Okra is an often-cross pollinated crop with up to 19-42% of cross pollination assisted by insects and planned pollination may improve the economic fruit yield and biological parameters. In view of this, a study was planned to assess the pollinator diversity and possible results (both biological and economical) of planned bee pollination. The study on floral visitors of okra recorded 28 insect species belonging to four insect orders, among which five species (*Apis cerana indica, Apis mellifera, Bombus haemorrhodalis, Lithurgus atratus* and *Xylocopa latipes*) were predominant.

The pollination behaviour and foraging activity showed that two non-*Apis* bee species (*X. latipes* and *B. haemorrhodalis*) were swift flyers and visited more number of flowers per unit time, whereas, other three spent significant time in foraging on single flower. It was noticed that, peak period of pollinators' visitation was between 9.00-11.00 h accounting to 113.76±7.65 insects/m^2, during which stigma receptivity and pollen germination were at its peak, thus, leading to optimum pollination and fertilization (Figure 4.3).

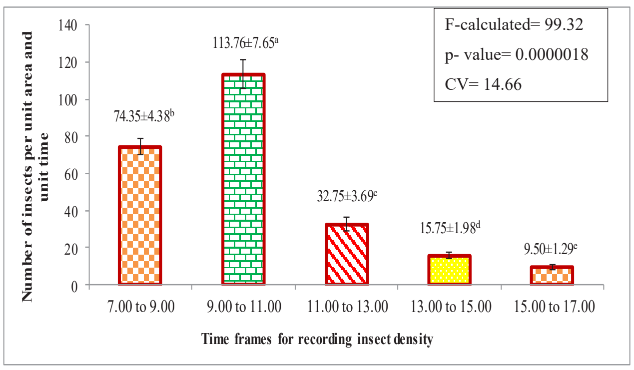


Figure 4.3. Pollinators' visitation in okra crop during peak flowering period at five-time frames of the day

Assessment of yield related parameters of insect pollinated flowers showed superior quality fruits with better capsule length (17-21 cm), capsule girth (5-8 cm), seeds per capsule (54-61), test weight (6.50-8.50 grams) and even the seed yield (22-30 quintals per hectare) than closed control and hand pollination (Table 4.5).

4.4.2. Molecular characterization and phylogenetic analysis of the native small carpenter bees (*Ceratina* spp.) and Himalayan Bumble bee (*Bombus haemorrhoidalis*)

Three species of *Ceratina* native to Indian Himalayas were molecularly characterized. Three species were reported as *C. sutepensis*, *C. smaragdula* and *C. similima* based on phylogenetic analysis and comparison with the NCBI database. Through BLASTn analysis of the obtained sequences, it was observed that our specimen *Ceratina sutepensis* voucher specimen Almora showed 99.83% identity to *Ceratina sutepensis* voucher CDT_NMH_2809 (NCBI accession number MK904769). While, the *Ceratina smargdula* voucher specimen_Almora recorded 99.83% identity with the *Ceratina smargdula*

Table 4.5. Effect of different pollination methods on enhancing the quantitative yield parameters of Okra.

Pollination treatments	Pod length (in cm)	Pod girth (in cm)	No. of Seeds per pod	Weight of seeds per pod (in grams)	Weight of each pod (in grams)	Test weight of seeds (in grams)	Seed yield (Quintals per ha)
A. c. indica	18.42 ± 0.59^{bc}	6.89 ± 0.17^{b}	54.40 ± 0.89^{b}	5.61 ± 0.26^{a}	9.90 ± 0.53^{a}	7.20 ± 0.11^{b}	24.31 ± 1.36^{ab}
A. mellifera	19.41 ± 0.45^{ab}	7.01 ± 0.29^{ab}	56.07 ± 1.14^{ab}	5.75 ± 0.24^{a}	10.98 ± 0.50^{a}	7.93 ± 0.10^{a}	26.51 ± 1.67^{ab}
B. haemorrhodalis	20.53 ± 0.39^{a}	7.73 ± 0.18^{a}	59.67 ± 0.63^{a}	6.06 ± 0.41^{a}	11.42 ± 0.64^{a}	8.11 ± 0.07^{a}	30.27 ± 4.33^{a}
Interaction (*A. c. indica + A. mellifera*)	17.96 ± 0.68^{bc}	6.85 ± 0.29^{b}	57.27 ± 0.91^{b}	5.73 ± 0.29^{a}	10.18 ± 0.48^{a}	7.29 ± 0.08^{b}	25.92 ± 0.34^{ab}
Hand pollination	16.83 ± 0.57^{c}	5.91 ± 0.14^{cd}	53.87 ± 0.95^{cd}	5.40 ± 0.33^{a}	9.37 ± 0.39^{a}	6.49 ± 0.25^{cd}	17.03 ± 1.76^{b}
Open control	18.51 ± 0.56^{bc}	6.53 ± 0.15^{bc}	55.73 ± 0.73^{bc}	5.75 ± 0.09^{a}	9.96 ± 0.40^{a}	6.88 ± 0.15^{bc}	20.36 ± 2.36^{ab}
Close control	14.95 ± 0.27^{d}	5.71 ± 0.14^{d}	46.33 ± 1.47^{d}	4.22 ± 0.15^{b}	7.60 ± 0.52^{b}	6.09 ± 0.11^{d}	16.91 ± 0.76^{b}
C.D.	1.38	0.59	2.76	0.76	1.32	0.36	7.18
SE(m)	0.49	0.21	0.98	0.27	0.47	0.12	2.30
C.V.	10.45	12.13	6.92	18.97	18.33	2.80	17.32
F-value	12.17*	17.75*	11.39*	4.84*	6.19*	29.01*	5.54*
p-value	0.00008	0.00017	0.00004	0.00011	0.00002	0.00013	0.00007

†*- The post-hoc Tukey's-B test, F- values and p-values were calculated to compare the means at 5% level of significance.

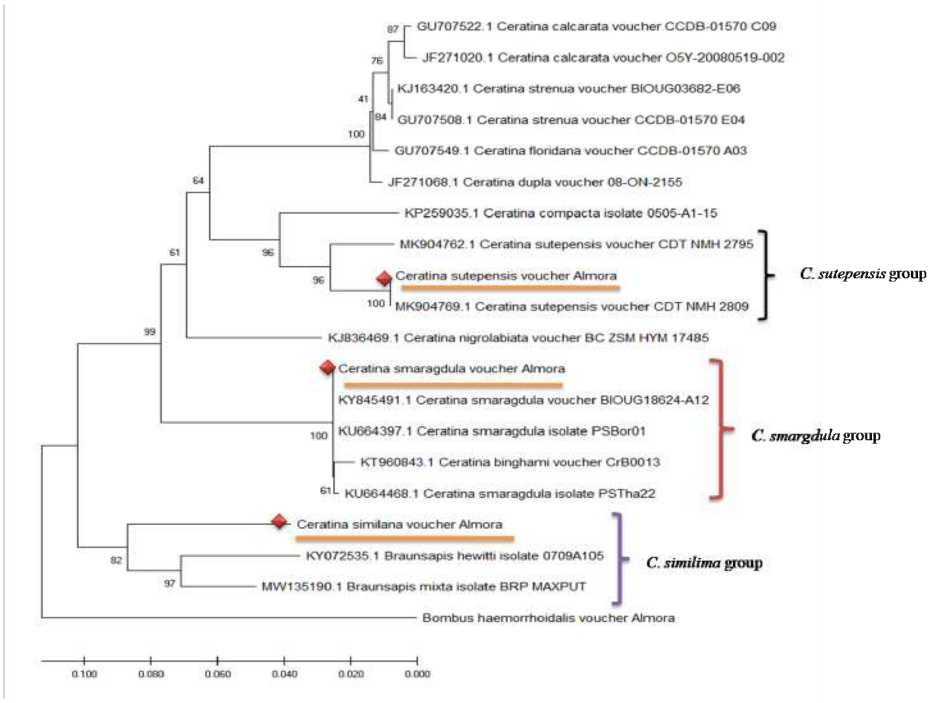


Figure 4.4. Minimum Evolution tree with bootstrap support (1000 replicates) showing clustering of different species of *Ceratina*, constructed using partial COI sequences.

isolate PSBor01 specimen (NCBI accession number KU664397). However, the *Ceratina similima* voucher specimen Almora showed only 92.03% identity to *Braunsapis mixta* isolate BRP_MAXPUT (NCBI accession number MW135190). Although both *C. similima* and *B. mixta* belong to same family Apidae and sub-family *Xylocopinae*, their classification at the tribe level varies, wherein the *Ceratina* species belongs to tribe Ceratinini and *Braunsapis* belongs to tribe *Allodapini*. When the phylogenetic tree was constructed with the MEGA X 10.0.5 software (Figure 4.4), it was observed that the three species of *Ceratina* native to Indian Himalayas formed three separate groups in the minimum evolution tree. The node support estimated using 1000 bootstrap pseudoreplicates, showed that *C. sutepensis* and *C. smargdula* species evolved together as they showed 100% node value. However, as no sequences of *C. similima* were obtained from the NCBI database, the phylogenetic analysis was carried out with the available closely related species of *Braunsapis.* The results showed that the *C. similima* species showed only 82% relatedness to *Braunsapis* species during the evolutionary analysis.

The molecular variation and phylogenetic relationship of this species was analyzed using partial cytochrome oxidase I (COI) and cytochrome *b* (cyt *b*) sequences of mitochondrial genome. The COI sequences were compared with available sequences of *B. haemorrhoidalis* and other *Bombus* species belonging to different subgenera to avail divergence within and between species, respectively. When the phylogenetic tree was constructed with the MEGA X 10.0.5 software (Figure 4.5), it was

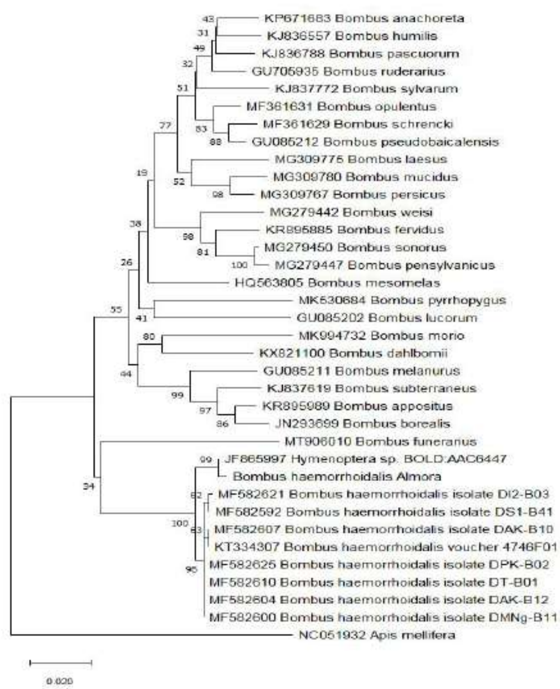


Fig. 4.5. Minimum evolution tree with bootstrap support showing clustering of different species of *Bombus* (starts with accession numbers) constructed using partial COI sequences.

observed that the *B. haemorrhoidalis* species native to Indian Himalayas formed separate groups with hymenopteran species BOLD deposit AAC6447 (MAHYM005-10.COI-5P) in the maximum likelihood evolution tree which is a Bombus species from Pakistan. The node support estimated using 1000 bootstrap pseudo-replicates, showed that these species evolved together as they showed 99% node value.

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

4.5.1. Management of fall army worm (*Spodoptera frugiperda*) of maize through locally available plant extracts

Locally available plant extracts were used for developing eco-friendly pest management strategy against fall army worm, *Spodoptera frugiperda* of maize. It was observed that, *Thuja* leaf + *Thuja* seed (extract 5%) recorded significantly superior pest reduction (91.50±6.34%), after recommended insecticides sprayed @ ETL. The per cent pest reductions were further followed by treatments of *Artemisia* + *Urtica* (leaf extract 5%) (86.93±5.79%) and *Melia* leaf + *Melia* seed (extract 5%) (81.40±4.98%) (Table 4.6).

During second year of experimentation it was observed that, *Thuja orientalis* leaf extract + *Thuja orientalis* seed extract (5% each) sprayed after every fort night interval in rotation reduced the pest infestation to 73.33±3.34% followed by *Melia azedarach* seed extract + *Melia azedarach* leaf extract (5% each) (63.33±5.25%) and *Datura* leaf extract + *Trifolium* leaf extract (5% each) (60.00±2.85%) (Table 4.7). Although, the local strain of entomopathogenic nematode (*Heterorhabditis indica*) reported highest mortality under laboratory conditions, but, it did not perform well under field conditions.

Table 4.6. Organic treatments imposed for management of fall army worm infecting maize and their per cent pest reduction in both vegetative and reproductive stages

Treatment	Pest reduction (%)	
	(Vegetative stage)	(Reproductive stage)
Sand + Ash (every 7 days)	56.67±3.97[e]	77.72±5.91[d]
Soil slurry + saw dust (every 7 days)	52.37±6.37[e]	78.63±3.78[d]
Parthenium + *Lanatana* (leaf extract 5%)	56.67±6.23[e]	77.61±6.28[d]
Thuja leaf + *Thuja* seed (extract 5%)	86.67±5.38[b]	91.50±6.34[b]
Artemisia + *Urtica* (leaf extract 5%)	73.33±7.19[c]	86.93±5.79[bc]
Melia leaf + *Melia* seed (extract 5%)	63.50±5.91[d]	81.40±4.98[cd]
Recommended insecticides @ ETL (positive control)	91.45±4.96[a]	98.67±7.83[a]
Water spray (negative control)	13.67±2.37[f]	11.28±1.69[e]
SE (m)	4.62	6.89
F- calculated value	97.65*	113.45*
p-value	0.000014	0.000072

Table 4.7. Organic treatments imposed for management of fall army worm infecting maize and their per cent pest reduction in both vegetative and reproductive stages

Treatment	Pest reduction (%)	
	(Vegetative stage)	(Reproductive stage)
Thuja orientalis leaf extract + *Thuja orientalis* seed extract (5% each)	33.33±3.34[c]	73.33±3.34[b]
Artemesia leaf extracts + Timur leaf extract (5% each)	23.33±1.18[d]	46.67±4.83[e]
Melia azedarach seed extract + *Melia azedarach* leaf extract (5% each)	46.67±3.34[b]	63.33±5.25[c]
Parthenium leaf extract + *Eupatorium* leaf extract (5% each)	50.00±4.23[b]	53.33±3.34[d]
Datura leaf extract + *Trifolium* leaf extract (5% each)	46.67±3.34[b]	60.00±2.85[c]
Entomopathogenic nematode dead cadavers (EPN) (1 cadaver / plant)	33.33±2.67[c]	33.33±1.82[f]

Recommended insecticides (Positive control)	80.00±4.23[a]	100.00±0.00[a]
Water spray (negative control)	13.33±1.82[e]	26.67±1.76[g]
SE (m)	6.97	4.27
F- calculated value	8.41	29.46
p-value	0.00041	0.000012

4.5.2. Screening of multipurpose insect trap against insect pests of tomato under polyhouse conditions

In order to reduce the use of insecticides and develop a suitable eco-friendly pest management strategy, a multipurpose insect trap was designed (Figure 4.6) and screened to test its effectivity against two important insect pests of tomato South American pin worm (*Tuta absoluta)* and green house whitefly (*Trialeurodes vaporariorum*) under polyhouse conditions (Table 4.8).

Table 4.8. Weekly average of insects trapped in different trap parts

Type of trap	*Tuta absoluta* trapped	*Trialeurodes vaporariorum* trapped
Yellow sticky trap	22.6±2.47	2498.7± 84.75
Water pan trap	12.3±0.65	324.9±21.59
Sleeve trap	09.7±0.23	18.4±3.49
Pheromone trap	36.3±5.67	-
Delta trap	11.8±1.37	927.7±29.8

By installation of one multipurpose insect trap in a polyhouse of 200 m^2 area, the infestation of *Tuta absoluta* by 71.25 ±5.28% and *Trialeurodes vaporariorum* by 48.45 ±3.25% in tomato can be reduced.

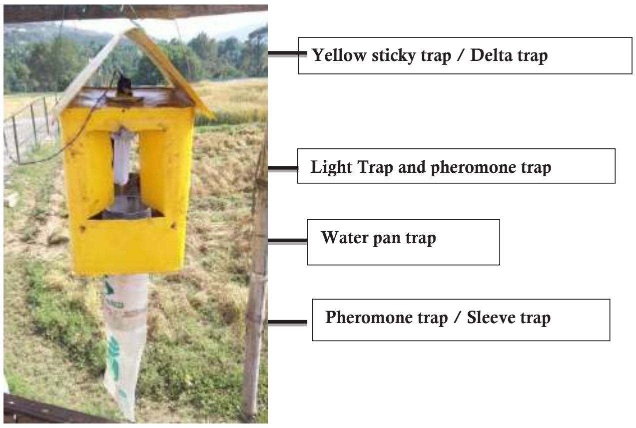


Fig. 4.6. Multipurpose insect trap designed at ICAR-VPKAS, Almora

4.5.3. *Recommendation of novel group of insecticides for management of important insect pests of hill crops*

Considering the economic damage caused by these insect pests in various crops, a total of 23 novel insecticide molecules were screened to test their toxicity and efficacy against insect pests (Table 4.9). Once the baseline susceptibility of insecticides was set, they were scientifically recommended to farmers for pest management and can be included in the package of practices of various crops cultivated in the Indian Himalayas.

Table 4.9. Important hill crops, their insect pests and effective insecticides with their dosage

Crop	Insect pest	Recommended insecticides	Dosage
Maize	Aphid (*Rhopalosiphum maidis*)	Difenthiuron 50% WP	0.3 g/L water
		Thiomethaxam 25% WG	0.3 g/L water
		Imidacloprid 17.8% SL	0.3 mL/L water
		Pymetrozine 50% WG	0.3 g/L water
		Acetamiprid 20% SP	0.3 mL/L water
	Fall army worm (*Spodoptera frugiperda*)	Emamectin benzoate 5% SG	0.3 g/L water
		Spinosad 45% SC	0.3 mL/L water
		Indoxacarb 14.5% EC	1 mL/L water
		Lamdacyhalothrin 5% EC	0.3 mL/L water
		Chlorantraniliprole18.5% SC	0.3 mL /L water
		Flubendiamide 39.35% SC	0.3 mL /L water
		Cyntraniliprole 10.26 OD	0.3 g/L water
Soybean	Soybean leaf bug (*Chauliops choprai*)	Difenthiuron 50% WP	0.3g/L water
		Cartap hydrochloride 50% SP	1 g/L water
		Pymetrozine 50% WG	0.3 g/L water

Crop	Insect pest	Recommended insecticides	Dosage
		Thiomethaxam 25% WG	0.3 mL /L water
		Imidacloprid 17.8% SL	0.3 mL /L water
		Buprofezin 25% SC	0.3 g/L water
Tomato	α. Fruit borers (*Helicoverpa armigera* and *Spodoptera litura*) β. South American tomato pin worm (*Tuta absoluta*)	Emmamectin benzoate 5% SG	0.4 g /L water
		Spinosad 45% SC	0.3 g/L water
		Indoxacarb 14.5% EC	1 mL/L water
		Lamdacyhalothrin 5% EC	0.3 mL /L water
		Chlorantraniliprole18.5% SC	0.3 mL/L water
		Flubendiamide 39.35% SC	0.3 mL /L water
		Cyntraniliprole 10.26 OD	0.3 g /L water
	Green house whitefly (*Trialeurodes vaporariorum*)	Thiomethaxam 25% WG	0.3 g/L water
		Imidacloprid 17.8% SL	0.3 mL/L water
		Pymetrozine 50% WG	0.3 g/L water
		Dinotefuron 20% SG	0.3 g/L water
		Difenthiuron 50% WP	0.3 g/L water
Chilly or Capsicum or Brinjal	Sucking insect pests (Aphids, Thrips or whiteflies)	Thiomethaxam 25% WG	0.3 g/L water
		Imidacloprid 17.8% SL	0.3 mL/L water
		Pymetrozine 50% WG	0.3 g/L water
		Dinotefuron 20% SG	0.3 g/L water
		Difenthiuron 50% WP	0.3 g/L water
	Mites in tomato, capsicum, chilly, brinjal and french bean	Abamectin 1.9% EC	0.3 mL/L water
		Chlorfenapyr 10% SC	0.3 mL /L water
		Etoxazole 10% SC	0.3 mL /L water
		Fenazaquin 18.3% SC	0.3 mL /L water
		Fenpyroximate 5% EC	0.3 mL /L water
		Propargite 57% EC	0.3 mL /L water
		Spiromesifen 22.9% SC	0.3 mL /L water
		Spirotetramat 15.3% OD	0.3 g/L water
Crucifers (Cabbage, Cauliflower, Broccoli, Radish and Toria)	Aphids (*Brevicoryne brassicae, Lipaphis erysimi*)	Difenthiuron 50% WP	0.3 g/L water
		Thiomethaxam 25% WG	0.3 g/L water
		Imidacloprid 17.8% SL	0.3 mL/L water
		Pymetrozine 50% WG	0.3 g/L water
		Acetamiprid 20% SP	0.3 mL/L water
		Dinotefuron 20% SG	0.3 g/L water
	• Diamond back moth (*Plutella xylostella*), • Cabbage butterfly (*Pieries brassicae* and *P. rapae*) • Semiloopers and other defoliators	Emamectin benzoate 5% SG	0.4 g /L water
		Spinosad 45% SC	0.3 g/L water
		Indoxacarb 14.5% EC	1 mL/L water
		Lamdacyhalothrin 5% EC	0.3 mL /L water
		Chlorantraniliprole18.5% SC	0.3 mL/L water
		Flubendiamide 39.35% SC	0.3 mL /L water
		Cyntraniliprole 10.26 OD	0.3 g /L water
Cucurbits (Summer squash, Bitter gourd, Ridge gourd, Cucumber, Pumpkin)	Red Pumpkin beetle (*Raphidopalpa foevicollis*)	Deltamethrin2.8% EC	1 mL/L water
		Lamdacyhalothrin 5% EC	0.3 mL /L water
		Indoxacarb 14.5% EC	1 mL/L water
		Cartap hydrochloride 50% SP	1 g/L water
		Emamectin benzoate 5% SG	0.3 g /L water

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

4.6.1. Development of in vivo based mass production system of EPNs

In-vivo mass production of native EPN, *Heterorhabditis indica VLEPN01* using *Corcyra* and *Galleria* larvae have been developed (Figure 4.7). A low-cost *Galleria* mass multiplication technique developed for mass production of EPN *H. indica VLEPN01* which can be utilized for field application for soil insect pest management. The effectiveness of both the larvae assessed based on mass production cost per box, duration of life cycle, rate of IJs production and number of larvae produced. Mass production cost per box, duration of life cycle, rate of IJs production were high for *Galleria* larvae in comparison to *Corcyra* (Figure 4.8). However, the number of IJs produced by *Galleria* was significantly higher than the *Corcyra*. Therefore, developed *in-vivo* mass production technique of EPN can be utilize for bio-control programme.

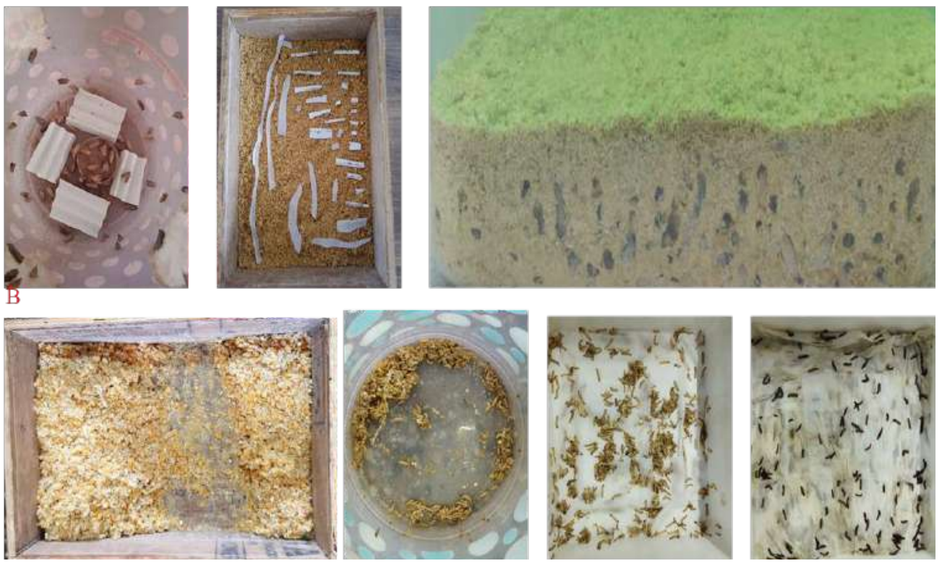


Fig. 4.7. *In vivo* based mass production system of EPNs

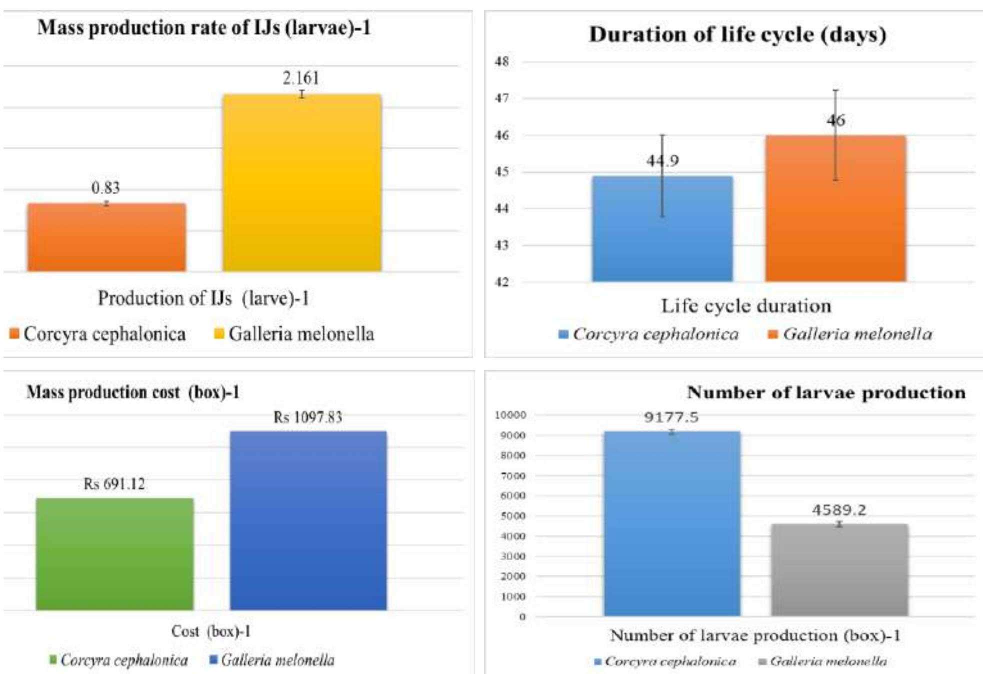


Fig. 4.8. Cost estimation of *in vivo* based mass production system of EPNs

4.6.2. Evaluation of different root knot nematode management practices under protected cultivation grown tomato

The effectiveness of different management practices either in alone or in combination were evaluated in a polyhouse grown tomato (cultivar Himsona). The effect of the different treatments on the growth parameters of tomato plants and nematode infection suggested T4 as the best treatment followed by T3>T2>T1 (Figure 4.9 & 4.10) in reducing the root galls, J_2 of the nematode in the soil and yield enhancement.

4.6.3. Standardization and optimization of DNA extraction techniques from different nematodes for molecular characterization

Four methods of DNA extraction from root knot nematodes (*M. incognita* and *M. graminicola*), entompathogenic nematode (*Heterorhabditis indica*) and necromenic nematode (*Pristionshus pacificus*) were examined. The DNA extraction protocols were

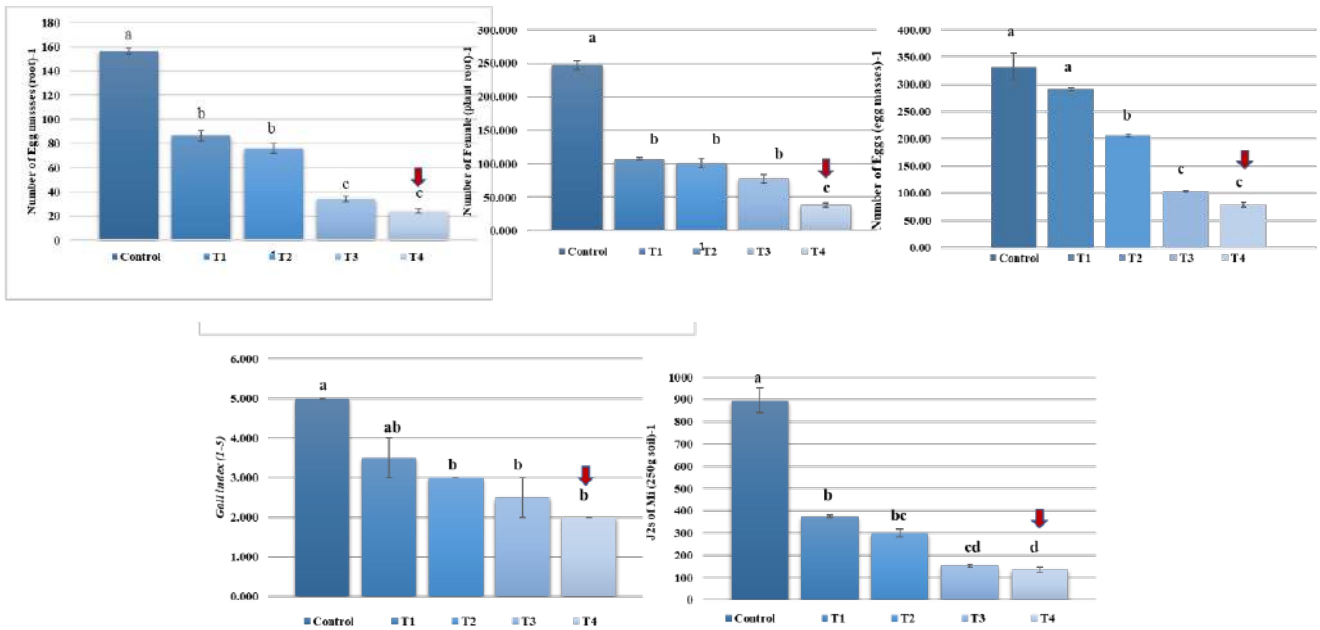


Fig. 4.9. Nematode infection parameters, T4>T3>T2>T1>control T1-Marigold as cover crop, T2-FYM enriched *Trichoderma* sp., T3-Marigold + *Trichoderma* in soil and seed, T4-Carbofuran application @ 1 kg a.i./m² and T5- infested control

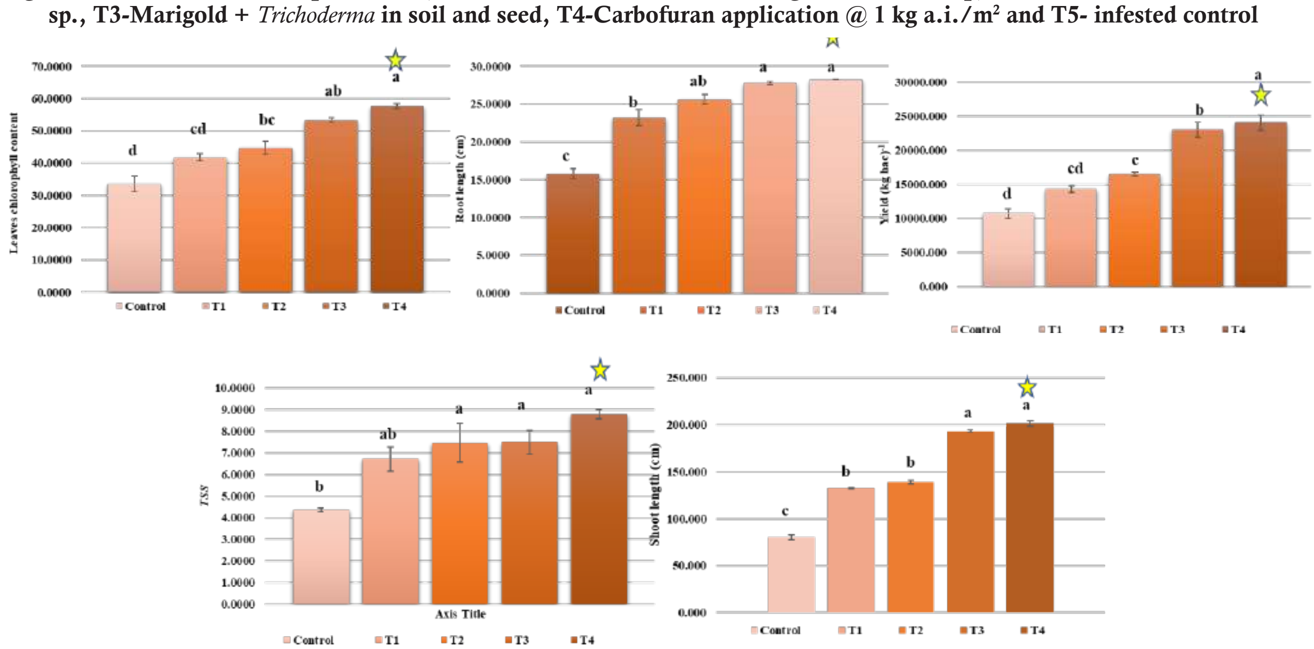


Fig. 4.10 Plant growth parameters, T4>T3>T2>T1>control, T1-Marigold as cover crop, T2-FYM enriched *Trichoderma* sp., T3-Marigold + *Trichoderma* in soil and seed, T4-Carbofuran application @ 1 kg a.i./m² and T5- infested control

Table 4.10. Different methods and tested nematodes

Method used	*M. incognita*	*M. graminicola*	*Heterorhabditis indica*	*Pristionshus pacificus*
Holterman lysis buffer	+	+	+	+
Hot shot lysis method	+	+	+	+
1X TE buffer	–	–	–	–
Direct method	–	–	–	–

investigated for their adaptation to single nematodes. Different methods including Hot shot lysis method, Holterman lysis buffer, 1X TE buffer and Direct method were examined. Positive amplifications were found for two methods (Hot shot lysis method and Holterman lysis buffer) (Table 4.10). The tested method could be used for survey and biodiversity analysis of nematode.

4.6.4. Abundance and diversity estimation of nematode associated with rabi crops

Forty-eight soil samples from 12 locations of Almora district were collected. Nematode was extracted using cobb sieving and decanting techniques. Nematodes were identified to generic level using the morphological method. Seven bacterivores genera (*Rhabditis, Acrobeles, Cephalobus, Plectus, Panagrolaimus, Diplogasteriana, Mesorhabditis*), three fungivores (*Aphelenchus, Dorylaimoides, Ditylenchus*), two omnivores (*Dorylaimus, Eudorylaimus*) eight plant parasitic genera (*Meloidogyne, Pratylenchus, Paratylenchus, Tylenchus, Tylenchorhynchus, Longidorus, Heterodera, Hoplolaimus, Helicotylenchus*) were identified. Overall population density was below damaging level.

4.6.5. Study of pesticidal compatibility of Heterorhabditis indica against different group of insecticides

Compatibility of indigenous entomopathogenic nematodes *Heterorhabditis indica* with different insecticides were investigated under laboratory conditions. EPNs at concentrations of 100 were tested with different insecticides at their recommended dosage. The findings suggested that combining EPNs and the pesticide concentrations can be a practical strategy for managing insect pest and could pave the way to use new management option in protecting organic farm vegetables from lepidopteran pests. Insecticides like dichlorovos, carbofuran, chlorguard were found non-compatible (Figure 4.11).

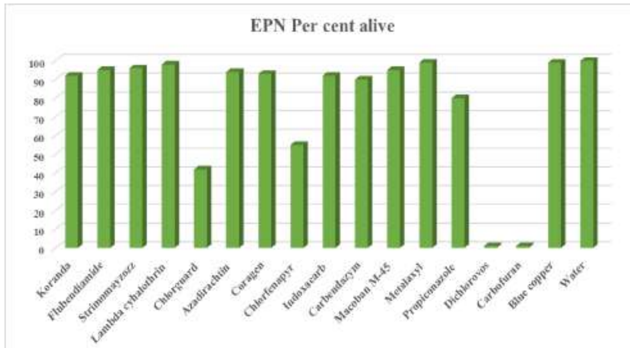


Fig. 4.11. Study of pesticidal compatibility of *Heterorhabditis indica* against different group of insecticides

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

4.7.1. Antimicrobial bioassay and disease suppression against *Magnaporthe grisea*

In vitro antimicrobial bioassay of endophytic bacteria were assessed by dual plate culture technique. Five out of 33 isolates exhibited antagonistic activity against *M. grisea.* Later, these isolates were selected for *in vivo* disease suppression under pot experiments, least disease severity (1 score in 0-9 disease scale) was observed in the treatments with JE44 and JE09 compare to the untreated control (Figure 4.12).

Fig 4.12. ***In vivo*** **disease suppression assay of endophytic bacteria (a) control (b) JE09 (c) JE44**

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

Research Project

- Addressing gender concerns in household food security in hill regions of Uttarakhand *[Drs. Kushagra Joshi, Renu Jethi (Up to 31 May 2022) & BM Pandey (Associate)]*

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

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

5.1 Addressing gender concerns in household food security in hill regions of Uttarakhand

Survey was conducted in a sample of 30 farm households to assess the status of women's empowerment in agriculture, level of household food security, livelihood status and farm diversity.

5.1.1 Pilot study on assessment of womens' empowerment in agriculture in mid-hills

An abbreviated version of the Women's Empowerment in Agriculture Index (WEAI) was used as a tool to measure women's empowerment in agriculture which diagnoses areas of disempowerment and design development programs to address those areas. The A-WEAI comprises of two sub-indexes, namely the five domains of empowerment (5DE) which is used to indicate both a level of general empowerment and the specific indicators that contribute the most to disempowerment. The five domains are production, resources, income, leadership, and time. For this pilot study, data were collected from villages of Hawalbagh block which lie in mid-hills of Uttarakhand.

Table 5.1. Status of women's empowerment in agriculture

Indices	Percentage
Disempowered Headcount (H)	76.92
Average Inadequacy Score (A)	46.00
Disempowerment Index (M0 = H x A)	35.30
Five domains of empowerment sub-index (5DE) (1-M0)	0.65 (<0.80)

Table 5.1 indicated that on average, women lack adequacy in 46% of the weighted indicators in the A-WEAI. 76.92% of women in the sample would be considered disempowered, whereas 23.08% of women in the area were reported as being disempowered. The five domains of empowerment sub-index value is 0.65 which is less than the cut-off 0.80 for empowerment status. Figure 5.1 showed the level of achievement in indicators of women empowerment by women farmers. Most of the women were making decisions in two activities on average out of four; owned 4.88 assets out of nine; made decisions on 0.46 credit-related decisions out of 4; had active membership in 0.46 groups out of one and spent about 11 hours a day in productive and reproductive work.

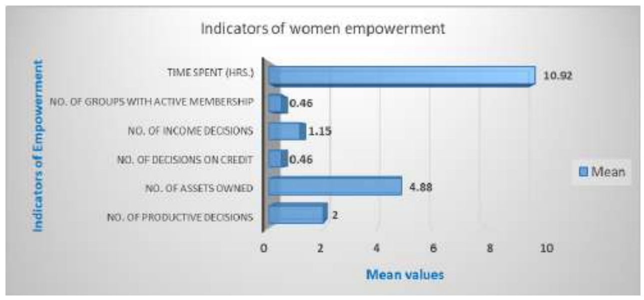


Fig. 5.1. Mean achievement in indicators of women empowerment in agriculture

With respect to the relative contribution of individual indicators that comprise the A-WEAI, women were most likely to achieve adequacy in asset ownership, access to and decisions on credit, and control over the use of income, and least likely to achieve adequacy in group membership and workload (Figure 5.2).

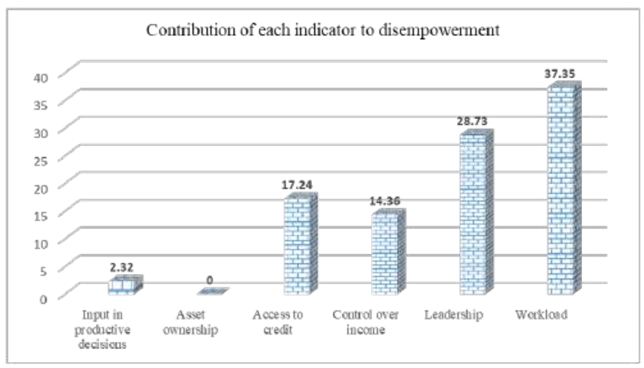


Fig. 5.2. Relative contribution of various domains to women's empowerment in agriculture

5.1.2 Level of household food security in mid hills

Household Food Insecurity Access Scale (HFIAS) was used which categorizes households into four categories of food insecurity severity ranging from food secure to severely food insecure. The HFIAS is an experiential scale that assesses whether households experience a lack of resources to obtain food and the way they cope.

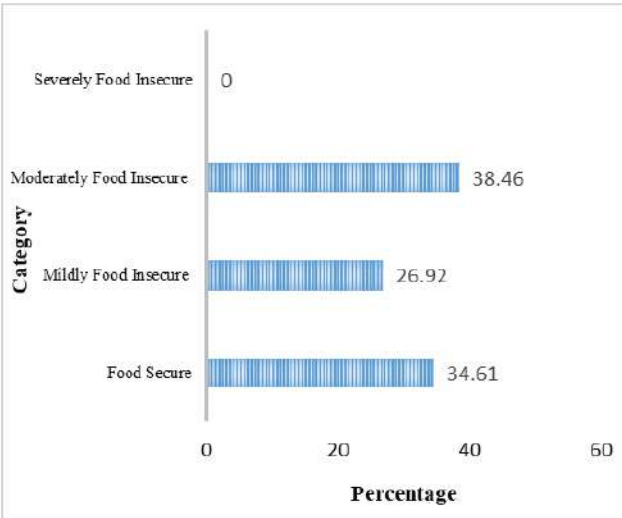


Fig 5.3. Level of household food security

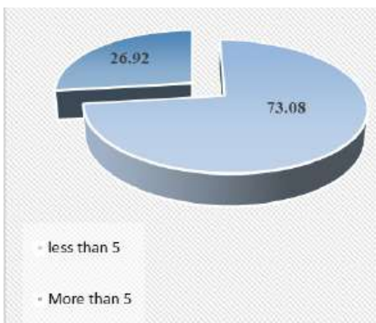


Fig 5.4 Dietary diversity status of women

In the pilot study among the non-sample households (Figure 5.3), some households were moderately food insecure (38%), 35% were food secure and 27% were mildly food insecure. Most of the households observed worry about food and were unable to eat preferred foods and ate few kinds of foods sometimes or rarely (Table 5.2). Mildly and moderately secure households were deficient in variety and preferences of the type of food and a few showed anxiety about household food supply. No household was observing severe food insecurity. Average household food security score was 4.61. The household dietary diversity was also assessed as a proxy indicator of nutritional status. Among the total households, 73% had poor dietary diversity scores showing micronutrient deficiency among women (Fig 5.4).

Table 5.2 Responses (%) of Households pertaining to items on Household Food Insecurity

S. No.	Occurrence	Rarely	Some-times	Often
1	Worry about food	0	30.8	5.56
2	Unable to eat preferred foods	0	50	2.78
3	Eat just a few kinds of foods	7.69	34.6	0
4	Eat foods they really do not want to eat	7.69	3.85	0
5	Eat a smaller meal	7.69	3.85	0
6	Eat fewer meals in a day	0	0	0
7	No food of any kind in the household	0	0	0
8	Go to sleep hungry	0	0	0
9	Go a whole day and night without eating	0	0	0

5.1.3 Socio-personal profile of the respondents

The socio-personal profile of the farmers including their household size, land ownership size, income, farming experience, education, poverty level, livelihood status, and crop diversity were assessed as independent variables which can affect household food security and women empowerment in agriculture which are the dependent variables. The socio-demographic details of the respondents are presented in Table 5.3.

Table 5.3. Socio-demographic profile of the selected respondents

Indicator	value
Mean household size	4.38
Av. distance from market (km)	7.88
Av. landholding (ha)	0.15
Av. cultivated land (ha)	0.11
Income source other than Ag. (%)	50
Time spent in work (h)	9.80
Time spent in secondary activities (h)	4.50
Farming experience (years)	9.6
Income (from all sources) Rs/month	7573
Household expenditure (Rs/month)	5429
Average livestock ownership	4.90
Primary education (%)	34.62
Secondary education (%)	23.08
Highschool education (%)	7.69
Intermediate education (%)	3.85
Above poverty level (%)	58.06
Below poverty level (%)	22.58

Crop diversity is important for ensuring people's access to nutritious food. A list of the crops grown and livestock reared was prepared. It was calculated by using the inverse of the number of crops grown by a household +1 (Adapted from World Bank 1997). The farm diversity score of the households was recorded as 0.052 (Table 5.4).

Table 5.4. Farm diversity of the selected households

Category	Percent households
Low (>25th percentile)	23.08
Med (25-75th percentile)	61.54
High (<75th percentile)	15.38
The Farm Diversity Index	0.052 (Max.= 0.09, Min.=0.03)

5.1.4 Livelihood analysis of farm households

A key component of the framework is people's access to the assets/capital (natural, social, human physical and financial), that enable them to support themselves and their families. According to this model, a community's resources can be analysed in terms of an "asset pentagon" that helps indicate areas to be enhanced. A composite index was developed on livelihood status including five subcomponents namely social capital (SC), human capital (HC), financial capital (FC), physical capital (PC) and natural capital (NC). Primary data from household surveys were used to construct the index. A balanced weighted average approach was used where each sub-component contributes equally to the overall index. Because each of the sub-components is measured on a different scale, it was first necessary to standardize each as an index. After each was normalised, the sub-components were averaged to calculate the value of each major component.

Livelihood Index= HC+SC+FC+PC+NC/5

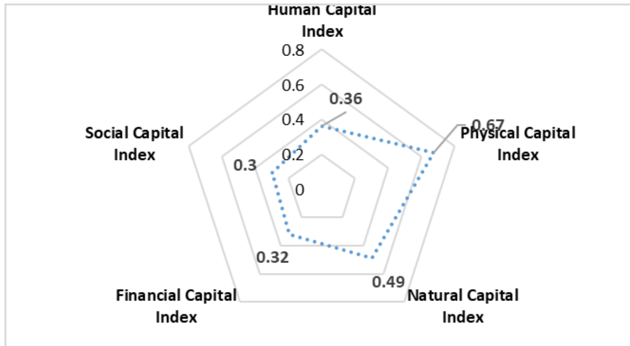


Fig. 5.5. Livelihood status of the selected households

The livelihood index value for the households selected for the pilot study was 0.43 including the social capital (0.30), physical capital (0.67), natural capital (0.49), financial capital (0.32) and human capital (0.36) (Fig 5.5). The households had the highest physical capital followed by natural, human, financial and social capital respectively.

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 Molecular Breeding Wheat *[Drs. Lakshmi Kant, Navin Chandra Gahtyari (w.e.f. October 14, 2022) 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. Anuradha 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 AICRP/ Network Projects

- Use of Plastics in Agriculture Particularly in Protected Cultivation, Water Harvesting and Packaging (AICRP on PEASEM) *[Drs. Jitendra Kumar, Shyam Nath & Er. Utkarsh Kumar (on study leave)]*
- Post-Harvest Technology for Value Addition and Marketing of Agricultural Produce (AICRP on PHET) [*Drs. Shyam Nath, Kushagra Joshi, Er. Jitendra Kumar & Dr. J.K. Bisht]*
- All India Network Project on White Grubs and Soil Arthropod Pests *[Mr. Amit Paschapur]*
- All India Coordinated Research Project on Mushroom *[Dr. K. K. Mishra]*
- Network Programme on Organic Farming (NPOF) *[Drs. Amit Kumar, P.K. Mishra, Krishna Kant Mishra, Amit Umesh Paschapur, Manoj Parihar (upto December 23, 2022) & Priyanka Khati]*

6.6 National Mission on Himalayan Studies (NMHS) Project

- National Mission for Sustaining Himalayan Ecosystems -Taskforce on Agriculture (NMSHE-TF-Ag) *[Dr. Pankaj K. Mishra]*

6.7 ICSSR Funded Project

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

6.8 DBT Funded Project

- Popularization of bio fortified maize hybrids in Himalayan states and central India with special reference to the north eastern region for sustainable nutritional security *[Drs. Rajesh Kumar Khulbe & Devender Sharma]*

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

Biochemical screening of maize DH lines for micronutrient content & other quality traits

A set of 50 maize DH lines from different source populations (MTC-2, MTC-4, MTC-8 and PQPM9) were screened for protein content, β- carotene, phytate P, Fe and Zn content in the grains. In the DH lines MTC-2 DH-12-1, MTC-4 DH-17, MTC-4 DH-28 and MTC-8 DH-22, high tryptophan content (>70%) was observed. Low phytic acid content (<2.5 mg/g) was observed in the DH lines MTC-2 DH-21, MTC-8 DH-13 and PQPM-9 DH-19-2. Moderate Fe (>40ppm) and high Zn (>33 ppm) were observed in two DH lines (MTC-4 DH-23 and PQPM-DH-203).

Quantifications of tryptophan in maize genotypes through HPLC

Total 57 samples of maize (FLPH, MTC, PQPM-9 DH and MQA populations) were analyzed for tryptophan content through HPLC. Range of content was found 0.37 (MTC-8 DH-9-1) to 1.00 (PQPM-9 DH-225-1). Total 8 samples (FLPH-49-2, FLPH-20-1, MTC-4 DH-17, PQPM-9 DH-147-2, PQPM-9 DH-177-1, PQPM-9 DH-225-1, PQPM-9 DH-4 and MQA-14-25-3) were found to have tryptophan content ≥ 0.70 (%) of protein.

6.2. Consortium Research Platform (CRP) Projects

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

Development and validation of breeder-friendly markers linked tolpa2gene

A diverse set comprising 43 low phytate lines and 12 high phytate lines was screened with the new *lpa2* gene-based marker. Estimation of phytate was simultaneously carried out in the lines. Analysis of the results indicated co-segregation of the new marker with lower phytate content in the set under study.

Expression analysis of lpa2 gene in different stages of kernel development

For validation of preliminary results obtained during *kharif* 2021, expression of *lpa2* gene (inositol phosphate kinase) was analyzed again during *kharif* 2022 at three developmental stage of maize kernel (blister stage, dough stage and physiological maturity stage). Expression values showed that enhanced expression of *lpa2* gene (phytic acid biosynthetic gene) lead to higher phytic acid content.

Screening of maize genotypes for phytate content

Total 300 samples of maize (different population with donors) were evaluated for phytate P content. The range was from 1.13 mg/g (S-22-LPH MLB-43-7-4-1-1) to 5.24 mg/g (BAJIM-06-15-1). Total 64 samples recorded phytate P content ≤2.50 mg/g. Total 89 samples of maize were quantified for phytate P, inorganic phosphorus and phytate P to total P. The content for phytate P was found in range of 1.27 mg/g (PA-14-1) to 3.94 mg/g (MLB-38-2-4) of sample. Inorganic phosphorus was found in range of 0.31 mg/g (VQL-2) to 2.24 mg/g (PVD-3-2*28-1-6) whereas the ratio for phytate P to total P was recorded in range of 20.21 (PVD-3-2*PA-12-1-3) to 90.65 (VQL-2). Total 44 samples recorded phytate P content ≤ 2.50 mg/g. Among these, 34 samples were found having phytate P to total P ≤ 60.

6.2.2 ICAR-CRP on Molecular Breeding in Maize

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

High lysine and tryptophan

VLQPM Hybrid 45 (QPM EDV of *Vivek* Maize Hybrid 45) was released and notified for Northern Hill Zone. FQH 186 (QPM version of *Vivek* Maize Hybrid 53) was promoted to final year in AICRP as well as SVT. Crosses generated (MQB x PVQPM 9 and MQA x MCA) for developing QPM+pro-vitamin A version of VLQPM Hybrid 45 and *Vivek* Maize Hybrid 53 were advanced.

Low phytate

FLPH 19 (low phytate EDV of *Vivek* Maize Hybrid 53) was promoted to final year in SVT on account of its yield parity with VMH 53 (4,321 kg/ha). Crosses (MQB x MLA and MQA x MLB) generated for developing Low phytate + QPM version of VMH 53 and VMH 45 were advanced.

High pro-vitamin A

Hybrid FPVH 1 was advanced to final year in AICRP trials based on yield superiority (7,069 kg/ha) over the check APQH 9 (6,073 kg/ha). Crosses (MQB x MLA and MQA x MLB) generated for developing pro-vitamin A+QPM version of FPVH 1 were advanced.

High amylopectin

For developing high amylopectin versions of VLMH 57 and CMVL 55, BC_2F_2 progenies of field corn inbreds V 412 and V 433 with waxy donor Pusa Wax 5411 and BC_2F_1 progenies of field corn inbreds V 407 and V 405 with waxy donor Pusa Wax 5411 were raised (Fig. 6.2.1). Foreground selection was carried out using genic marker WX2507 (for waxy1 gene) and background selection was performed using a set of background markers. Progenies positive for the waxy allele and showing high recurrent genome recovery were advanced.

Fig. 6.2.1. BC_2F_2 progenies of field corn inbreds V 412 and V 433 with waxy donor Pusa Wax 5411

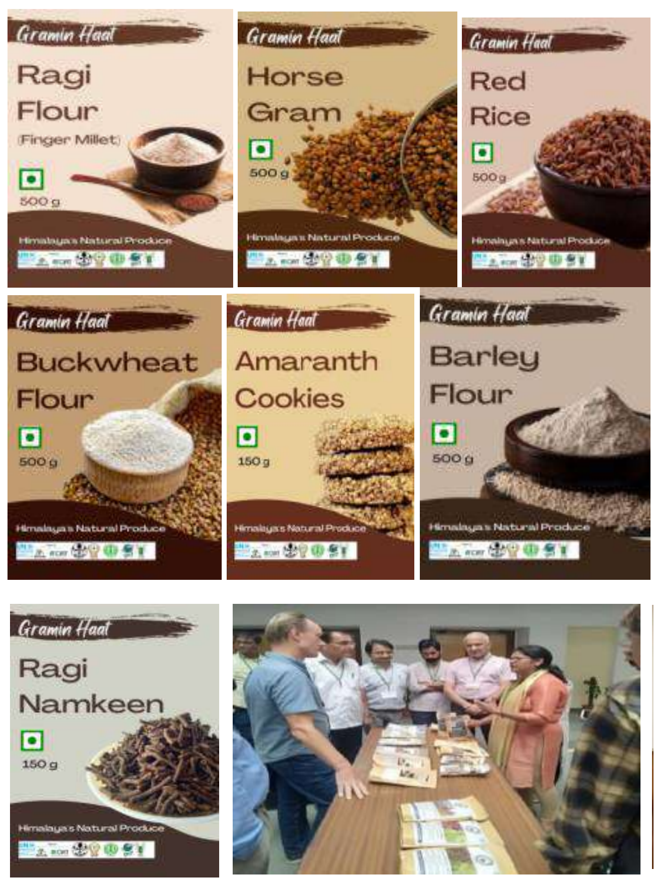
6.2.3. ICAR-CRP on Molecular Breeding Wheat

Two popular wheat varieties *viz.,* VL *Gehun* 907 (timely sown condition) and VL *Gehun* 892 (late sown condition) has started showing susceptibility to the new races of yellow rust pathogen were selected to pyramid durable rust resistance genes *viz., Yr*10 and *Lr* 24. During *Rabi* 2021-22, F_6s RILS [(VL *Gehun* 892/ Yr10/5*Datatine //VL *Gehu*n 892), (VL *Gehun* 892/ FLW1//VL *Gehun* 892), (VL *Gehun* 907/ Yr10/5*Datatine //VL *Gehun* 907) and (VL *Gehun* 907/ FLW 1 //VL *Gehun* 907)] were planted at experimental farm, Hawalbagh. The individual plant to progeny maintained from the previous season (*rabi* 2020-21) was further aggregated during the season, wherein similar phenotype plants (towards to recurrent parent) were nominated and entered as the station trial entries during the season *rabi* 2021-22. A total of 22 derived entries of VL *Gehun* 907 were tested in timely sown rainfed and irrigated conditions. Similarly, a total of 14 derived entries of VL 892 were tested in restricted late sown conditions during 2021-22 to identify the most promising marker assisted derived lines.

6.3. UN Environment-GEF Project

6.3.1 Mainstreaming agricultural biodiversity conservation and utilization in agricultural sector to ensure ecosystem services and reduce vulnerability

- Collaborative effort of ICAR-VPKAS, Almora and NGO *Lok Chetna Manch* in mainstreaming local crops (developed brand *Gramin Haat*) (Fig. 6.3.1).



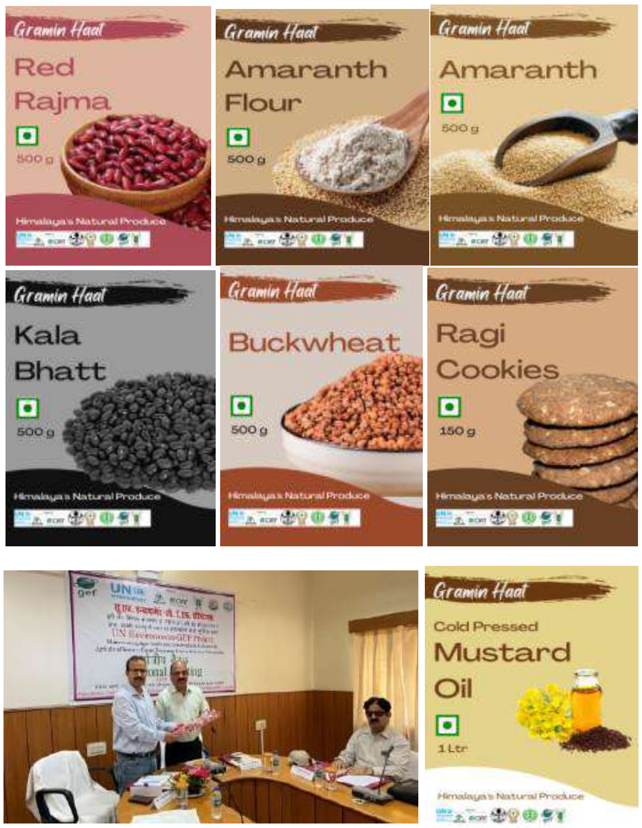


Fig. 6.3.1. Whole grain, flours and value-added products of target crops

- Evaluation of rice landraces (30) for agro-morphological diversity.
- Rice FVs *Bartia Dhan* (REG/2018/68) and *Chwar Dhan* (REG/2016/949) got registered under PPV &FR Authority, New Delhi.
- Three rice FVs *Lal Dhan*, *Baurani Dhan* and *Kawthuni Dhan* were submitted to PPV & FR Authority, New Delhi for their registration.
- Rice (2) and finger millet (2) FVs were multiplied during *kharif* 2022 for their further submission to PPV &FR Authority, New Delhi.
- Regional meeting and Farmer-Scientist interface under UN Environment-GEF project at ICAR-VPKAS, Almora on 08th June 2022.

6.4. PVP & DUS test through ICAR-SAU system

Kidney bean: One candidate variety *viz.*, 2879/3769 along with three reference varieties *viz.*, IPR 98-5, HUR 137 and PDR 14 and VL *Rajma* 63 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. Flowers and pods of kidney bean candidate variety 2879/3769

Soybean: Eight candidate varieties *viz.*, 22SB1, 22SB2, 22SB3, 22SB4, 22SB5, 22SB6, 22SB7 and 22SB8 along with two reference varieties *viz.*, VL *Soya* 63 and VL *Soya* 89 were raised for grow out test and characterized for 22 DUS traits as per national guidelines for the conduct of test for DUS on soybean.

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

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

Development of Fish Feed Pellet Machine

The Institute has developed a machine for making fish feed pellet operated manually as well as electrical power. It consists of hopper, pelleting unit, motor, drives system and heating element. It is designed to be driven by a 0.5 HP, single-phase electric motor with pelleting disc and compressing roller has been incorporated in machine for uniformity of pellet size

Fig. 6.5.1. Development of Fish feed pellet Machine

and increase the efficiency of machine. A heating element has been incorporated in machine to heat the coming out compressed feed for heating/puffing the pellet. The test that determines the performance of the pelletizer was carried out which showed a throughput capacity of 2 kg/h. The pelleting disc produced pellets size in the range of 2.73-3.31 mm diameter and 2.46–6.58 mm length respectively. Therefore, the develop machine is suitable for small and medium scale fish and poultry farming in hilly region (Fig. 6.5.1)

Preparation and standardization of fish feed pellets

The formulated and nutritional analysis of fourteen fish feed recipes was carried out based on locally available resources (Table 6.5.1). The nutritional compositions of prepared fish feed have 30-50% protein, 25-35% carbohydrate, 15-25% fat, 10-15% fiber, 2-3% mineral and others included vitamin-C, preservative, anti-oxidant (1-2%). The mentioned items *i.e.,* soybean, mustard cake, lentil and azola (protein and fat source), wheat and maize (carbohydrate), rice burn and finger millet (fiber and mineral) have been used in this experiment. Nutritional quality of prepared fish feed pellets showed that among the different recipes mustard cake + rice bran + wheat flour (5:3:2) provided better nutrients content than others.

Table 6.5.1. Fish feed compositions and ratio of different component

Recipe No.	Recipe components	Ratio
R1	Sb+Rb+M	5:3:2
R2	Sb+Rb+Fm	5:2.5:2.5
R3	Sb+Rb+W	5:3:2
R4	Mc+Rb+M	5:3:2
R5	Mc+Rb+Fm	5:2.5:2.5
R6	Mc+Rb+W	5:3:2
R7	Az+L+Rb+M	2.5:2.5:3:2
R8	Az+L+Rb+Fm	2.5:2.5:2.5:2.5
R9	Az+L+Rb+W	2.5:2.5:3:2
R10	Sb+Mc+Az+L+Rb+Fm+M+W	1.25:1.25:1.25:1.25:1.5:1.5:1:1
R11	Sb+Az+Rb+Fm+M+W	3:2:1.5:1.5:1:1
R12	Sb+L+Rb+Fm+M+W	3:2:1.5:1.5:1:1
R13	Mc+Az+Rb+Fm+M+W	3:2:1.5:1.5:1:1
R14	Mc+L+Rb+Fm+M+W	3:2:1.5:1.5:1:1

**Sb (Soybean); Rb (Rice burn); M (Maize); W (wheat); Fm (Finger millet); Mc (Mustard cake); Az (Azola); L (Lentil)

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

Extraction of turpentine oil from pine needle and utilization of pine needle for product development

Different methods are used to separate oils from the various plant materials. Free falling pine needle was used to extract the essential oils using different solvents (hexane, acetone and methanol) through soxhlet extraction process and steam distillation process. The yield of essential oils varied from 3.5% to 6.3% on weight basis due to variation in solvent polarity and solubility of essential oils and colour of oils varies from light yellow to dark green. The order of essential oils getting from solvent distillation process is methanol extracted oil > hexane extracted oil > acetone extracted oil. Essential oil extracted from steam distillation resulted in higher yield and economically beneficial for small entrepreneur at village level. A small scale steam distillation unit (Fig. 6.5.2) for extraction of essential oil from pine needle was developed having 10 kg batch capacity. The steam distillation unit comprised of heating unit, steaming chamber, condensation and separating unit. The overall dimension (LxBxH) of the unit is 90x60x180 cm respectively. The estimated cost of the steam distillation was Rs. 20,000/-

Fig. 6.5.2. Small scale steam distillation unit for extraction of essential oil from pine needle

Preparation and nutrient content estimation of ready to use pine needle peat

After extraction of essential oils from dry pine needles by using steam distillation, the digested pine needles were thoroughly wash with running water and dried under open condition to maintained around 50% moisture level and used for peat preparation. It was one of the by-products. Wetted digested pine needle, fresh cow dung and field soil in different combination was used for pine peat (Fig. 6.5.3) by using manual pressure. The nutrient content of different prepared pine needle peat was mentioned in Table 6.5.3. The water retention capacity of prepared peat has been performed and it was found that it has ability to absorb or retain 3–4-times water by it weight which has almost equal to commercially used coco peat. Pine peat prepared from digested pine needles, cow dung and soil at the ratio of 2:1:1 provided the better nutrients content than others pine peat as well as commercially available cocopeat. The germination test of tomato and capsicum crops in seed tray was also performed using the standardized pine needles peat which showed almost 80-90% with health growth.

Dry and digested pine Pine needles peat

Fig. 6.5.3. Pine needles peat prepared from digested pine needles, cow dung and soil 2:1:1)

Table 6.5.3. Nutrient's content of different pine needles peat along with cocopeat

Constituents	Digested pine: cow dung: field soil			Digested pine: cow dung	Cocopeat
	1:1:1	1:0.5:0.5	2:1:1	1:1	Commercial
pH	7.05	6.37	6.54	6.22	6.15
EC (dS/m)	0.78	0.92	0.86	0.97	0.63
OC (%)	0.46	0.40	0.53	0.47	0.45
N (%)	0.56	0.54	0.61	0.52	0.58
P (%)	0.36	0.32	0.39	0.28	0.24
K (%)	1.05	0.92	1.08	0.87	1.11
Fe (ppm)	22.7	21.5	24.6	22.4	18.4
Mn (ppm)	20.4	18.2	21.2	17.8	15.6
Zn (ppm)	21.6	20.7	24.7	20.2	22.3
Cu (ppm)	6.8	6.3	7.3	6.2	5.4

Inter locking bricks for fencing wall

Different kind of inter locking bricks was tried with different compositions (Table 6.5.4) of digested pine needle, cow dung line and water. Digested pine needle after steam distillation was dried and pulverized to pieces (Fig. 6.5.4). The pulverized pine needle was soaked overnight and mixed with cow dung and lime. Inter locking block of serial number 7 in the same table was final brick. The dried weight of the interlocking block was 1.5 kg. Third by-product was pine bio briquette for cooking and room heating. The digested and open sun dried pine needle was partially burned in the charcoal making unit for 8 hours. After that charcoal was crushed and mixed with fine soil to make bio-briquette of 3:1 ratio. For burning this pine bio-briquette, exiting stove was modified to increase the burning hours of pine bio-briquette.

6.5.3. All India Network Project on white grubs and Soil arthropod pests

Monitoring of scarab beetle populations at Experimental Farm Hawalbagh

Scarab beetles were collected with the help of light trap (VL white grub beetle trap; IN 290170). A total of 4,872 pleurostict scarab beetles of 46 species and 23 genera belonging to 5 subfamilies *viz.*, *Aphodiinae*, *Cetoniinae*, *Melolonthinae*, *Rutelinae* and *Dynastinae* were trapped in light trap during May to October 2022 (Fig 6.5.5). Maximum pleurostict scarab beetles were trapped in June month (47.06%). Members of the subfamily *Melolonthinae* dominated with 59.85% of the species, followed by *Rutelinae* (33.99%), *Dynastinae* (6.06%), *Aphodiinae* (0.08%) and *Cetoniinae* (0.02%). The predominant species were *Maladera similana* (15.56%), *Lepidiota stigma* (11.23%), *Anomala dimidiata* (8.25%), *Anomala* sp. 2 (7.64%), *Xylotrupes gideon* (5.71%) and *Sophrops* sp. 2 (5.60%).

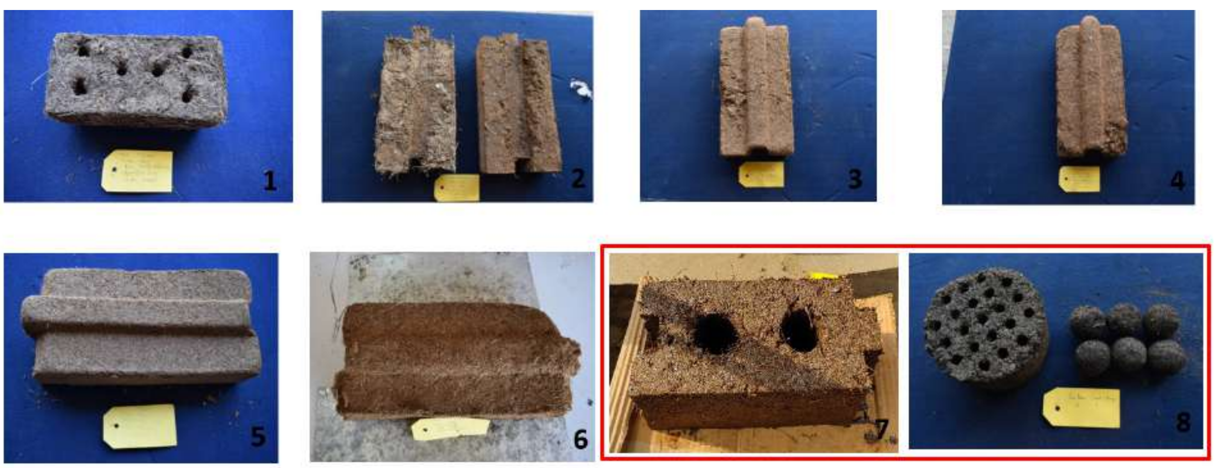


Fig. 6.5.4. Different types of interlocking digested pine (DP) blocks for fencing

Table 6.5.4. Composition of Interlocking fencing block (IFD) from digested pine needle (DP)

S. No	DP (g)	Cow Dung (g)	Lime (g)	Water (ml)
1	Chapped = 200 Charcoal = 14	800.00	0.00	1200.00
2	Chapped = 500	3000.00	1000.00	1600.00
3	Chapped = 750	3000.00	10.00	1000.00
4	Chapped = 750 Soil = 1000	2000.00	100.00	1500.00
5	Chapped = 750 Soil = 1000	2000.00	100.00	-
6	Chapped = 1000	2000.00	100.00	1700.00
7	Pulverized and overnight soaked = 2000	3000.00	250.00	No water
8	Pine Briquette	Pine Charcoal = 488.00	Fine Soil = 162.00	250.00

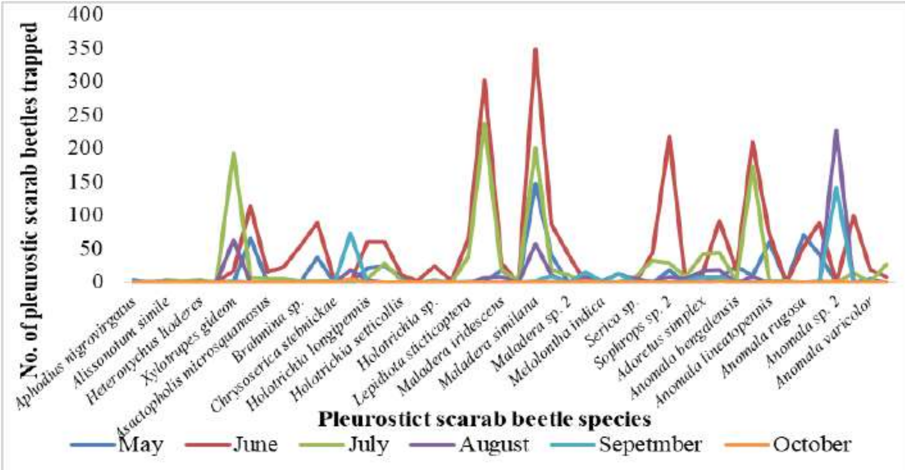


Fig. 6.5.5. Pleurostict scarab beetle species trapped in light trap during 2022

Estimation of diet breadth of Pleurostrict scarabaeid beetles native to mid- Himalayan regions of Uttarakhand

Scarabaeids constitute one of the most diverse groups of insects with polyphagous habit and majority of them are serious pests of cultivated and wild plants throughout the world. It is therefore important to understand their diet breadth, species composition & abundance for devising efficient pest management strategies. The collection of the scarabs was restricted to the pleurostrict (phytophagous) group, belonging to the subfamilies *Melolonthinae, Rutelinae, Cetoniinae* and *Dynastinae*. The *in-situ* samplings were carried out both during day time (10:00-16:00 hours- diurnal species) & night time (18:30-21:30 hours- nocturnal species) from second fortnight of May till the second fortnight of July, 2020 and 2021, during which the beetles emerge out of soil for feeding and mating. The beetles were collected from various host plants by hand picking and with the help of an insect net. In addition the presence of scarab beetles on different host plants were recorded to know their host preferences and diet breadth by closely observing their physical presence and symptoms of defoliation. A comprehensive list of 34 pleurostict scarab beetle species along with their host range are mentioned in Table 6.5.5.

Molecular characterization and estimation of cellulolytic potential of gut bacteria isolated from four white grub species native to Indian Himalayas

An investigation was carried out to isolate, identify and molecularly characterize the cellulose-degrading bacterial isolates from the guts of four white grub species (*Anomala bengalensis*, *Brahmina coriacea*,

Table 6.5.5. Preferred host plants of pleurostict scarab beetles

Host plant	Scarab beetle species
Carya illinoinensis	*Brahmina coriacea, Holotrichia longipennis, Holotrichia rosettae, Holotrichia* sp., *Maladera similana, Sophrops* sp. 1, *Sophrops* sp. 2, *Adoretus simplex, Adoretus versutus, Anomala bengalensis, Anomala varicolor*
Cedrus deodara	*Holotrichia setticollis*
Dalbergia sissoo	*Holotrichia setticollis*
Helianthus annuus	*Holotrichia longipennis, Holotrichia rosettae, Holotrichia setticollis, Maladera similana, Sophrops* sp. 2, *Adoretus simplex, Adoretus versutus*
Hibiscus rosa-sinensis	*Maladera similana, Sophrops* sp. 2, *Adoretus simplex, Adoretus versutus*
Juglans regia	*Holotrichia longipennis, Holotrichia rosettae, Maladera similana, Sophrops* sp. 2, *Adoretus simplex, Adoretus versutus*
Lagerstroemia indica	*Apogonia setosa, Asactopholis microsquamosus, Hilyotrogus holosericeus, Holotrichia longipennis, Holotrichia rosettae, Holotrichia setticollis, Holotrichia* sp., *Maladera iridescens, Maladera similana, Maladera* sp. 1, *Sophrops* sp. 2, *Adoretus nasalis, Adoretus simplex, Adoretus versutus, Anomala bengalensis, Anomala dimidiata, Anomala lineatopennis, Anomala rufiventris, Anomala rugosa, Anomala varicolor, Anomala xanthoptera*

Ligustrum nepalensis	*Chiloloba acuta*, *Clinteria spilota, Oxycetonia jucunda, Apogonia setosa, Holotrichia rosettae, Lepidiota stigma, Maladera iridescens, Maladera similana, Sophrops* sp. 2, *Adoretus simplex, Adoretus versutus, Anomala dimidiata, Anomala lineatopennis, Anomala rufiventris, Anomala tristis, Anomala varicolor, Anomala xanthoptera*
Rosa indica	*Oxycetonia versicolor, Apogonia setosa, Brahmina coriacea, Chrysoserica stebnickae, Glycosia tricolor, Hilyotrogus holosericeus, Holotrichia longipennis, Holotrichia rosettae, Holotrichia setticollis, Holotrichia* sp., *Maladera iridescens, Maladera marginella, Maladera similana, Maladera* sp. 1, *Maladera* sp. 2, *Melolontha furcicauda, Sophrops* sp. 1, *Sophrops* sp. 2, *Adoretus* sp., *Adoretus nasalis, Adoretus simplex, Adoretus versutus, Anomala bengalensis, Anomala dimidiata*
Sapium sp.	*Chrysoserica stebnickae, Holotrichia longipennis, Holotrichia rosettae, Holotrichia setticollis, Maladera similana, Sophrops* sp. 2, *Adoretus simplex, Adoretus versutus*
Solanum tuberosum	*Maladera similana*
Tagetes erecta	*Maladera similana*
Thuja occidentalis	*Holotrichia setticollis, Lepidiota stigma*
Zinnia elegans	*Chiloloba acuta, Clinteria klugi, Clinteria spilota, Oxycetonia jucunda, Maladera iridescens, Maladera similana, Maladera* sp. 1, *Maladera* sp. 2, *Adoretus* sp., *Adoretus nasalis, Adoretus simplex, Adoretus versutus*

Holotrichia longipennis and *Holotrichia setticollis*) native to Uttarakhand, Himalayas. The third instar larvae of white grubs were dissected under aseptic conditions into different gut compartments, crushed, serially diluted and inoculated on cellulolytic media to isolate cellulose-degrading bacteria. Identification of bacterial isolates was done through 16S rRNA sequencing and comparing them with their closest match in GenBank, NCBI. A total of 25 potent strains of cellulose-degrading bacteria were isolated and sequenced for 16S rRNA gene (Table 6.5.6). The cellulolytic bacterial community was represented by only two phyla: Firmicutes and Actinobacteria. *Bacillus* was the most dominant group with 19 isolates followed by *Paenibacillus* with three, *Streptomyces* with two and *Nonomuraea* with single bacterial isolate. Cellulolytic index was tested using Carboxymethyl cellulose (CMC) agar medium as substrate. The values ranged between 0.05 and 16 showing a variable cellulolytic activity (Table 6.5.7). *Bacillus stratosphericus* strain CBG4MG1 (10.78±4.18), *Bacillus cereus* strain CBG2FC1 (10.33±3.53), *Bacillus* sp. strain CBG3MG2 (7.28±0.16) and *Paenibacillus ginsengagri* strain CBG1FC2 (5.66±2.67) were the most potent cellulose-degrading bacteria isolated from the gut of *B. coriacea*, *H. longipennis, H. setticollis* and *A. bengalensis,* respectively. Thus, the cellulolytic bacteria isolated from the gut of selected white grub species may be good sources for profiling novel isolates for industrial use besides identifying eco-friendly solutions for agro-waste management.

Table 6.5.6. The details of 16S rRNA sequences of molecularly characterized cellulolytic bacterial isolates submitted to NCBI database

Strain ID	Accession number	Species	Closest strain in GenBank	Identity %
Anomala bengalensis				
CBG1AH	ON677965	*Streptomyces* sp.	*Streptomyces thermocarboxydus* strain EGI124 (MN704433)	97.21
CBG1AH2	OL913919	*Bacillus licheniformis*	*Bacillus licheniformis* strain Huaian_207_1 (MN309979)	98.99
CBG1FC1	OL913955	*Paenibacillus* sp.	*Paenibacillus glycanilyticus* strain MG12 (MZ545609)	96.45
CBG1FC2	OL913956	*Paenibacillus ginsengagri*	*Paenibacillus ginsengagri* isolate TS IW 08 (AM992187)	99.90
CBG1FC3	OL913957	*Bacillus* sp.	*Bacillus* sp. (in: Bacteria) strain F4 (MW137950)	93.68

CBG1PH1	OL913948	*Bacillus stratospphericus*	*Bacillus stratospphericus* strain MH5 (ON086335)	99.05
CBG1PH2	OL913949	*Paenibacillus amylolyticus*	*Paenibacillus amylolyticus* strain IARI-NIAW2-33 (KF054925)	99.31
Holotrichia longipennis				
CBG2MG1	OL913870	*Bacillus* sp.	*Bacillus* sp. strain NN107 (MN396131)	98.16
CBG2AH1	OL913920	*Bacillus subtilis*	*Bacillus subtilis* strain D35 (KC441771)	99.38
CBG2FC1	OL958509	*Bacillus cereus*	*Bacillus* sp. strain CG7 (MF919473)	99.25
CBG2FC2	OL958534	*Bacillus paralicheniformis*	*Bacillus paralicheniformis* strain HBUM06943 (MF662215)	100
CBG2PH1	OL913950	*Streptomyces* sp.	*Streptomyces capoamus* strain ACJ 26 (KY585978)	94.32
CBG2PH2	OL913951	*Bacillus subtilis*	*Bacillus subtilis* strain HBUA5664842 (ON306789)	99.90
CBG2PH3	OL913952	*Bacillus thuringiensis*	*Bacillus thuringiensis* strain GTG-65 (JX283457)	99.33
Holotrichia setticollis				
CBG3MG1	OL913872	*Nonomuraea* sp.	*Nonomuraea* sp. R07-01 gene (LC011608)	98.14
CBG3MG2	OL913874	*Bacillus* sp.	*Bacillus* sp. (in: Bacteria) strain AIBL 29 (MK490765)	99.10
CBG3MG3	OL913878	*Bacillus velezensis*	*Bacillus velezensis* strain SM-95 (MT377909)	99.53
CBG3MG4	OL913879	*Bacillus licheniformis*	*Bacillus licheniformis* strain Huaian_207_1 (MN309979)	99.50
CBG3MG5	OL913880	*Bacillus subtilis*	*Bacillus subtilis* strain R8S6 (MH844957)	99.06
CBG3AH1	OL913921	*Bacillus tequilensis*	*Bacillus tequilensis* strain MS01 (KX668274)	99.90
CBG3FC1	OL958542	*Bacillus toyonensis*	*Bacillus toyonensis* strain ADY06 (MH084795)	98.21
Brahmina coriacea				
CBG4MG1	OL913881	*Bacillus stratospphericus*	*Bacillus* sp. (in: Bacteria) strain NN107 (MN396131)	99.32
CBG4FC1	OL958543	*Bacillus pumilus*	*Bacillus pumilus* strain GB34 (DQ683078)	99.78
CBG4FC2	OL958544	*Bacillus subtilis*	*Bacillus subtilis* strain AB-61 (KT027758)	99.39
CBG4FC3	OL989161	*Bacillus licheniformis*	*Bacillus licheniformis* strain Huaian_207_1 (MN309979)	99.50

Table 6.5.7. Cellulolytic index of selected cellulolytic bacteria isolated from selected white grub species

Phylum	Source	Strain ID	Species	Cellulolytic index
***Anomala bengalensis* (CBG1)**				
Actinobacteria	AH	CBG1AH	*Streptomyces* sp.	1.62±0.81[f]
Firmicutes	AH	CBG1AH2	*Bacillus licheniformis*	2.45±0.26[e]
Firmicutes	FC	CBG1FC1	*Paenibacillus* sp.	1.90±0.23[e]
Firmicutes	FC	CBG1FC2	*Paenibacillus ginsengagri*	5.66±2.67[c]
Firmicutes	FC	CBG1FC3	*Bacillus* sp.	2.70±0.25[e]
Firmicutes	PH	CBG1PH1	*Bacillus stratosphericus*	5.53±1.11[c]
Firmicutes	PH	CBG1PH2	*Paenibacillus amylolyticus*	3.30±1.22[e]

***Holotrichia longipennis* (CBG2)**				
Firmicutes	MG	CBG2MG1	*Bacillus* sp.	3.80±0.757[d]
Firmicutes	AH	CBG2AH1	*Bacillus subtilis*	1.81±0.89[f]
Firmicutes	**FC**	**CBG2FC1**	***Bacillus cereus***	**10.33±3.53[a]**
Firmicutes	FC	CBG2FC2	*Bacillus paralicheniformis*	4.34±1.76[d]
Actinobacteria	PH	CBG2PH1	*Streptomyces* sp.	5.39±0.73[c]
Firmicutes	PH	CBG2PH2	*Bacillus subtilis*	2.89±1.22[e]
Firmicutes	PH	CBG2PH3	*Bacillus thuringiensis*	4.75±0.14[d]
***Holotrichia setticollis* (CBG3)**				
Actinobacteria	MG	CBG3MG1	*Nonomuraea* sp.	4.67±2.33[d]
Firmicutes	**MG**	**CBG3MG2**	***Bacillus* sp.**	**7.28±0.16[b]**
Firmicutes	MG	CBG3MG3	*Bacillus velezensis*	2.93±1.34[e]
Firmicutes	MG	CBG3MG4	*Bacillus licheniformis*	4.95±0.61[c]
Firmicutes	MG	CBG3MG5	*Bacillus subtilis*	4.16±1.51[d]
Firmicutes	AH	CBG3AH1	*Bacillus tequilensis*	2.45±0.26[e]
Firmicutes	FC	CBG3FC1	*Bacillus toyonensis*	1.32±0.57[f]
***Brahmina coriacea* (CBG4)**				
Firmicutes	**MG**	**CBG4MG1**	***Bacillus stratosphericus***	**10.78±4.18[a]**
Firmicutes	FC	CBG4FC1	*Bacillus pumilus*	3.73±1.13[d]
Firmicutes	FC	CBG4FC2	*Bacillus subtilis*	2.87±1.33[e]
Firmicutes	FC	CBG4FC3	*Bacillus licheniformis*	5.50±0.29[c]
			SE (m)	1.492
			CV	60.334
			F value	2.601
			p value	0.00239

6.5.4. All India Coordinated Research Project on Mushroom

Germplasm Collection and Conservation

During the rainy season, a total of 22 mushroom samples were collected from forest areas of district Almora, Bageshwar and Nainital. Nine were identified and cultures of *Ganoderma lucidum* and *Cantharellus cibarius* has been established.

Laetiporus sulphureus

Ramaria botrytis

Trametes versicolor

Amanita jacksonii

Infundibulicybe gibba

Lentinus sp.

Cortinarius meinhardii

Volvariella bombycina

Hygrocybe conica

Evaluation of high yielding varieties/strains of oyster mushroom (Pleurotus pulmonarius) on wheat straw

A total of 10 strains of *Pleurotus pulmonarius* were evaluated for their yield. Strain PL-21-10 resulted in highest yield (88.33 kg/100 kg dry wheat straw substrate) followed by strain PL-21-03 (66.31 kg/100 kg dry substrate).

Evaluation of shiitake mushroom (Lentinula edodes) strains on wheat straw

Out of 10 strains evaluated for their yield, strain IVTL-21-01 resulted in highest yield (37.88 kg/100 kg dry wheat straw substrate) followed by strain IVTL-21-05 (31.40 kg/100 kg dry substrate). However, strain IVTL-21-04 did not fructificate.

6.5.5. Network Project on Organic Farming

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

The performance of four crop management practices *viz.,* 100% organic, 50% organic + natural farming practice (seed/seedling treatment with beejamrit + ghanjeevamrit @ 250 kg/ha + jeevamrit @ 500 litres/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. The results of study revealed that amongst different management practices, application of 100% system N requirement through FYM recorded highest system (in terms of finger millet equivalent) productivity (4,678.8 kg/ha) of grain amaranth–wheat + lentil system which was around 222.6% higher as compared to 100% inorganic management. In respect of finger millet+black soybean–wheat+toria cropping system also, application of 100% system N through FYM have recorded around 207.6% higher system yield as compared to 100% chemical crop management practice.

Correlation analysis was performed amongst the different soil properties at the end of the cropping system (Table 6.5.8) and it was found that the soil

Table 6.5.8. Evaluation of organic, inorganic and integrated production systems under rainfed conditions

	Soil pH	Soil EC (µS/cm)	SOC (%)	Available P (kg/ha)	Acid Phosphatase activity (µg PNP/g soil/hr)
Soil EC (µS/cm)	0.859**				
SOC (%)	0.740**	0.750**			
Available P (kg/ha)	0.912**	0.890**	0.845**		
Acid phosphatase activity (µg PNP/g soil/hr)	0.518**	0.482*	0.652**	0.465*	
Alkaline phosphatase activity (µg PNP/g soil/hr)	0.883**	0.886**	0.852**	0.970**	0.387NS

pH has a very strong significant correlation with soil EC, soil available P status and alkaline phosphatase soil enzyme activity. The relationship between the soil available P and soil organic carbon status was also found strongly positive. Thus, correlation study revealed that consistent application of inorganic fertilizers reduces alkaline P activity, soil pH and soil EC.

Evaluation of natural farming practices under soybean + maize-garden pea + green coriander cropping system

Significantly higher system yield {2 years (2020-21 & 2021-22) mean yield 85.2 q/ha} of soybean + maize-garden pea + green coriander system was recorded under Integrated Crop Management-1 package (sole crop of soybean+ 50% of system P through FYM + 50% of NPK through inorganic sources + need based pesticides for pest management), which was on par with AI-NPOF package (100% system P through FYM + seed inoculation with biofertilizer consortium @ 15g/kg seed, system yield 83.3 q/ha), Natural Farming (NF)-1 practice (without beejamrit, ghanjeevamrit & jeevamrit and with mulching + intercropping, system yield 81.1 q/ha) and Complete Natural Farming (system yield 79.2 q/ha) treatment. Treatment NF-2 (with beejamrit, ghanjeevamrit & jeevamrit and without mulching + intercropping) and control recorded lowest system yields, 66.4 and 70.2 q/ha, respectively. Yield advantage in NF-1 and Complete Natural Farming practices is accrued due to inclusion of intercropping. AI-NPOF package was costliest practice (cost involved Rs. 130.6×103/ha) followed by ICM-2 practice (sole crop of soybean+ 50% of system P through FYM + 50% of NPK through inorganic sources + organic pest management; cost Rs. 110.9×103/ha and Complete NF practice (cost Rs. 105.4×10^3/ha). AI-NPOF package recorded highest soil organic carbon (1.22%), acid phosphate (118.0 µg PNP/g soil dm/h) and alkaline phosphate activity (47.4 µg PNP/g soil dm/h) followed by Integrated Crop Management practices.

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

It was observed that, during the laboratory bioassay Nimbicidine 3mL/L recorded the highest mortality of 53.33% among the organic treatments, followed by *Parthenium* leaf extract 5% (26.67%). However, the field assays recorded very different results, wherein, *Melia azedarach* leaf extract 10% spray recorded 56.5% reduction in sucking bug population followed by Nimbicidine 3mL/L (51.2%) and *Beauveria bassiana* 3g/L (48.3%). In the present study, insecticide cartapa hydrochloride 1g/L used as a positive control recorded the highest mortality of 100% under laboratory condition and 99.3% mortality under field assays.

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

The laboratory bioassay conducted with ten organic treatments against Toria aphid showed that, Nimbicidine 3mL/L recorded 72.7% mortality, followed by *Metarhizium anisopliae* 3g/L (44.3%) and *Alternaria alternata* strain VLH1 (38%). The best treatments were carried forward for field assays and it was noted that, Nimbicidine 3mL/L recorded 52.7% mortality, followed by *Beauveria bassiana* 3g/L (41.3%) and *Metarhizium anisopliae* 3g/L (35.7%). The novel entomopathogenic fungi *Alternaria alternata* strain VLH1 did not perform well under field conditions. However, the insecticide Acetamiprid 0.25 g/L used as a positive control recorded the highest mortality of 98.3% under laboratory condition and 90.7% mortality under field assays.

6.6. National Mission on Himalayan Studies (NMHS) Project

6.6.1 National Mission for Sustaining Himalayan Ecosystems -Taskforce on Agriculture (NMSHE-TF-Ag)

Matila village (1650 m amsl) of Tadikhet Block of Almora district, located in Sitlakhet – Kakrighat motorway, has been identified for the implementation of project activities. The village has 204 families, out of which about 90 families belong to Scheduled Caste. A Farmers –Scientist Interaction was organized for need assessment of the village. The main means of livelihood of the villagers are farming, horticulture and daily wages. Most of the families have their own consolidated land with private source of water, which has fruit trees like pear, plum, peach, etc. Wild animal menace is the main problem of the region.

Baseline survey of the village

Baseline survey of selected village Matila was conducted during July- September 2022, in which socio-economic status of village was studied and information was gathered on cropping system, climate information, climate change perception, awareness and adoption of adaptation practice, constraints faced by rural people and their needs were assessed.

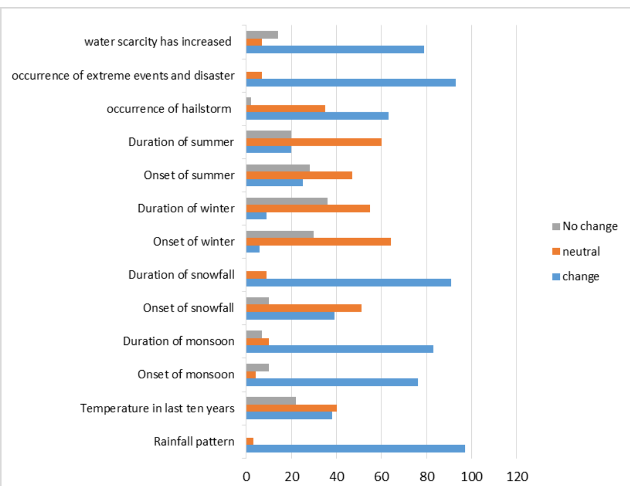


Fig. 6.6.1. Climate change perception of farmers in village Matila

Based on farmers' perception in baseline survey, it was found that there has been an increase in occurrences of extreme weather events like landslide and heavy rains. Locals have observed drying or decreasing flow of water in traditional water sources like *naula* (little depression aquifers), *dhara* (spring) and *gadhera* (small river tributary). Farmers have reported that the occurrence of snowfall has reduced, duration of summer is longer and onset of summer is early. Moreover, the change in rainfall pattern has largely affected sowing time, germination and yield of field crops like wheat, black soyabean, spring rice and finger millet. Farmers reported that they experienced a loss of around 30 to 50 per cent wheat yield due to no rains in grain filling stage.

Development of participatory adaptation strategies in selected villages

On the basis of need assessment and literature review, participatory adaptation strategies selected for pilot testing includes

- Introduction and testing of climate resilient crops and improved crop varieties.
- Providing weather based agro-advisory to farmers for informed decision making.
- Promotion of scientific cultivation of crops and improved farming practices among farmers.
- Promotion and development of water and soil conservation activities.
- Organizing farmers in self-help group and involvement of farmers in entrepreneurial activities.
- Developing a proper marketing channel through FPO linkage.

Demonstration in selected village

Demonstrations on finger millet, buckwheat, capsicum, maize, okra, ginger, turmeric wheat, garlic, fenugreek, coriander, onion, radish, vegetable pea and potato were laid out at farmers' fields. Besides, a pre-sowing camp on vegetable productions and IPM was also organized.

Fig. 6.6.2. Demonstration in selected village

Mobile agro-advisory: Looking at importance of informed decision making in farming, mobile agro-advisory was provided to farmers through VPKAS WhatsApp group on weather conditions and scientific cultivation of selected crops.

Farmers meeting and lectures: Exposure visit of farmers to *kisan mela*, ICAR-VPKAS, Almora was organized on September 28, 2022. Farmers visited demonstration sites of the institution and learnt on aspect of agricultural machinery. Lecture was also organized on Farmers Day celebration and Mushroom day. A total of 28 farmers participated in the programme and acquired knowledge on various aspects of mushroom cultivation.

Fig. 6.6.3. Farmers-scientist interactions and pre-sowing camps

Training and capacity building programme

One method demonstration was organized on use of line maker tool in sowing of vegetable crops on October 20, 2022, in which 30 farmers participated. VL Line maker is distributed among farmers on trial basis with an aim to test and popularize small friendly tools. Besides, a method demonstration on importance and application of bio-fertilizer on wheat crop was also organized on November 09, 2022 in which 70 farmers participated.

6.7. Gender Dynamics in information network usage across NW and NE Himalayan region of India

Information networks of vegetable growers across gender

The study's goal was to discover the dominant information networks by gender as well as the centrality measures of the information sources to evaluate their dominance and influence inside the network. In addition, an effort was made to identify the variables that might affect information network usage among male and female vegetable growers. The study findings would enable the extension system for developing suitable extension strategy and policy framework for enhancing the vegetable production in the state. For the purpose of selecting respondents, a multi-stage sampling approach was used in the study. A total of 320 vegetable growers were picked to be respondents (Fig. 6.7.1).

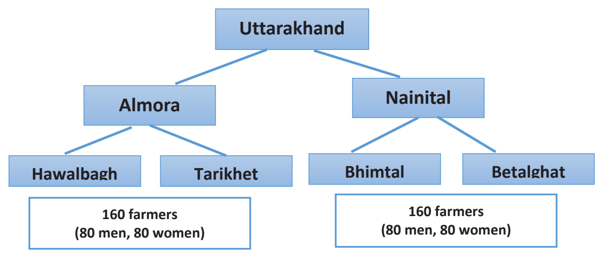


Fig. 6.7.1. Sampling plan of the study

Although there are a lot of evidences showing that men and women get their knowledge from different sources, extension services can use female networks to approach more households while promoting new technology (Fig. 6.7.2 & 6.7.3).

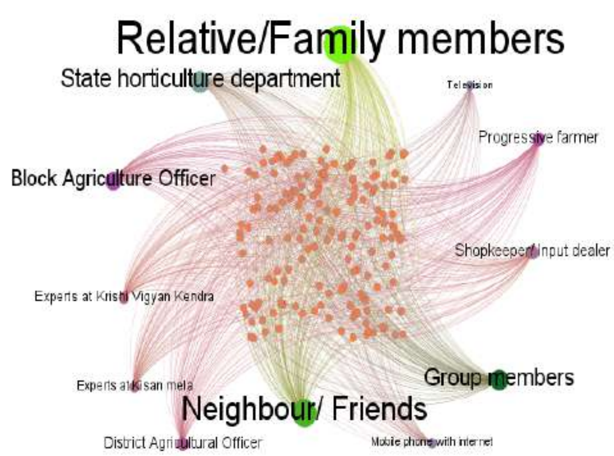


Fig. 6.7.2. Network structure of female vegetable growers

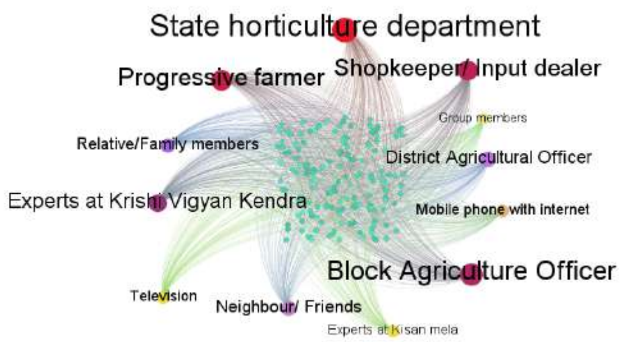


Fig. 6.7.3. Network structure of male vegetable growers

Local interpersonal sources of information were quite popular among women farmers as they chose relative/family members, neighbours/ friends and group members as their most preferred information sources. Whereas more formal and cosmopolite interpersonal information sources were preferred by the male vegetable growers as they chose State horticulture department as their preferred information source followed by progressive farmer and shopkeeper/ input dealer. Among electronic media both male and female farmers chose mobile phone with internet over television as the most potent mass media.

Network structures of farmers across gender

The person with the most network connections would influence the information dissemination and technology adoption in their network. Since nodes and the links that connect them are the two fundamental elements of networks, size and density are the two fundamental network properties. The number of nodes in a network determine its size, whereas density measures the proportion of linkages that are actually formed to all conceivable ties.

The attributes of the network for male and female vegetable farmers are depicted in Table 6.7.1. Networks of two-mode affiliation between farmers and information sources are shown in the social network analysis results. Their replies indicated the most significant and often used sources of information served as the sole basis for the structures. A network with a density of 0 is said to be entirely disconnected, whereas a network with a density of 1 is said to be fully connected. Density values are particularly helpful when comparing networks with similar sizes. Low-density ratings are typical for networks that are quite vast. The network of female farmers was less dense than the male farmer's networks, which indicates that the communication between the women growers was operating through sparse network villages. About 9 per cent of nodes in women's networks were connected while in men's networks about 14% of nodes were connected. While more open or sparse networks may provide better access to more varied information, denser networks may increase the possibility of sharing resources that are extremely similar.

Table 6.7.1. Network attributes of male and female vegetable growers

Network attributes	Male	Female
Density	0.14	0.09
Average degree	13.49	11.32
Modularity	0.097	0.162
Network diameter	3.00	4.00
Average path length	1.89	2.01

Similarly, the higher average degree of network shows more connectedness among the actors. In the case of the male the key actor *i.e.*, information source was connected to about 14 vegetable growers whereas in the case of females an information source was connected to about 11 vegetable growers. Higher network diameter of female's network shows that the two nodes or actors are much far apart than in the men's network. Average path length was higher among female networks which means less connectivity among the nodes and communication network among males is relatively more efficient compared to females. Higher modularity of female's network reveals that there are more small factions/ groups in their network than that of men's network.

Centrality measures of information networks

To evaluate their dominance and influence inside the network, centrality metrics of the information sources of different networks were determined. In the case of male farmers, the centrality measures were highest for the Horticulture department, followed by progressive farmers and input dealers/ shopkeepers. These were the most sought sources (in-degree centrality), are in a position to spread information quickly (closeness centrality), and have a high influence amount of influence over the flow of information in the network (Betweenness centrality) (Table 6.7.2 & 6.7.3).

Table 6.7.2. Centrality measures of existing information sources among the male farmers

Information sources	Centrality measures		
	In-Degree	Betweenness	Closeness
Neighbors/ Friends	111	951.352	0.610
Relative/Family members	116	875.695	0.633
Progressive farmer	142	1549.481	0.784
Group members	90	539.194	0.531
Shopkeeper/ Input dealer	139	1476.875	0.763
State horticulture department	150	1970.160	0.846
Block Agriculture Officer	137	1722.196	0.750
District Agricultural Officer	113	990.728	0.619
Experts at Krishi Vigyan Kendra	133	1247.087	0.724
Experts at Kisan mela	98	653.996	0.558
Television	97	733.111	0.555
Mobile Phone with internet	103	731.118	0.577

Table 6.7.3. Centrality measures of existing information sources among the female farmers

Information sources	Centrality measures		
	In-Degree	Betweenness	Closeness
Neighbour/ Friends	135	2394.693	0.737
Relative/Family members	149	3684.597	0.838
Progressive farmer	89	712.082	0.527
Group members	119	1583.812	0.647
Shopkeeper/ Input dealer	70	730.150	0.464
State horticulture department	101	1637.205	0.566
Block Agriculture Officer	93	1320.156	0.534
District Agricultural Officer	85	693.512	0.511
Experts at Krishi Vigyan Kendra	78	504.565	0.494
Experts at Kisan mela	73	455.601	0.480
Television	54	206.095	0.429
Mobile Phone with internet	58	279.525	0.413

Informal sources of information, such as family members, had the highest centrality measures for female farmers, followed by neighbors and friends, and group members. Mostly the dominant sources were interpersonal sources, which were localite for female farmers.

Factors affecting information networks usage by female vegetable growers

A simple linear regression analysis was done to understand the factors determining information source usage by vegetable growers across gender. The factors were different for men and women vegetable growers. For that the SPSS[3] software was used. It is evident that the factors that affect Agriculture Network Usage among female vegetable growers were Education, farming experience, hours dedicated to farming, group membership and contact with extension agency (Table 6.7.4). Group membership has positive and significant relation with Agriculture Network Usage.

Table 6.7.4. Factors affecting information network usage by female vegetable growers

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	3.980	.954		4.170	.000
Age	-.009	.014	-.052	-.657	.512
Education*	.202	.093	.165	2.177	.031
Family size	-.054	.051	-.075	-1.047	.297
Income	2.643E-6	.000	.038	.519	.604
Landholding	.012	.010	.082	1.138	.256
Farming experience*	.502	.165	.270	3.045	.003
Hours dedicated to farming*	-.191	.073	-.208	-2.604	.010
Group membership*	.700	.274	.179	2.555	.011
Access to mobile	.777	.420	.133	1.848	.066
Contact with extension agency*	.723	.313	.173	2.312	.022
Frequency of contact	.235	.143	.118	1.640	.103

Income, Land holding, Access to mobile, contact with extension agency and Frequency of contact were the main factors that affected the Agriculture Network Usage among male vegetable growers (Table 6.7.5). The results reveal that in general, women are less likely to contact formal sources of information and have more informal sources of information in their networks, whereas males tend to contact the formal sources.

Table 6.7.5. Factors affecting information network usage by male vegetable growers

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	5.361	1.387		3.865	.000
Age	.006	.013	0.53	-.020	.984
Education	-.209	.140	-.150	-1.479	.143
Family size	.073	.050	.140	1.453	.150
Income*	1.439E-5	.000	.239	2.568	.012
Landholding*	.028	.011	.260	2.528	.014
Farming experience	-.040	.159	.026	-.252	.802
Hours dedicated to farming	-.003	.093	-.003	-.032	.974
Group membership	-.233	.471	-.050	-.495	.622
Access to Mobile*	1.728	.710	.233	2.433	.017
Contact with extension agency*	2.033	.412	.567	4.930	.000
Frequency of contact*	-.449	.125	-.386	-3.585	.001

6.8. DBT Funded Project

6.8.1. Popularization of bio fortified maize hybrids in Himalayan states and central India with special reference to the north eastern region for sustainable nutritional security

Frontline demonstrations of biofortified (QPM) hybrid VLQPMH 59 were conducted in Dhanpau-Lakhwad tribal village cluster and Kwanu tribal village cluster, Dehradun, in about 30 acre area to enhance maize production, productivity and nutritional security of the tribal farmers. Seed of VLQPMH 59 was distributed to 52 farmers for conducting demonstrations in about 12.0 ha. The traditional local cultivar, Dhanpau Local and Kwanu Local, were used as the check. Dhanpau Local is an early maturing, relatively tall and low yielding cultivar. Kwanu Local is a late maturing (10 days late to VLQPH 59) tall and low yielding cultivar. Monitoring visits were carried out during the different crop growth stages. Yield data and farmers feedback was collected at maturity and a field day was organized in the village cluster on 06.09.2022 at Dhanpau and on 07.08.2022 at Kwanu (Fig. 6.2.2). According to the farmers, the yield of VLQPMH 59 was about 1.5 to 2 times that of their local cultivar. The yield data collected showed an increase ranging from 38.5 to 74.6 per cent over the local cultivar.


Fig. 6.8.1. Maize field day at Dhanpau (Kalsi) and Kwanu (Chakrata) in district dehradun of uttarakhand

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 were 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 29 training courses for farmwomen, farmers, and rural youths on various topics related to disciplines of Horticulture, Home Science 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 1,200 participants (545 female and 655 male) attended the programmes (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	16	482	344	**842**
Home Science	12	100	161	**273**
RAWE training	1	73	40	**114**
Total	**29**	**655**	**545**	**1,200**

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 17.5 ha during *Rabi* 2021-22, 2022-23 & *kharif* 2022 and a total of 335 farmers were benefited (Table 7.1.2 & 7.1.3).

Table 7.1.2. Front line demonstration conducted during *rabi* 2021-22

Crop	Variety	Area/ Nos.	No. of farmers
Pea	VL *Sabji Matar* 13, VL *Sabji Matar* 15	1	45
Lentil	VL *Masoor* 514, VL *Masoor* 126, VL *Masoor* 133	7.5	94
Total		**8.5**	**139**

Table 7.1.3. Front line demonstration conducted during *kharif* 2022

Crop	Variety	Area/ Nos.	No. of farmers
Okra	VL *Bhindi* 2	1.0	58
Total		**1.0**	**58**

7.1.3. On Farm Trials

Total four On-Farm Trials (OFTs) were conducted covering 22 farmers (Table 7.1.4).

Table 7.1.4. On farm trials

Title	Crop/ Variety	No of Farmers
Control of bitter pit in apples	Apple	7
Assessment of yield and quality of saffron in different altitude of higher hills of Uttarkashi district. (2nd Year)	Saffron	5
Effect of mulching on strawberry production under mid hill conditions of Uttarkashi district	Strawberry	5
Assessment of Module for Prevention of Anemia	-	5

7.1.4. Seed Production

A total 44.33 q seeds of cereals, pulses and vegetables and 11,380 seedlings were produced at KVK farm.

7.1.5. Other Extension Activities

- Live streaming of Celebration of PM *Kisan Samman Nidhi* Fund Release programme was organized on January 01.
- National Nutrition Girl Child Day was celebrated on January 24 in which 22 farmers participated.
- Flag hoisting celebration was organized on

January 26 commemorating Republic Day.

- International Women's Day was organized on March 08.
- World Environment Day was celebrated on June 05.
- B.Sc Agriculture students (113) from different agriculture colleges of country joined KVK Uttarkashi for 4 month Rural Agricultural Work Experience (RAWE) training during the reporting year.
- Celebrated Parthenium eradication week from August 16 to 22 during which various programmes like Farmers *gosthi*, Rallies, parthenium eradication drive at KVK and nearby villages were organized.
- Organized *Har Ghar Tiranga* under *Azadi Ka Amrit Mahotsav* to commemorate 76th Independence Day of India during August 13-15.
- Organized National Nutrition week during September month in which total 153 farmers/ RAWE students participated.
- Organised *Poshan Abhiyaan Evam Vriksharopan Karyakram* on September 17 in which Nutri kitchen gardening kits were distributed to farmers during this program.
- Celebrated *Hindi Diwas* on September 14 by organising various programs during *Hindi Chetna Mass* from September 14-30 at KVK Campus.
- *Mahila Krishak Diwas* was celebrated by KVK officials along with 49 women farmers at Patara Village on October 15.
- KVK, Uttarkashi organized integrity oath, extempore competition, essay competition, slogan competition, poem recitation competition, speech competition and *kisan goshti* during observance of Vigilance Awareness Week from October 31 to November 6.
- KVK, Uttarkashi organized Special *Swachhta* Campaign 2.0 during October 02-31 at KVK Uttarkashi , nearby areas and adopted villages.
- KVK celebrated World Soil Day and distributed Soil Health Cards on December 05. A total of 100 farmers, students & officials participated in the program.
- KVK organised and performed various activities under *Swachhta Pakhwada* during December 16-31 at different locations. KVK staff, RAWE trainees and field workers actively participated in the activities.
- Organized *Kisan Diwas* on December 23 in which a total of 66 farmers and students participated.

7.2. Krishi Vigyan Kendra, Kafligair

7.2.1. Trainings

The KVK (ICAR-VPKAS), Kafligair, Bageshwar organized 36 training programmes, with the participation of 831 farmers (478 males, 353 females) including 07 numbers of sponsored training programmes on various topics (Table 7.2.1.).

Three vocational training programmes of seven days on "Scientific Bee Keeping" were also organized under National Bee and Honey Mission (NBHM). Seventy five trainees successfully completed these trainings.

Table 7.2.1. Training Programmes organized during 2022

Discipline	No. of trainings	No. of Trainees		
		Male	Female	Total
Plant Protection	12	135	78	213
Horticulture	08	133	36	169
Home Science	07	30	170	200
Animal Science	02	41	05	46
Sponsored Training	07	139	64	203
Total	**36**	**478**	**353**	**831**

7.2.2. Front Line Demonstrations

Front Line Demonstrations (FLDs) on various crops in *kharif* 2022 were conducted on 13.60 ha area benefitting 378 farmers (Table 7.2.2). It resulted in increased average yield of various crops from 14.5 to 46.5 per cent.

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

Crop	Variety	Area (ha)	No. of beneficiaries
Cereals & Millets	VL *Dhan* 65, VL *Dhan* 68, PB1509	11.65	260
Oil seeds	VL Soya 89	1.30	73
Vegetables	Cabbage- Varun F1	0.50	30
	VL Tomato 4	0.15	15
Sub-total		**13.60**	**378**

Demonstration under newly initiated NICRA project

Crop	Variety	Area (ha.)	No. of beneficiaries
Cereals & Millets	VL *Dhan* 158, VL *Dhan* 156, VL *Mandua* 380, VL *Madira* 207, VL Amber popcorn	14.27	62
Oil seeds	VL Soya 47, VL Soya 89 and VL Soya 65	4.32	62
Vegetable	French Bean (Arka Komal), Bhindi (Pusa 06, Kashi lalima), Capsicum (california wonder), Amaranthus (Co-2), Bottle gaurd (NDBGH-4, PS), Brinjal (Pusa Hara Baingan-5), Chilly (LCA-620), Cowpea (KNS)	1.50	62
Fodder	Hybrid Napier (NB-21)- 6 q	0.50	40
	Total	**20.59**	**226**

7.2.3. Production of Seed and Bio-products

A total of 31.65 q quality seed including 14.12 q of *rabi* 2021-22 and 17.53 q of *kharif* 2022 was produced. Vegetable seedlings (1,37,710 No.), 160 q vermi-compost and 6441.00 lit milk were produced. A total revenue of Rs 5.24 lakhs was generated.

7.2.4. Other Important Activities

- Organized three training programme of 7 days on Scientific Bee Keeping under NBHM (NBB) from February 22-28, February 24-March 02 and March 21-27 and a total 75 farmers were benefitted.
- Organized awareness programme on International Women's Day on March 08 on the theme gender equality. Seasonal vegetable seed kits were also distributed among 35 farmwomen for establishing nutritional garden.
- KVK, Bageshwar participated in *Kisan Mela* on March 25 organized by ICAR-VPKAS, Almora along with 90 farmers.
- District Magistrate, Bageshwar and Director, ICAR-VPKAS, Almora jointly launched NICRA project in Bageshwar district on March 25.
- Organized *Kisan Mela Krishak Bhagidari Prathmikta Hamari* under ATMA scheme in association with District Agriculture Department, Bageshwar on April 26. A total 191 farmers were participated in the programme.
- Organized *Kisan Gosthi* on *Annadata Devo Bhavo* programme at Karalapaladi village on April 24. A total 80 farmers participated in the programme.
- Organized 4 field days on VL *Gehun* 829, VL *Gehun* 967, Pant Lentil 4 and Pant Shweta benefitting 160 farmers.
- Organized programme during live telecast of honorable Prime Minister's address on release of PM *Kisan Samman Nidhi* on May 31 at KVK Campus, Kafligair.
- Organized *Krishak Gosthi* on PPV & FRA on May 31.

- 28 polyhouses were constructed under SCSP project and 15 demonstrations of button mushroom was managed by KVK, Kafligair in village Uderkhani and Lob.
- Organized 14th Scientific Advisory Committee (SAC) meeting on August 06 under the chairmanship of Director, ICAR-VPKAS. District Magistrate, Bageshwar Smt. Reena Joshi was the chief guest on this occasion.
- Organized various activities during *Parthenium (Gajar ghas)* Eradication Awareness Week during August 16-22
- Organized one day awareness workshop on Natural Farming on November 23, with participation of 250 farmers.
- Organized various activities under Special *Swachhata Abhiyan* 2.0 from October 02-31 and *Swachhata Pakhwada* during December 16-31.
- Organized various on and off campus awareness programmes on the occasion of Vigilance Awareness week during October 31-November 06.
- Fifteen B.Sc. Agriculture students from Graphic Era Hill University, Bhimtal, Uttaranchal University, Dehradun, and Galgotias University, Noida have joined KVK Bageshwar for Rural Agricultural Work Experience (RAWE) training.

7.3 Institute Headquarter

7.3.1. Trainings organized in the Institute

Institute organized 14 trainings and 07 exposure visits for farmers and agricultural officers benefitting 602 persons during 2022 (Table 7.3.1 & 7.3.2).

Table 7.3.1. Trainings organized for farmers at the institute

S. No.	Topic	Beneficiaries	Duration	Coordinators	No. of Trainees
1.	Short Course on Hill Agriculture	Student from Banaras Hindu University, Varanasi	January 02-05, 2022	Drs. Rakesh Bhaumik, Priyanka Khati, M S Bhinda and Ashish Kumar Singh	28
2.	*Janjatiya krishakon ki pramukh rabi faslon ke beej utpadan mein kaushal vridhi*	Tribal farmers of Sitarganj block of Udham Singh Nagar	January 04-08, 2022	Drs. Renu Jethi, Navin Chander Gahtyari and Devender Sharma	31
3.	*Parvatiya Krishi Hetu Unnat Utpadan Takniki*	Staff members of Himmothan Society (an NGO) and adopted farmers of Almora and Chamoli district	March 07-09, 2022	Drs. B.M.Pandey, Jeevan B and Hitesh Bijarniya	28
4.	*Parvatiya Krishi Hetu Unnat Utpadan Takniki*	Farmers of Chamoli and Rudraprayag district	March 14-16, 2022	Drs. Kushgra Joshi, Amit Kumar and Amit Pashchapur	25
5.	*Parvatiya Kshetron Men Shankar Makka QPM 59 Ka Krishak Sahbhagita Bijotpadan*	Farmers of Kapkot block of Bageshwar district	March 24-25, 2022	Drs. R. K. Khulbe and Devender Sharma	22
6.	Short Course on Hill Agriculture	Student from Banaras Hindu University, Varanasi	May 27-31, 2022	Drs. J.P. Aditya, Rakesh Bhowmik and Amit Kumar	31
7	Training Program on "*Parvatiya Kshetron Men Aay Vradhi Hetu Sanrkshit Kheti*" under institute TSP	Farmers of Joshimath block of Chamoli district	June 12-16, 2022	Drs. B. M. Pandey, N. K. Hedau and Gaurav Verma	19

8	Short Course on Hill Agriculture	Student from Banaras Hindu University, Varanasi	June 17-21, 2022	Drs. Tilak Mandal, Jeevan B and Priyanka Khati	28
9.	Short Course on Hill Agriculture	Student from Banaras Hindu University, Varanasi	June 23-26, 2022	Drs. Kushagra Joshi, Jitendra Kumar and Mr. Amit Umesh Pashchapur	27
10.	Fall Armyworm: Symptoms, Identification &Integrated Management Strategies	NEH and Uttarakhand state officials	July 12, 2022	Mr. Amit U. Paschapur	52
11.	White grubs: Symptoms of Damage and Integrated Management Strategies	NEH and Uttarakhand state officials	July 13, 2022	Mr. Amit U. Paschapur	38
12.	Training Program on "*Krishi Masheeno evam upkarano ke marammat evam Rakharakhaw*" under institute SCSP	Farmers of Almora, Bageshwar, Nainital and Pauri	July 21-31, 2022	Drs. Shyam Nath, Hitesh Bijarniya and Jitendra Kumar	16
13.	Training Program on "*Pyaj Evam Lahsun Ke Bijotpadan Evam Rakhrakhav*"	Farmers of Chamoli and Rudraprayag districts	August 17-19, 2022	Drs. Nirmal Kumar Hedau and Rahul Dev	21
14.	Training Program on "*Dhingari Mashroom Utpadan*" under institute SCSP	Farmers of Bageshwar district	August 23-24, 2022	Drs. K.K.Mishra and Gaurav Verma	14

Table 7.3.2. Exposure visits organized for farmers at the institute

S.No.	Topic	Beneficiaries	Duration	Coordinators	No. of Trainees
1.	Exposure visit of students	Students of Junior High School, Mahatgaon	February 28, 2022	Drs. BM Pandey and Shri JP Gupta	18
2.	Exposure visit of farmers and Krishak Vaigyanik Sanwad	Farmers of Bageshwar and Almora districts	April 28, 2022	Drs. MS Bhinda and Anuradha Bhartiya	45
3.	Exposure visit of Students	Students of Grace Public Junior High School, Almora	June 08, 2022	Mr. Narain Ram	40
4.	Exposure visit of farmers	Farmers of Almora district	September 12, 2022	Dr. Rajendra Meena	30
5.	Exposure visit of Students	Students of Army Public School Ranikhet, Almora	September 24, 2022	Drs. Anuradha Bharati and Jitendra Kumar	27
6.	Exposure visit of farmers	Farmers of Almora and Chamoli districts	November 24, 2022	Dr. Ramesh Singh Pal	29
7.	Exposure visit of Students	Farmers of Chamoli district	November 28, 2022	Dr. B.M. Pandey	33

7.3.2. *Krishi Samridhi* Programme

Krishi Samridhi, a radio based programme, an initiative of ICAR-VPKAS, Almora for promoting Good Agricultural Practices among farmers. It is a live, 15 minutes syndicated talk-based radio programme for farmers of hill districts of Uttarakhand in which 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 52 talks broadcasted in year 2022 is presented in Fig. 7.3.1.

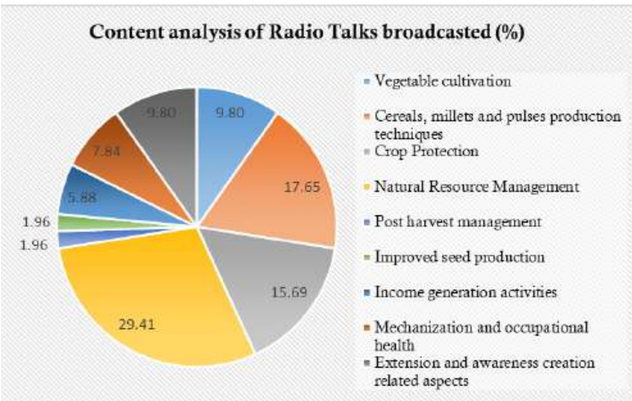


Fig. 7.3.1. Content analysis of radio talks broadcasted

7.3.3. 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 0930 AM to 0530 PM. In year 2022, 79 queries were received from farmers, details of the queries raised is shown in Fig. 7.3.2.

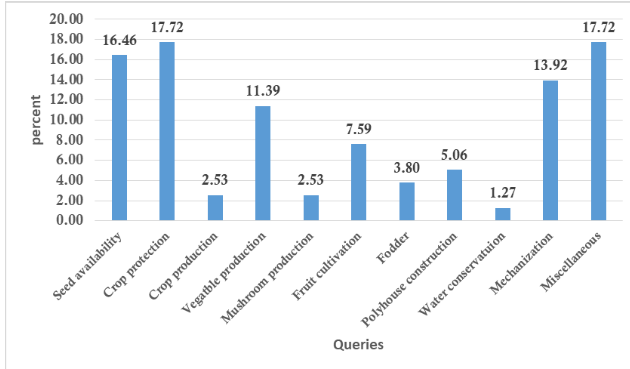


Fig. 7.3.2. Content analysis of queries raised by farmers through helpline service

7.3.4. Agro-advisory through ICT platforms

Agro-advisories are provided to farmers through Need based SMS services and *m-Kisan* portal. Information are sent to farmers on different contents like varieties, crop protection measures, nutrient management, farmers fairs/field days, seed production, government schemes etc. benefiting registered farmers. 87 advisories were sent to 765 farmers through 35 WhatsApp groups, 02 messages through *mKisan* to 245 farmers; 05 need-based messages to 245 farmers through phone were sent during reporting period.

7.3.5. Social media Platforms

Social media is the most recent form of digital communication. Social media platforms like face book 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 face book 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.

8. Success Stories

8.1. Addressing the Nutritional Security through Improved Technologies

The Challenge

Maize is India's third most important cereal crop next to rice and wheat. In spite of this fact, its production and productivity is relatively low, mainly due to the non-availability of quality seeds of improved varieties, less crop management and crop care by the farmers and poor post-harvest processing technologies. Moreover, normal maize is deficient in essential amino acids, particularly tryptophan and lysine; consequently, people consuming normal maize as a staple diet suffers from protein malnutrition. Quality Protein Maize (QPM), possessing *opaque-2* (*o2*) allele in the homozygous recessive condition in the presence of endosperm modifiers, contains nearly twice the amount of tryptophan and lysine as compared to normal maize. The biological value of QPM's protein is, therefore, almost double (80%) of the normal maize (45%) and its quality is equivalent to 90% that of milk protein *i.e.* casein.

The Solution

To enhance the nutritional security in the hill region, institute has developed five QPM maize hybrids along with their package of practices. Among the five 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 diseases and rich in nutritional quality (Tryptophan 0.77%, Lysine 3.33%). Post-harvest activities of maize are tedious and time-consuming, for which the *Vivek* Maize Sheller developed by the institute is the solution to replace manual shelling.

The Application

Frontline demonstrations of bio-fortified (QPM) hybrid VLQPMH 59 were conducted in Dhanpau-Lakhwad tribal village cluster and Kwanu tribal village cluster, Dehradun, in about 30 Acre area to enhance maize production, productivity and nutritional security of the tribal farmers. The yield of VLQPMH 59 was about 1.5 to 2 times that of their local cultivar. The yield data collected showed an increase ranging from 38.5 to 74.6 per cent over the local cultivar. The farmers also reported that damage due to fall army worm was relatively less in the hybrid variety than in the local cultivars. It was also less susceptible to diseases than the local cultivars. Due to its shorter stature and sturdy stem, it suffered less lodging damage. Bird damage was also relatively less due to tighter husk than the local cultivar. The maturity was also at par with that of the local cultivar and VLQPMH 59, therefore, fitted well in their existing cropping sequence.

The Impact

According to the farmers, the taste of *rotis* made from VLQPMH 59 flour, were as tasty as that of their local cultivar. Though the grain of VLQPMH 59 was sold relatively at lower rate in the local *mandi* @ Rs. 20-22/kg, compared to their local cultivar @ Rs. 24-25/Kg, the overall gain was much higher due to its significantly higher yield than the local cultivar. The income from 1 acre of maize cultivation increased from ₹ 44,000 to ₹ 46,200 with a net benefit of ₹ 21,905 in the improved practice. The benefit-cost ratio rose from 0.92 to 1.87 with the interventions. Overall, the farmers earned an additional benefit of ₹ 12,600 from additional yield and use of maize sheller compared to the conventional practice.

The sheller saved considerable time and energy compared to manual shelling and significantly reduced the drudgery involved in manual shelling.

8.2. Farmers' Participatory Seed Production (FPSP) of wheat variety VL *Gehun* 967

The Challenge

The availability of quality wheat seed is a major concern for the farmers of Uttarakhand hills. Moreover, there is a need to demonstrate the yield potential of newly released varieties to popularize it among the farmer's community. VL *Gehun* 967 is a newly released and notified wheat cultivar having excellent agronomic characteristics which need to be popularized among farmers.

The Solution

In order to enhance the quality seed availability to the farmers and to demonstrate the yield superiority of the newly released wheat variety, VL *Gehun* 967 was included in the on-going farmer participatory seed production (FPSP)-cum-varietal demonstration programme of the institute in the Tharu tribal villages, Jhankat (Latitude: 28°949056°, Longitude 79°791728°) and Nakulia (N 28°58.832', E 79°42.876') of Sitarganj (district Udham Singh Nagar, Uttarakhand). The farmers of these villages showed their keen willingness for the FPSP of VL *Gehun* 967 due to the associated monetary benefits and potential performance of the variety.

The Application

The farmers involved in the participatory seed production were regularly given institutional support in the form of quality seed of the variety, regular monitoring of their fields by the scientific team for a range of seed production activities like weed management, insect and disease management, rouguing activities and other on-field training-cum-demonstration activities. Besides, farmers were also trained at the institute to gain technical know-how regarding good agricultural practices as well as for quality seed production. In the process, the new variety is also being disseminated and popularized to the nearby region farmers.

The Impact

From the last three years, tribal farmers of the Sitarganj area have been cultivating the variety and producing truthfully labelled (TL) seeds of the wheat variety VL *Gehun* 967. The details of the seed procured from the farmers is as follows

Year	Procurement (q)	Remittance to farmers (Rs.)
2019-20	41.38	91,036
2020-21	142.00	3,40,800
2021-22	134.57	3,22,968
Total	**317.95**	**7,54,804**

The income received by seed-producing farmers by direct procurement of seed by the institute was Rs. 7.54 lakhs. Apart from the monetary benefits, the technology was received by the farmers at an accelerated rate and the variety demonstrated a yield advantage of 5-7% over the local cultivars.

8.3. Enhanced income through protected vegetable and mushroom production

The Challenge

Mr. Madan Mohan is a young farmer of village Uderkhani of district Bageshwar. His primary occupation is agriculture; however, previously he was also engaged in copper smithy. He is having around 12 nali land, out of which only 03 nali is irrigated. He has been growing various crops for their family need. But enhancement of income has always been a challenge.

The Solution

ICAR-VPKAS, Almora through its KVK, Kafligair, Bageshwar started working in this village under Schedule Cast Sub Plan (SCSP) scheme. Mr. Madan Mohan showed interest for vegetable production in polyhouse and mushroom production. But he was not having any experience or skill of this venture. Moreover, his economic condition also not allows him investing for these enterprises. Therefore, through extending the benefits of SCSP project, one VL portable polyhouse was constructed in his field as well as 5 q pasteurized compost was also provided to him during 2022. Training as well as advice for both the enterprises was also provided to him.

The Application

Mr. Madan Mohan took keen interest in protected vegetable and mushroom production. He remained in touch with ICAR-VPKAS and performed all the processes and followed the advice. The close monitoring, awareness, zeal to grow a new product in the area and sincerity led to produce a bumper crop of button mushroom and Mr. Madan Mohan produced 100 kg saleable button mushroom. Likewise, he got 7.5 q vegetable production of tomato, capsicum, cabbage, cauliflower, french bean from polyhouse measuring 62.4 square meters. Most importantly, these produces were off season when there was no glut available with the local retailers from Haldwani *mandi*.

The Impact

With all these efforts, he earned an income of Rs. 41,250.00 that was double than his previous usual farm income. Moreover, his interest and hard work and continuous learning habit let these both the enterprises highly profitable for him as well as became inspiration for the fellow farmers. His sincerely and efforts were also recognized as felicitation in ICAR-VPKAS, Almora *Kisan Mela*.

8.4. Adoption of improved varietal technologies of pulses and oilseeds has improved the income of hill farmers

The Challenge

Pulses and oilseeds are one of the major *kharif* pulses in North Western Himalayan hills particularly, in the state of Uttarakhand. These crops have an integral role in the sustainability of hill agriculture as well as in providing livelihood and food security to the millions of rural inhabitants. Lack of quality seeds of improved varieties, poor crop management, agricultural mechanization and post-harvest processing rendered farmers of the region devoid of reaping the potential benefits from its cultivation.

The Solution

Improved high yielding cultivars of soybean (VL Soya 89) and *Bhat* (VL *Bhat* 201) have appreciable yield potential of 23-24 q/ha and 15-16 q/ha, respectively along with resistance against frog eye leaf spot, bacterial pustules, pod blight and other diseases prevalent in hilly region of Uttarakhand. Improved variety of horse gram VL *Gahat* 19 was also introduced in farmer fields as demonstration. This variety has a yield potential of 8-10 q/ha as compared to local cultivars along with resistance against anthracnose and leaf spot. 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. High yielding varieties along with improved crop management practices were demonstrated in different villages of Almora district, where soybean, *Bhat* and horse gram were grown in large scale.

The Application

In Jyoli village, Hawalbagh, Almora, frontline demonstrations (FLDs) of *kharif* legume crops were conducted. Thirty three farmers (26 female & 7 male) participated in the conduction of FLDs and enthusiastically introduced improved varieties of these crops in their fields. Frontline demonstrations of VL Soya 89 and VL *Bhat* 201 was conducted in 4 ha area whereas VL Gahat 19 covered 2 ha area in the farmer's fields. Improved small tools like sickle, kutla, hand hoe, garden rake and line maker *etc.* were also introduced for ease in practicing the improved agricultural practices from sowing to harvesting of the produce. Awareness for the preparation of value added products like tofu and milk were also created among farmers for income generation.

The Impact

As a result of adopting improved varietal technologies along with recommended package of practices under FLDs, appreciable yield enhancement and profitability was realized at farmers field. With full package of practices for soybean cultivation, the crop yield improved significantly in soybean by 20-25% than traditional varieties and cultivation practices followed in the region. However, this increase was more with black soybean varieties *i.e.* 35-40%. The income of farmers with the improved varieties was increased from Rs. 23,911 to 46,692 in soybean and Rs. 33,943 to 46,167 in black soybean from per hectare land. Using full package of practices for cultivation, crop yield improved remarkably from 30-35%.

9. Farmers' Feedback

Sh. Harish Singh, Jhankat, Sitarganj, Udham Singh Nagar

I have been fortunate enough to be associated with ICAR-VPKAS, Almora, Uttarakhand for the past seven years. The association with the institute farmer's participatory seed production (FPSP) has immensely benefitted me and many fellow farmers here at village Jhankat, block Sitarganj, District Udham Singh Nagar. Back then I was a conventional wheat grower, but association with the ICAR-VPKAS, Almora helped me turn into a seed producer. With the immense support provided in the form of technical know-how from the scientific and technical staff, critical inputs, and on-farm and institute-level trainings, I was able to produce truthfully labelled seeds for wheat varieties VL *Gehun* 804, VL *Gehun* 829, VL *Gehun* 907, VL *Gehun* 967, VL *Gehun* 953 and VL *Gehun* 2014. This helped me to fetch higher rates for the seed crop compared to the prevailing mandi rates for wheat grains. I whole heartedly thank them for this longstanding association.

I have been cultivating local *Bhat*, soybean and horse gram from long ago for household consumption and selling little surplus in local market. Cultivation of these legumes was not very profitable for me because local varieties which I was using were poor yielding, trailing lodging prone and susceptible to disease and insect attack. During 2022, Front Line Demonstrations of improved varieties were conducted in my village and I along with other farmers of village came in contact with the team of ICAR-VPKAS, Almora and adopted the improved varieties VL Soya 89, VL *Bhat* 201 and VL *Gahat* 19 with recommended production technology. The performance of these varieties was extremely encouraging and profitable, therefore, I will be growing the improved seeds of these legumes in future too.

Shri Jeevan Chandra Pant, Jyoli, Almora

Smt. Deepa Devi, Rawari, Dwarahat, Almora

The varietal demonstration of paddy varieties *viz*. VL *Dhan* 158, VL *Dhan* 88, VL *Dhan* 68, VL *Dhan* 69 and VL *Dhan* 85 during *kharif* 2022 has been an insightful and valuable experience for me and other farmers of this region. It allowed us to witness and learn about new and improved varieties of rice. This exposure was highly beneficial as it gave us a chance to explore the potential of these varieties and compare them to the ones we currently cultivate. We appreciate the effort put into bringing these varieties to our attention. Observing the characteristics, adaptability and disease resistance of these varieties helped us understand their potential benefits. This experience has expanded our knowledge and empowered us to make informed decisions about our future cultivation choices. One of the most significant advantages of the varietal demonstration was the opportunity to assess the yield potential of the showcased varieties and witnessed the comparative performance of different varieties under similar conditions allowed us to evaluate their productivity and profitability. Overall, the varietal demonstration has equipped us with knowledge, exposed us to new possibilities and empowered us to make informed decisions about our farming practices. I would like to express our heartfelt gratitude for organizing the varietal demonstration program in our village.

Prior to coming in contact with ICAR-VPKAS, Almora under Schedule Caste Sub Plan project, I had been growing cereal, pulses and few vegetables only for household consumption within almost no farm income. Under the scheme of ICAR-VPKAS, Almora awareness for protected vegetable and mushroom production was spread and training on protected vegetable production and mushroom production was also provided. Under the SCSP scheme of ICAR-VPKAS, one polyhouse was constructed and I started growing off-season high value vegetables as well as the production of button mushroom was also taken up. These farming components provided me good income as well as confidence to work technically on scientific lines of production. I request ICAR-VPKAS Almora to continue the support and guidance so that our livelihood may be further improved.

Shri Madan Mohan, Uderkhani, Bageshwar

10. National Programme

10.1 *Swachhata Pakhwada*

Institute celebrated 16-day long celebration on cleanliness campaign during December 16-31, 2022. Various activities and programmes were organized to mark the occasion and the entire fortnight was celebrated as *Swachhata Pakhawada*. On the first day, *Swacchata* banners were displayed at various places in Almora and Hawalbagh campuses. The Director and staff of the institute took pledge for clean environment in premises and working place.

On December 17, 2022 *Madari Naula* at Experimental Farm Hawalbagh was cleaned. Water storage tank, drainage line facilities, floors, roof, grasses and garbage were cleaned in catchment area of *Naula*. A group of ICAR-VPKAS employees also cleaned water storage tank, drainage line facilities, floors and garbage in catchment area of Badreshwar *Naula* (water spring adopted by institute) in Almora city.

Kisan Diwas & National Mushroom Day

Kisan Diwas (farmer's day) and National Mushroom Day was organized at Experimental Farm, Hawalbagh as a part of the action plan of *Swachhta Pakhwada* on December 23, 2022. *Kisan Gosthi* was organized in which 50 farmers of adopted villages under Scheduled Caste Sub Plan and NMSHE-II were encouraged about the benefits of scientific cultivation of onion and garlic. On National Mushroom Day, scientific lecture on recycling of agro-wastes for mushroom production was delivered. Farmers shared their experiences

and problems in farming while adopting new technologies. Director, ICAR-VPKAS emphasized the importance of *Swachhata* as well as mushroom cultivation in day-to-day life. Onion seedlings and small tool kits were distributed among farmers.

An essay & drawing competitions for school children on cleanliness was organized on December 26. Theme of essay was '*Hamara Swacch Vidyalaya'*. 'Twenty students from Gyan Vigyan Academy, Hawalbagh participated. The students were sensitized about the aim of national cleanliness drive and its importance in making the country healthy and prosper.

Swachchhata sangosthi evam patrakar sammelan

The institute organized *Swachchhata sangosthi evam patrakar sammelan* on December 30, 2022. The Chief Guest, Prof. Sunil Nautiyal, Director, GB Pant National Institute on Himalayan Environment, Almora appreciated the efforts of institute for implementing the programme in successful manner. Praising the research work of the institute, he said that institute is doing excellent work for the stakeholders. He also expressed his views on Himalaya and emphasize on 9 R's (Reduce, Reuse, Recycle, Repair, Remake, Refuse, Remember, Respect and Restore) to save our mother earth. During the programme, award of excellence and cash prize was also conferred to the three institute staff as Environmental Friend for their great contribution in making *Swachhta* Campaign a great success.

Special Campaign 2.0

The institute has undertaken Special Campaign 2.0 for *swachhata* in offices and disposal of pending matter from October 2- 31, 2022 as per guidelines from Govt. of India. Many programmes were organized during the period.

Citizen Centric Initiative

Naula is the most imperative source of natural seepage of drinking water; it is normally in a four-sided (rectangle or square) shape with stairs on all the sides. This is commonly covered by stone slates and a wall is raised along its three sides. The *Naulas* are designed to collect water from the underground seepage and are used by the local population for fulfilling their everyday needs. The institute employees participated in Special Campaign 2.0 and *Naulas* were cleaned in catchment area of *Badreshwar Naula*.

Other Sustainable Initiatives

Disposal of expired pesticides was conducted at Experimental Farm Hawalbagh. Initially, appropriate site far from water sources, housing complex and farm land was identified and expired chemicals from various departments were brought to the disposal site safely. The staff was provided with protective gloves and masks for draining out hazardous chemical from the containers. Under the supervision of scientists, 44 expired chemicals were disposed of.

Swachhata campaign was organized at Gyan-Vigyan Children Academy, Hawalbagh in which more than 100 students along with teachers participated. The scientists created awareness for cleanliness among students and delivered talks on safe disposal of bio-degradable and non-degradable wastes.

10.2 Tribal Sub Plan

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 were adopted under Tribal Sub Plan with the objective of socio-economic development of the tribal communities.

Fabrication of Polyhouses for Income Enhancement

A total of 15 naturally ventilated polyhouses of 100 sq. m area were fabricated at farmers' field in Parsari and Merag villages of Joshimath block of Chamoli district. All farmers were given tomato, capsicum and cucumber seed for protected cultivation. A brief training on "Protected Cultivation" was organized at Farmers Resource Centre, Parsari. Besides, five days training program on "*Parvatiya Kshetron Mein Aay Vriddhi Hetu Sanrakshit Kheti*" was also organized at Experimental farm, Hawalbagh in which nineteen participants from 2 villages Parsari and Merag participated. Farmers were trained on production and protection technologies for protected cultivation, and marketing.

Fabrication of naturally ventilated polyhouses in Parsari and Merag villages

Krishak Gosthis and Farmer-Scientist Interactions

A farmers-scientists interaction was organized at village Virahi (migration village of Kailashpur) to assess the performance of vegetable crop varieties provided by the institute and seed of VL Bean 2 produced by seven farmers Self Help Groups of Kailashpur village under participatory mode was also collected. Two farmers-scientists interactions were organised at Farmers Resource Centre at Parsari vilage. A method demonstration and training programme was organised on improved agricultural practices for temperate fruit plants. A total of 1450 plants of apple, kiwi, peach, plum, apricot, etc. were distributed among more than 60 tribal farmers. Besides, a meeting was convened with the key farmers of Kailashpur, Malari and Niti for plantation of temperate fruits in the region and 850 plants of apple and apricot were distributed for planting.

A pre-sowing training programme was organized on vegetable cultivation and seeds of cabbage, cauliflower, coriander, squash, tomato and capsicum were distributed to the farmers of Merag and Parsari. A total of 120 farmers participated in the programme. A visit of scientists to Dhanpau-Kwanu cluster was undertaken for monitoring of ongoing activities and distribution of maize shellers.

Two farmers–scientists interactions were convened for demonstration of maize sheller in both locations. Besides, various wheat varieties under FLDs were also monitored.

Technology Demonstrations

Maize FLDs in Kashmir

FLDs of maize hybrids VLQPMH 59 were conducted in Kashmir in 03 ha area in collaboration with SKUAST-K. FLDs were conducted in district Anantnag and Kupwara. The total number of beneficiaries were 72. The yield of VLQPMH 59 ranged from 50.0-62.0 q (average 55.0 q) and gain over the local cultivar ranged from 28.2-87.5% (average 56.0q). The yield of local cultivar ranged from 31.0-39.0 q (average 35.4 q).

Rice FLDs in Rajouri, Jammu

Rice varieties VL *Dhan* 85, VL *Dhan* 68 and VL *Dhan* 158 were demonstrated in the farmers' field of Rajouri, Jammu in about 3.5 ha area with the help of Regional Agricultural Research Station (RARS) Rajouri, SKUAST-Jammu. The improved cultivar has shown better performance compared to the local checks. A field day cum scientist-farmers interface meet was also organized to enhance awareness among the farmers and to collect feedback from the farmers.

Distribution of inputs

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 varieties were distributed in Kwanu cluster of Jaunsar tribal area of district Dehradun. In addition, seeds of turmeric (25 q), ginger (1 q), garden pea (15 q) and onion (40 kg) were also distributed for demonstrations. In Dhanpau-Lakhwad village cluster, wheat varieties VL *Gehun* 829 and VL *Gehun* 953 were the top performers with an average yield of 34.1 q/ha and 24.7 q/ha. Likewise, in the Kwanu cluster of Jaunsar tribal area, the wheat variety VL *Gehun* 967 was at the top with an average yield of 23.2 q/ha. The improved wheat varieties were able to outyield local cultivars by 40-45%.

In the newly adopted tribal clusters, a total of 80.0 q seed of newly developed and popular wheat varieties VL *Gehun* 967, VL *Gehun* 953, VL *Gehun* 2014 and VL *Gehun* 907 was supplied to SKUAST-Jammu for conducting demonstrations in tribal areas of district Rajouri, Kathua, Poonch, Udhampur, Kupwara and Anantnag in Jammu & Kashmir. The seed was shared with more than 300 tribal farmers. The improved wheat varieties showed an average yield advantage of 16-18% over the local cultivars.

In addition, a total of 2300 plants of apple, kiwi, peach, plum, apricot etc. were distributed among the farmers of Chamoli district. More than 100 polytunnels were distributed to the farmers of Joshimath cluster and 50 maize shellers were distributed among farmers of Dhanpau and Kwanu tribal area.

Distribution of maize shallers to Dhanpau farmers

Establishment of Farmer Participatory Seed Production System

Rajmash is the main cash crop of remote villages (Kailashpur, Malari, Gamshali, Niti etc.) of Niti Valley. A total of 717 kg seed of french bean variety VL Bean 2 was procured from seven Self Help Groups of the village. However, approx. 90 per-cent VL Bean 2 seed of last year produce was distributed among 500 tribal farmers of Niti-Mana valley. Wheat seed production demonstration-cum-farmer participatory seed production of wheat varieties VL *Gehun* 829 and VL *Gehun* 967 was organized in one acre each in Yamunakhadar (Vikasnagar, Dehradun) and total of 19.66 q seed (13.33 q VL *Gehun* 829 and 6.33 q VL *Gehun* 967) was produced.

Parental seed of VMH 45 was provided to SKUAST-K for taking up F_1 seed production. F_1 seed production of VMH 45 was taken up SKUAST-K in farmer's field and 10.0 q seed of VMH 45 was produced. The seed was procured for use in outreach programmes of SKUAST-K.

10.3 Schedule Caste Sub Plan

Handing over of polyhouses

43 VL Portable polyhouses (62.4 m^2 surface area with 12.0 m length x 5.2 m width x 2.6 m height) was fabricated for SC farmers in the Bageshwar and Nainital districts of Uttarakhand.

Agriculture input distribution

Several inputs like, VL polytunnel (50), seeds of improved varieties (100 kg of cereals and vegetables), VL tool kits (109), VL Solar Dyer (50) and bee boxes (03) were distributed to SC farmers. A live demonstration on honeybee keeping and use of power operated knapsack sprayer was done during Kisan Mela of the institute.

Training programme on skill development

A 10 days' hands on training on "कृषि मशीनों एवं उपकरणों के मरम्मत एवं रखरखाव पर व्यक्तिगत प्रशिक्षण" was organized during July 21-30, 2022 with aim to develop skills in youth of adopted villages so that they can repair and maintain the machinery and equipments distributed in their villages. A total of 16 trainees from the villages of Almora, Nainital, Bageshwar and Pauri Garhwal districts learnt about the measurement of angles and dimensions, metal cutting, welding, lath operations, fabrication, repair and replacement of components, construction of poly tank and field operations of various machineries. The training created opportunity and enabled them to open their own repairing shops for self- employment.

Training programme on oyster mushroom cultivation

A two days training programme on "Oyster Mushroom Cultivation" was organized during August 23-24, 2022 for the farmers of institute adopted village Lakahni, Bageshwar. A total of 14 progressive farmers participated in the training program. Farmers were made acquainted with cultivation technology including substrate preparation, spawning, disease & insect pest management etc. Farmers were also imparted hands on training on cultivation of oyster mushroom.

Frontline demonstration of improved varieties of finger millet

Frontline demonstrations of two improved varieties of finger millet (VL *Mandua* 376 and VL *Mandua* 352) were conducted at Lakhni and Uderkhani villages. The improved varieties along with management practices exhibited yield advantage of 43.2 and 36.5%, respectively over the farmers' practice. A finger millet field day was organized on September 01 at Lakhni village to demonstrate the benefits of adopting high yielding short duration varieties, management technologies and value-added products for use in the household and for sale as well as profitability of finger millet production in comparison to major crops.

Frontline demonstration of VL Sweet Corn Hybrid 2

Frontline demonstrations of VL Sweet Corn Hybrid 2 were conducted in Dadim (1.5 ha.) village of district Nainital under SCSP programme. In the FLDs, the green cob (with husk) yield of VL Sweet Corn Hybrid 2 ranged from 157.1 to 174.8 q/ha. Maize Field Day was also organized at on September 20, 2022.

Hands on training cum demonstration for installation of drip irrigation at farmer's field

A hands-on training cum demonstration for installation of drip irrigation system at farmer field was organized. The drip irrigation system was installed under all polyhouses constructed at farmers' field in Darim village of Nainital District and Lakhani and Uderkhani village of Bageshwar District. The prevailing terrace cultivation in the region provides ample scope for gravity-fed micro irrigation system. It is recommended that the gravity-fed micro irrigation system must be integrated with the water harvesting system for effective and economic utilization of water in

vegetable cultivation. It effectively addresses the issue of water management and may increase area under irrigation in hilly region.

Fabrication of VL Poly-tanks

Polytank technology through farmers participatory approaches have been demonstrated at field level. The polytanks were constructed in Darima village of Nainital district and Lakhani and Uderkhani villages of Bageshwar district with involvement of farmers. The hands on training/capacity building regarding tank construction, installation of micro-irrigation system and laying of poly sheet, silpaulin sheet, have been provided by institute and cleaning of site, digging and leveling cost of tank were borne by farmers.

Polytank construction at field of Shri Manohar Lal, village Darima

Brick lining of polytank technology has been demonstrated at farmer's field for rainwater harvesting and storage of spring water for irrigation during lean period. Use of brick lining tank to supplement the water for vegetable production in hilly terraces resulted in enhancing water productivity per unit of area.

Organization of Kisan Diwas at farmer's field

Kisan Diwas was organized at SCSP village Uderkhani on December 23, 2022. On this event, 75 farmers were participated. Awareness was created about the issues faced by the hill farmers to promote sustainable agriculture. The officials delivered lectures on innovative farming techniques, market trends, government schemes and policies.

Jal Shakti Abhiyan

An awareness programme under *Jal Shakti Abhiyan* was organized at village Uderkhani on August 18, 2022. The farmers were made aware about how to ensure water security and sustainability in hilly region by integrating water conservation, water resource management and rainwater harvesting. A total of 20 farmers participated.

Exposure visits and exhibition

Farmers from SCSP adopted villages Lakhani, Uderkhani, Darima, Lob and Shaharfatak visited institute along with their produce during *Kisan Mela* and Foundation Day on March 25, 2022 and July 04, 2022, respectively.

10.4 North Eastern Hills (NEH) programme

Technology demonstrations

Finger millet

Finger millet variety VL *Mandua* 376 was demonstrated in farmers' fields in village Shernup of district Tawang, Arunachal Pradesh in collaboration with KVK Tawang. Finger millet yield was 14.25 q/

ha which was 39.7% higher than the local cultivar (10.20 q/ha). During *kharif* 2022, seed of finger millet varieties VL *Mandua* 352 and VL *Mandua* 382 was provided to KVK East Kameng (Arunachal Pradesh) for demonstrations. In the demonstrations conducted in village Sopung Bana, Seppa, the performance of VL *Mandua* 352 was significantly higher than the local cultivar.

Field demonstration of finger millet variety VL *Mandua* 376 in village Shernup, Tawang, Arunachal Pradesh and farmers with produce

Maize

Demonstrations of QPM hybrid VLQPMH 59 and sweet corn hybrid CMVL Sweet Corn Hybrid 1 (CMVLSC 1) were conducted in collaboration with KVK Sepahijala (Tripura). In district Sepahijala, maize is mainly cultivated for green cobs. The crop VLQPMH 59 and CMVLSC 1 gave higher number of cobs per unit area compared to the local cultivars. Besides, the cob size was bigger and grain filling also was better than the local cultivar.

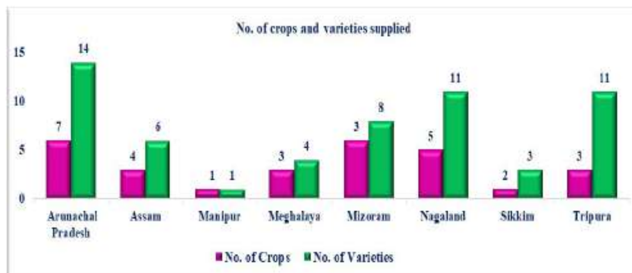
VLQPMH 59 demonstration in Kalikanta Para, Jampuijala RD, district Sepahijala, Tripura and farmers with their produce

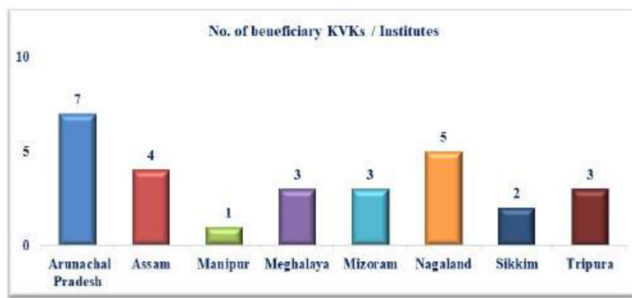
Soybean

Soybean variety VL *Bhat* 201 was demonstrated at KVK West Kameng (Arunachal Pradesh). The variety performed very well in the demonstration. The demonstration plot was also visited by Additional Deputy Commissioner Dirang Shri J.T. Obi. About 50 kg was retained by the KVK for conducting farmer field demonstrations during *kharif* 2023.

Seed supplied

A total of 21.72 q seed was supplied to 28 KVKs/ institutes across the 8 NER states. The seed supplied comprised 24 varieties of 09 crops.





10.5 Mera Gaon Mera Gaurav

Five inter-disciplinary teams of scientists have been formed who visited the villages adopted in 5 clusters of Uttarakhand to cater the needs of the farming communities. During the year 2022, 26 villages from five blocks of Almora district were visited regularly by the teams. The areas of national priority likewise soil and water conservation, mechanization, agricultural productivity, insect-pest management measures were taken care of.

Activities organized under MGMG by the Institute

Name of activity	No. of activities conducted	No. of farmers benefitted
Awareness created	18	311
Demonstrations conducted	36	66
Interface meeting/ *Goshthies*	10	255
Literature support provided	03	135
Training organized	03	75
Visit to village by teams	20	400
Mobile based advisories	226	618
Students' exposure visit	01	30
Total	**234**	**1406**

Details of activities conducted in adopted village clusters

Activity	Particulars	
Facilitation for		
i) Technology (No.)	Numbers	02 (Polycement tank, Portable Poly house)
	Area (ha)	0.40
	Farmers benefitted (No.)	04
ii) Seeds (q)	Area (ha)	2.66
	quantity (q)	2.303
	Farmers benefitted (No.)	250
iii) Planting materials (Onion seedlings VL *Piaz* 3)	Area (ha)	0.036
	quantity (No.)	19500
	Farmers benefitted (No.)	24
iv) Any other VL Chaff cutter, Drip irrigation system, Button Mushroom, Polytank, Portable polyhouse, Ferterra 0.4 G and other insecticides	Area (ha)	1.11
	quantity (No.)	VL Chaff cutter (01)+ Mushroom (150 bags) + 11 (Drip irrigation sets)+ 2 (polyhouse) + 2 (polytank) =166
	quantity (q)	0.08
	Farmers benefitted (No.)	46

10.6 Participation in Fit India Freedom Run 3.0

The Institute employees participated in month-long Fit India Freedom Run 3.0 organized from October 02-31, 2022 on the commemoration of "*Azadi ka Amrit Mahotsav*". During the programme, a series of events namely, run/walk/sports for the campaign were organized.

11. Trainings & Capacity Building

Training of Institute Personnel

The following institute personnel were deputed for different HRD programmes as per Annual Training Plan (ATP) during 2022 (Table 11.1).

Table 11.1. Details of trainings undergone by institute staff

Duration	Participant	Topic	Venue
International			
September 13-19, 2022	Dr. Amit Kumar	New Agriculture Innovation Programme on "Achieving Food Security Using Smart Farming Solutions"-Study Visit	Galilee International Management Institute (GIMI), Israel
National			
Scientific staff			
February 01-21, 2022	Dr. Shyam Nath	Recent advances in electronic devices, artificial intelligence and machine learning for precision agriculture.	ICAR-CIAE, Bhopal, M.P.
March 09-11, 2022	Mr. Jeevan B.	Data Visualization using R	ICAR - NAARM, Hyderabad
March 21-30, 2022	Mr. Ashish Kumar Singh	Capacity Building Workshop in Nematode Taxonomy & Satellite Symposium on Advances in Nematology (CBNT_SSAN 2022).	Department of Zoology, CCS University, Meerut
December, 22 – 26, 2022	Er. Shyam Nath	Online Training on Adobe Illustrator for scientific figures and illustrations (online mode)	SIAS RESEARCH FORUM
Technical staff			
May 23-25, 2022	Drs. Kamal K. Pande, Pankaj Nautiyal, Manisha Arya & Mr. Harish Chandra Joshi	Agri Buisness Management opportunities for youth (online mode)	SAMETI, (GBPUA& T Pantnagar), Uttarakhand
May 31-August 7, 2022	Dr. Pankaj Nautiyal	Statistical Techniques for Agriculturists (online mode)	Indian Institute of Technology, Kanpur, UP.
August 2-6, 2022	Mr. Devendra Singh Karki	Advances in Web and Mobile application development (online mode)	ICAR-NAARM, Hyderabad
Aug 22-23, 2022	Mr. Sachin Panwar	Training on Identifying constraints & enhancing resilience of various farming systems to climate change & variability in NICRA villages	ICAR-CRIDA Hyderabad
Aug 22-24, 2022	Dr. Manisha Arya & Mrs. Nidhi Singh	Advance vocational training for women of hill and tribal areas	Dr. R. S. Tolia Uttarakhand Academy of Administration (ATI), Nainital, Uttarakhand
September 27-30, 2022	Dr. Kamal Kumar Pande	Extension and Motivational Skills for Extension Officers	SAMETI, Pantnagar,Uttarakhand

October 8-9, 2022	Dr. Kamal Kumar Pande	Present status, challenges and prospects of small ruminants pastoralist	ICAR-CSWRI, North temperate regional centre, Gadhsa (Kullu) HP
October 10-12, 2022	Drs. Kamal Kumar Pande & Pankaj Nautiyal	Out Scaling Natural Farming through KVKs	Dr. YS Parmar University, Nauni, Solan, HP
December 3, 2022	Dr. Pankaj Nautiyal	Out Scaling Natural Farming through KVKs	RVSKVV, Gwalior (MP)
December 12-13, 2022	Dr. Nawal Kishor Singh	Natural Farming	Natural Farming Training Institute, Gurukul, Kurakshetra, Haryana
Dec 15-16, 2022	Mr. Neeraj Joshi	Out Scaling of Natural Farming through KVKs	Gurukul Kurukshetra
December 15-21, 2022	Dr. Nawal Kishor Singh	Natural Farming	Natural Farming Training Institute, Gurukul, Kurakshetra, Haryana
December 15 – 21, 2022	Ms. Rohini Khobragade	Computer Applications for Technical Personnel of ICAR	ICAR-IASRI, New Delhi.
Administrative staff			
November 15-19, 2022	Shri Sachin Kumar Pandey	Capacity Building Programme for ICAR-CJSC Members of ICAR Institutes/HQs being organized	ICAR-NAARM, Hyderabad

12. Awards & Recognitions

- Dr. A.R.N.S. Subbanna and Mr. Amit Umesh Paschapur received Edita David Memorial Award-2022.
- Mr. Amit Umesh Paschapur received Best Oral Presentation Award-2022 during the National symposium organized by IPS-MEZ chapter and ICAR-VPKAS, Almora.
- Mr. Amit Umesh Paschapur received Golden Achievers Award-2022 by Council for Academic and Performance Appraisal (CAPA), New Delhi.

- Mr. Amit Umesh Paschapur received Young Researcher Award-2022 by Society for Advancement in Agricultural Technology and Development, Bageshwar, Uttarakhand.
- Dr. Kushagra Joshi received Best Oral Paper Presentation Award for "Social network structures among the vegetable growers: Evidence from hill farmers of Uttarakhand" in GRISAAS-2022 during November 21-23, 2022 at Birsa Agricultural University, Ranchi, Jharkhand, India.

GRISAAS-2022

VII[th] International Conference on

Global Research Initiatives for Sustainable Agriculture & Allied Sciences

21-23 November 2022

Organized by :

Astha Foundation, Meerut (U.P.) India

Certificate

This is to certify that Dr./Er./Ms./Mr. Kushagra Joshi, ICAR VPKAS, Almora, Uttarakhand, India has presented his/her Paper (Oral) entitled "Social network structures among the vegetable growers: Evidence from hill farmers of Uttarakhand" authored by Kushagra Joshi and Jyoti Rawal, received Best Oral Presentation Award in Technical Session XI[th] of the VII[th] International Conference in Offline/Online on GRISAAS-2022 during 21-23 November 2022 at Birsa Agricultural University, Ranchi, Jharkhand, India

Dr. P.B. Singh, Organizing Secretary | Dr. Netrapal Malik, Organizing Secretary | Dr. S.P. Singh, Organizing Chairman

13. Linkages & Collaborations

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

13.1. 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

13.2. 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

13.3. International Organizations

- IRRI, Manila, Philippines
- CIMMYT, Mexico
- ICRISAT, Hyderabad, India
- ICARDA, Syria

13.4. 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

14. Important Committees of the Institute

14-1- jktHkk"kk dk;kUo;u lfefr

- डॉ0 लक्ष्मी कान्त– निदेशक, अध्यक्ष
- डॉ0 रेनू जेठी– वरिष्ठ वैज्ञानिक, सदस्या (31.05.2022 तक)
- डॉ0 प्रियंका खाती– वैज्ञानिक, सदस्या (01.06.2022 से)
- 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

14.2. Institute Joint Council (IJC)

Chairman – Dr Lakshmi Kant, Director

Members (Official Side) – Drs. N.K. Hedau, Pr. Scientist; Kushagra Joshi, Sr. Scientist; Shri R.S. Negi, Senior Administrative Officer; 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 (upto 22.03.2022); Mr. Omkar Pratap, Sr. Technician (*w.e.f.* 23.03.2022), Mr. Neeraj Kumar Pandey, Technical Assistant; Mr. Mohan Chandra Bhatt, Technician; Mr. Bhagwan Ballabh Tiwari, SSS

14.3. Research Advisory Committee (RAC)

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; Shri Sanjay Bisht, Non-Official/ farmer member (*w.e.f* 04.05.2022); Shri Sanjeev Deshta, Non-Official/ farmer member (*w.e.f* 04.05.2022)

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

14.4. Institute Management Committee (IMC)

Chairman – Dr Lakshmi Kant, 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 (upto 16.10.2022); Dr. Mamta Arya, Office In-Charge, NBPGR Regional Station, Bhowali (upto 16.10.2022); Dr. J.K. Bisht, ICAR-VPKAS, Almora (upto 16.10.2022); Dr. Lakshmi Kant, ICAR-VPKAS, Almora (upto 16.10.2022); Dr. Mukesh Kumar, PS & I/c IT Unit, ICAR-IASRI, New Delhi (*w.e.f.* 19.12.2022); Dr. Nityanand Pandey, Pr. Scientist, ICAR-DCFR, Bhimtal (*w.e.f.* 19.12.2022); Dr. N.K. Hedau, Pr. Scientist, ICAR-VPKAS, Almora (*w.e.f.* 19.12.2022); Dr. K.K. Mishra, Pr. Scientist, ICAR-VPKAS, Almora (*w.e.f.* 19.12.2022), Finance & Accounts Officer, IVRI, Bareilly (upto 09.08.2022); Sr. Finance & Accounts

Officer, IVRI, Bareilly (*w.e.f.* 10.08.2022); Shri Sanjay Bisht, Non-Official/ farmer member (*w.e.f* 04.05.2022); Shri Sanjeev Deshta, Non-Official/ farmer member (*w.e.f* 04.05.2022)

Member Secretary – Sr. Administrative Officer

14.5. Institute Research Council (IRC)

Chairman – Dr Lakshmi Kant, Director

Members – All the Scientists of ICAR-VPKAS, Almora

Member Secretary – In-charge (PME Cell)

14.6. 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. N.K. Hedau, Pr. Scientist & I/c Head, Crop Improvement Division

14.7. 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, Pr. Scientist; Finance and Accounts Officer

(*w.e.f.* 01.11.2022)

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

Members – In-Charge (PME Cell), Drs. R.K. Khulbe, Pr. Scientist; Shyam Nath, Scientist, Finance and Accounts Officer

14.8. 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

14.9. PERMISNET/PIMSICAR/HYPM

Nodal Officer – Dr. Kushagra Joshi, Sr. Scientist

14.10. 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

14.11. Vigilance Officer (VO)

Dr. J.K. Bisht, Pr. Scientist

14.12. Grievance Cell (GC)

(upto 20.10.2022)

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

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

(*w.e.f.* 21.10.2022)

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

Members - Drs. Priyanka Khati, Scientist; Farm Coordinator; Sr. Administrative Officer; Finance & Accounts Officer

14.13. Women Cell (WC)

Chairman - Dr. Renu Jethi, Sr. Scientist (upto 31.05.2022)

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

Member Secretary - Ms. Usha Birdi, Assistant (upto 05.04.2022)

14.14. Internal Complaint Committee (ICC)

Chairman - Dr. Kushagra Joshi, Scientist

Members - Mrs. Renu Sanwal, A.C.T.O.; Ms. Usha Birdi, Assistant (upto 05.04.2022); Mrs. Lata Harbola, Programme Coordinator, Chirag

14.15. Purchase Advisory Committee (PAC)

(Upto 26.09.2022)

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 – In-Charge (Purchase & Store

(*w.e.f.* 27.09.2022)

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

Members – Drs. R.K. Khulbe, Pr. Scientist ; Navin Chandra Gahtyari, Scientist ; Gaurav Verma, Scientist ; Amit Kumar, Scientist ; Sr. Administrative Officer; Finance & Accounts Officer

Member Secretary - Administrative Officer (Purchase & Store)

14.16. Standing Purchase Committee (SPC)

(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)

14.17. Technical Vetting/Screening Committee (TVC)

(Upto 26.09.2022)

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)

(w.e.f. 27.09.2022)

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

Members – Drs. P.K. Mishra, Pr. Scientist; K.K. Mishra, Pr. Scientist; Ramesh Singh Pal, Sr. Scientist; Er. Shyam Nath, Scientist ; Drs. Devender Sharma, Scientist; Manoj Parihar, Scientist; Mr. Amit Umesh Paschapur, Scientist ; Sr. Administrative Officer; Finance & Accounts Officer

Member Secretary - In-Charge (Purchase & Store)

14.18. Institute Bio-safety Committee (IBSC)

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

Members – Dr. Indra D. Bhatt, 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) Dr. K.K. Mishra, Pr. Scientist, Plant Pathology (Internal experts) Dr. Gaurav Verma, Scientist, Plant Pathology (Internal experts) *w.e.f.,* 08-08-2022 Dr. Rakesh Bhowmick, Scientist, Agricultural Biotechnology (Internal experts)

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

14.19. 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

14.20. Public Information Cell (PIC)

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

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

Program Coordinator, KVK, Bageshwar

Program Coordinator, KVK, Uttarkashi

14.22. Strengthening Statistical Computing for NARS

Nodal Officer- Dr. Kushagra Joshi, Scientist

14.23. *mKisan*

Nodal Officer – Dr. Kushagra Joshi, Scientist

14.24. Institute *Swachhta Abhiyan* Committee (ISAC)

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

Member – Mr. Lalit Mohan Tewari, AAO

14.25. Human Resource Development (HRD)

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

14.26. Research Data Management (RDM)

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

Co-Nodal Officer- Dr. Renu Jethi, Sr. Scientist (Upto 31.05.2022)

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

14.27. Institute Germplasm Identification Committee (IGIC)

Chairman- Dr. N.K. Hedau, Pr. Scientist & I/c Head, Crop Improvement Division

Member- Drs. R.K. Khulbe, Pr. Scientist; Shyam Nath, Scientist; Amit Pashchapur, Scientist

14.28. Innovation Cell (IC)

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

Members- Dr. Renu Jethi, Sr. Scientist (upto 31.05.2022); Dr. D.C. Joshi, Sr. Scientist; Sr. Administrative Officer

14.29. Mera Gaon Mera Gaurav (MGMG)

Nodal Officer- Dr. Kushagra Joshi. Scientist

14.30. Media Coverage (institute's technology) Committee

(Upto May 31, 2022)

Nodal Officer- In-Charge, Social Sciences

Members- Drs. Renu Jethi, Sr. Scientist (upto 31.05.2022); Kushagra Joshi, Sr. Scientist; Jitendra Kumar, Scientist; Amit Pashchapur, Scientist and Mr. Devendra Karki, Technician

(*w.e.f.* June 1, 2022)

Coordinator- In-Charge, Social Sciences

Members- Drs. Kushagra Joshi, Sr. Scientist; Manoj Parihar, Scientist (upto 23.12.2022), Devender Sharma, Scientist and Mr. Devendra Karki, Technician

15. List of Publications

15.1 Scientific Papers Published in Peer Reviewed Journals/Proceedings

Research Papers	NAAS Rating
Juliana P, He X, Poland, J., Roy K.K., Malaker, P.K., Mishra, V.K., Chand, R., Shrestha S., Kumar, U., Roy, C., Gahtyari, N.C., Joshi, A.K. and Singh P.K. (2022). Genomic selection for spot blotch in bread wheat breeding panels, full-sibs and half-sibs and index-based selection for spot blotch, heading and plant height. *Theoretical and Applied Genetics,* 135,1965–1983. https://doi.org/10.1007/s00122-022-04087-y	11.70
Guru, P.N., Mridula, D., Dukare, A.S., Ghodki, B. M., Paschapur, A. U., Samal, I. and Subbanna, A.R.N.S. (2022). A comprehensive review on advances in storage pest management: current scenario and future prospects. *Frontiers in Sustainable Food Systems*, 444.	11.63
Paschapur, A., Subbanna, A.R.N.S., Gupta, J., Parihar, M. and Mishra, K. K. (2022). Insect pest scenario in Uttarakhand Himalayas, India, under changing climatic conditions. *International Journal of Biometeorology*, 66, 1445–1460.	9.79
Stanley, J., Subbanna, A., Mahanta, D., Paschapur, A.U., Mishra, K. K. and Varghese, E. (2022). Organic pest management of hill crops through locally available plant extracts in the mid-Himalayas. *Annals of Applied Biology*, 1–15.	8.75
Paschapur, A.U., Subbanna, A.R.N.S., Singh, A.K., Jeevan, B., Stanley, J., Rajashekara, H., Mishra, K. K., Kant, L. and Pattanayak, A. (2022). *Alternaria alternata* strain VLH1: a potential entomopathogenic fungus native to North Western Indian Himalayas. *Egyptian Journal of Biological Pest Control*, 32(1), 1-15.	8.00
Paschapur, A.U., Bhat, S., Subbanna, A.R.N.S., Hedau, N.K., Mishra, K.K. and Kant, L. (2022). Insect pollinators of eggplant (*Solanum melongena* L.) in the Indian Himalayas and their role in enhancement of fruit quality and yield. *Arthropod-Plant Interactions*, 16, 349–360.	7.99
Kumar, U., Singh, D.K., Panday, S.C., Bisht, J.K. and Kant, L. (2023) Spatio-temporal trend and change detection of rainfall for Kosi River basin, Uttarakhand using long-term (115 years) gridded data. *Arabian Journal of Geosciences*, https://doi.org/10.1007/s12517-023-11244-0, 16, 173.	7.83
Paschapur, A.U., Bhat, S., Subbanna, A.R.N.S., Chaudhary, S., Hedau, N.K., Mishra, K.K. and Kant, L. (2022). Role of entomophily and artificial pollination in enhancing the quality and yield of seed onion (*Allium cepa* L.) in the Indian Himalayas. *Journal of Apicultural Sciences*, 66(02), 28-36.	7.53
Danu, N., Paschapur, A.U., Subbanna, A.R.N.S., Stanley, J., Singh, A. K., Bisht, I. and Gupta, J.P. (2022). Molecular characterization and estimation of cellulolytic potential of gut bacteria isolated from four white grub species native to Indian Himalayas. *Journal of Asia-Pacific Entomology*, 102036.	7.30
Dev, R., Hedau, N.K., Pal, R.S., Paschapur, A.U. and Kant, L. (2022). Assessment of genetic diversity in leafy mustard (Brassica juncea var. rugosa) germplasm for agro-morphological and biochemical traits in north-west Himalayan ecosystem using multivariate analysis. *Scientist*, 1(3), 5099-6017.	6.85
Maurya, R. P., Koranga, R., Samal, I., Chaudhary, D., Paschapur, A. U., Sreedhar, M. and Manimala, R.N. (2022). Biological control: a global perspective. *International Journal of Tropical Insect Science*, 1-18.	6.77
Gahtyari, N.C., Jaiswal, J.P., Sharma, D., Talha, M., Kumar, N and Singh, N.K. (2022) Genetic analysis and marker association of physiological traits under rainfed and heat stress conditions in spring wheat (Triticum aestivum L.). *Genetika* 54(3), 1049–1068. DOI: 10.2298/ GENSR2203049G	6.75
Singh, A.K., Paschapur, A.U., Mondal, T., Parihar, M., Mishra, K.K., and Kant, L. (2022). Molecular characterization of necromenic nematode Pristionchus pacificus and associated bacteria: A new record. *Indian Journal of Agricultural Sciences*, 92(10), 1253-1257.	6.37

Mishra K.K., Kant, L., Kumari, J. and Kumar, A. (2022). Mining of the national gene bank collection identifies resistance sources for loose smut of wheat in Northern Himalayan conditions. *Indian Phytopathology.* 10.1007/s42360-022-00540-6	5.95
Joshi K. (2022). Need Based Information Media for Farmers in Hill Regions of Uttarakhand: Implications for Extension. *Indian Journal of Extension Education,* 58(1), 136-141.	5.95
Bhat, S., Paschapur, A. U., Subbanna, A.R.N.S., Stanley, J., Gupta, J.P., Mishra, K.K. and Kumar, S. (2022). Genetic Divergence and Phylogeny of North-Western Indian Himalayan Population of Honey Bee (Hymenoptera: Apidae) Inferred from Mitochondrial DNA Sequences. *Indian Journal of Ecology,* 49(4), 1440-1448.	5.79
Singh, N.K., Upadhyay, A.K., Kamboj, A., Shukla, M., Ambwani, T.K., Kumar, R., Sharma, H. and Shukla, N. (2022). Evaluation of Various Methods for Genomic DNA Extraction from Pure Cultures of Lysis Resistant Campylobacters Isolated from Wild Animals. *J. Anim. Res.,* 12(05), 775-781.	5.43
Paschapur, A.U., Subbanna, A.R., Parihar, M., Bhat, S., Mishra, K.K. and Kant, L. (2022). Hornet pests of honey bees in the Indian Himalayas and a low cost trapping device for their eco-friendly management. *Emergent Life Sciences Research*, 8(1), 183-194.	5.41
Kumar, U., Singh, D.K., Panday, S.C., Bisht, J.K. and Kant, L. (2022). Development and evaluation of seasonal rainfall forecasting (SARIMA) model for Kumaon region of Uttarakhand. *Indian J. Soil Conserv,* 50(3), 190-198.	5.28
Nutan, D., Subbanna,A.R.N.S., Stanley, J., Paschapur, A.U., Gupta, J. P. and Bisht I. (2022). Efficacy of commonly used insecticides against Pleurostrict scarab beetles (Coleoptera: Scarabaeidae) native to Indian Himalayas. *Journal of Experimental Zoology India,* 25, 401-410.	5.25
Singh, N.K., Upadhyay, A.K., Maansi, Kumar, R., Kamboj, A., Ambwani, T. K., Sharma, H., Shukla, N. and Kumar, A. (2022). Comparative Studies on Growth Performance of Thermophilic Campylobacters Isolated from Wild Animals on Different Culture Media. *Biological Forum – An International Journal,* 14(2), 1060-1063.	5.11
Chandrashekara, C., Mishra, K.K., Stanley, J., Subbanna, A.R.N.S., Hooda, K.S., Pal, R.S., Bhatt, J.C. and Pattanayak, A. (2022). Management of diseases and insect-pests of French bean in Northwestern Indian Himalayan region using integrated approaches. *J. Hortl. Sci.*, 17(2), 448-460.	5.08
Paschapur, A.U., Subbanna, A.R.N.S., Gupta, J.P., Mishra, K.K. and Kant, L. (2022). How susceptible are the Indian, Himalayan populations of insect pests to novel groups of insecticides. *Biological Forum – An International Journal*, 14(1), 121-130.	5.05
Kumar, U., Kumar, J., Singh, S., Bisht, J.K. and Pattanayak, A. (2021) Construction of geotagged polytanks in higher hills of Uttarakhand for water resource development and management: Jal Shakti Abhiyan, *Indian Journal of hill Farming,* 34 (2), 21-28.	5.04
Bhat, S., Subbanna, A.R.N.S., Stanley, J., Paschapur, A. U., Gupta, J. P., Kumar S and Mishra, K. K. (2022). Molecular characterization and phylogenetic analysis of the native small carpenter bees (*Ceratina* spp.) of North Western, Indian Himalayas. *Asian Journal of Microbiology Biotechnology and Environmental Science*, 23 (2), 94-103	5.00
Nutan, D., Stanley, J., Paschapur, A.U., Subbanna, A.R.N.S., Gupta, J. P. and Bisht, I. (2022). Differential Susceptibility of Popillia cupricollis (Coleoptera: Scarabaeidae: Rutelinae) to Different Groups of Insecticides. *Applied biological Research*, 24(1), 115-118.	4.96
Bhat, S., Subbanna, A.R.N.S., Paschapur, A. U., Stanley, J., Kumar, S. and Gupta, J. P. (2022). Phylogeny of Indian Himalayan population of Bombus haemorrhoidalis Smith 1852 (Hymenoptera: Apidae) inferred from mitochondrial DNA sequences. *Entomon,* 47(1), 61-70.	4.69
Choudhary, M., Panday, S.C., Meena, V.S., Yadav, R.P., Singh, S., Parihar, M., Mishra, P.K., Bisht, J.K. and Pattanayak, A. (2022). Long-term tillage and irrigation management practices: impact on carbon budgeting and energy dynamics under Rice-Wheat rotation of Indian mid -Himalayan region. *Conservation*, 2,388-401. https:// doi.org/10.3390/conservation2020026	NA
Kumar, U., Panday, S.C., Kumar, J., Parihar, M., Meena,V.S., Bisht, J.K. and Kant, L. (2022). Use of a decision support system to establish the best model for estimating reference evapotranspiration in sub-temperate climate: Almora, Uttarakhand . *Agricultural Engineering International: CIGR Journal*, 24 (1), 41-50.	NA

15.2 Book/e-Book

Thakur MP, Singh RP, Singh HK and Mishra KK (2022). Compendium of Mushroom Diseases. Indian Phytopathological Society, IARI, New Delhi. 132p

15.3 Popular Articles

Joshi HC, Pande KK, Singh Nidhi and Mishra Krishna Kant. (2022). Bemausami mushroom utpadan ka badhata prachalan. *Phal Phool*. May-June, 32-34.
Mishra Krishna Kant, Gupta Jaiprakash and Kant L. (2022). Mahila krishak ki mushroom utpadan me uplabdhiyan. *Phal Phool*. March-April, 51-52.
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15.4 Book Chapters

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15.5 Institute Publications

- ICAR-VPKAS Newsletter Vol. 25 (No. 2)
- ICAR-VPKAS Newsletter Vol. 26 (No. 1)

15.6 Extension Leaflets

- 141/2022.

16. Consultancy, Patents & Commercialization of Technology

16.1. Commercialization of Institute Varieties and Machineries

Name of Technology	Date of MoA	Date of ending license	Name of company	Revenue earned (Rs.)
VL *Syahi Hal*	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 Small Tool Kit	27.04.2022	26.04.2025	Green Tech Solution, Deval Chaur Kham, Manpur West, Manpur West, Haldwani, Nainital-263139, Uttarakhand, India	90,000 + 16,200 (GST @ 18% of license fee)
	23.06.2022	22.06.2025	M/s Himalayan Hi-Tech Nurseries, 85, Subhash Nagar Bhotia Parao, Haldwani, Nainital-263139, Uttarakhand, India	90,000 + 16,200 (GST @ 18% of license fee)
VL Piaz 3	25.04.2022	24.04.2027	Sewa International, Plot No. 49, Deen Dayal Upadhyay Marg, New Delhi-110002	50,000 + 9,000 (GST @ 18% of license fee)
VL White Grub Beetle Trap 1	24.06.2022	23.06.2026	Doon Trunk House, Lower Mall Road, Almora, Uttarakhand – 263601, India	1.00 Lakh plus 18,000 (GST @ 18% of license fee)

Handing over the certificate to M/s Himalayan Hi-Tech Nurseries for the commercialization of VL Small Tool Kit

Handing over the certificate to Green Tech Solution for the commercialization of VL Small Tool Kit

Handing over the certificate to *Dunagiri Swayat Sahkarita* for the commercialization of VL Syahi Hal

17. RAC, IMC & IRC Meetings

17.1. Research Advisory Committee (RAC) Meeting

The XXVI Research Advisory Committee (RAC) meeting was held on September 15 & 16, 2022 under the Chairmanship of Dr. H. S. Gupta, Agricultural Farmer's Commission, Govt. of Assam (Former Director General, Borlaug Institute of South Asia (BISA) as well as Former Director, ICAR- IARI, New Delhi and ICAR-VPKAS, Almora). The RAC members namely Dr. Hemendra Chandra Bhattacharyya, Dean Daffodil College of Horticulture, DMET, Khetri, Assam; Dr. C. Chattopadhyay, Former Vice Chancellor, UBKV, West Bengal and Principal Scientist, CRIJAF, Kolkata; Dr. S. R. Maloo, Ex. Director Research, MPUAT, Udaipur; Dr. Anjani Kumar, Principal Scientist, IFPRI, New Delhi, Farmer's member Shri Sanjeev Deshta, Dr. Lakshmi Kant, Director, ICAR-VPKAS, Almora and Dr. J. K. Bisht, Member Secretary, RAC (ICAR-VPKAS) along with HODs and Scientists were also present in the meeting.

17.2. Institute Management Committee (IMC) Meeting

The meeting of Institute Management Committee was held at the institute on July 26, 2022 under the chairmanship of Director Dr. Lakshmi Kant. The other members Dr. J.K. Bisht, Pr. Scientist & Head, CPD; Dr. Raj Narayan, Pr. Scientist, ICAR-ATARI, Zone II, Jodhpur; Shri Sanjeev Deshta, non-official member; Shri Sanjay Bisht, non-official member; Mrs. Radhika Arya, Member Secretary also attended the meeting.

17.3. Evaluation of Experiments by Field Monitoring Team

The monitoring of field experiments during *Rabi* 2021-22 was carried out on April 07, 2022 and *Kharif* 2022 was carried out on September 23, 2022 at Experimental Farm, Hawalbagh. All the scientists participated and monitored the experiments. The progress of experiments was reviewed by the Director, Dr. Lakshmi Kant.

17.4. Institute Research Council (IRC) Meeting

The meeting of Institute Research Council (IRC) was held on May 5-6, 2022 for *kharif* 2022 and October 12-13, 2022 for *rabi* 2022-23 under the chairmanship of the Director Dr. Lakshmi Kant to discuss *kharif* and *rabi* programmes, respectively in length. The progress of all research projects was reviewed and new experiments were discussed.

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

Name of Scientist (s)	Conference/Seminar/Webinar/Workshop/Symposia/ Meeting
International	
Drs N C Gahtyari & Devender Sharma	1st International Symposium on Cereals for Food Security and Climate Resilience organized virtually from ICAR-IIWBR, Karnal during January 18-20, 2022
Drs K K Mishra & N C Gahtyari	Global wheat germplasm conservation and use community organized virtually by EWG germplasm on June 15, 2022
Dr Tilak Mondal	International Conference on "Advances in Agriculture and Food System towards Sustainable Development Goals" held at GKVK, Bangalore through virtual mode during August 22-24, 2022
Dr Kushagra joshi	VII International Conference on Global Research Initiative for Sustainable Agriculture and Allied Sciences during November 21-23, 2022
National	
Drs R K Khulbe & Devender Sharma	State seed availability meeting Zayad/Kharif 2022 through virtual mode organized by Directorate of Agriculture, Dehradun, Uttarakhand on January 20, 2022
Mr Amit U Paschapur	Annual review meeting of the Monitoring Pesticide Residues at National level scheme during February 18-19, 2022
Drs K K Mishra, Gaurav Verma, Ashish K Singh, Amit U Paschapur, Devender Sharma, Hitesh Bijarniya, Mahendar Singh Bhinda, Tilak Mondal	National Symposium on "Recent trends in Phytopathology to address emerging challenges for achieving food security" during February 21-22, 2022
Dr Devender Sharma	Workshop on 'OECD Seed Certification', through virtual mode organized by ICAR-IISS, Mau during February 21-24, 2022
Drs Lakshmi Kant & N C Gahtyari	Meeting on deciding priority traits for various centers through virtual mode organized by ICAR-IIWBR, Karnal on February 22, 2022
Dr Devender Sharma	National Conference on "Maize for Resource Sustainability, Industrial Growth and Farmers' Prosperity" through virtual mode during February 23–25, 2022
Dr Devender Sharma	Seventh meeting of Reconstituted Programme Steering and Monitoring Committee (PSMC) under Biotech-Krishi Innovation Science Application Network (Biotech-KISAN) through virtual mode on February 24, 2022
Dr Mahendar Singh Bhinda	National Webinar on "Biofortified Crops for Balanced Nutrition and Immunity Boosting" organized by ICAR-National Institute for Plant Biotechnology, New Delhi held on February 28, 2022
Dr Devender Sharma	Virtual meeting with NABARD officials on March 04, 2022
Dr R K Khulbe	NASF DH Maize project Annual Review meeting through virtual mode on March 07, 2022
Dr Tilak Mondal	12th edition of "Bengaluru India Nano- Virtual Event" held during March 7-9, 2022

Dr Devender Sharma	Training workshop on data visualization using R organized by ICAR-NAARM Hyderabad during March 9-11, 2022
Dr R K Khulbe	IP Workshop organized by ICAR-NIBSM, Raipur through virtual mode during March 15-16, 2022
Dr R K Khulbe	SPM and SMAM meeting at Secretariat, Dehradun on March 21, 2022
Dr K K Mishra	Executive Council Meeting of Indian Phytopathological Society, New Delhi at SKN Agric. University, Jobner-Jaipur, Rajasthan on March 22, 2022
Dr K K Mishra	8th International conference on Plant Pathology: Retrospect and Prospects organized by Indian Phytopathological Society, New Delhi and SKN Agric. University, Jobner-Jaipur, Rajasthan during March 23-26, 2022
Dr Mahendar Singh Bhinda	Sustainable Development Goals (SDG) workshop organized by Block Development Office, Hawalbagh on March 25, 2022
Dr N C Gahtyari	Field day selection for wheat and barley at Issapur farm, NBPGR, New Delhi on March 28, 2022
Dr Devender Sharma	Maize germplasm day organized by ICAR-IIMR Ludhiana on March 28, 2022.
Dr Devender Sharma	IMIC-Asia III Maize field day organized CIMMYT Asia at ICRISAT Hyderabad on March 29, 2022
Dr N C Gahtyari	Field day selection for wheat and barley at ICAR-IIWBR, Karnal on March 30, 2022
Drs R K Khulbe, J P Aditya & Devender Sharma	SVRC meeting through virtual mode on April 01, 2022
Dr R K Khulbe	SVRC meeting at Secretariat, Dehradun on April 04, 2022
Dr Syam Nath	SMAM meeting at Secretariat, Dehradun on April 04, 2022
Dr Rahul Dev	Monitoring of breeder's seed certification committee, VL Garlic, VL *Pyaz* 3 and VL *Sabji Matar* 13 at experimental farm Hawalbagh April 05, 2022
Dr N C Gahtyari	NHZ Wheat and barley monitoring of breeding, agronomy and Pathology trial at Almora, Majehra and Ranichauri during April 21-23, 2022
Drs R K Khulbe & Devender Sharma	65th Annual Maize Workshop at HAU, Hisar during April 19, 2022.
Drs K K Mishra, J P Aditya, Shyam Nath, Jitendra Kumar, Hitesh Bijarniya & Rahul Dev	Interface meeting with state officials on April 23, 2022
Dr Rahul Dev	"Anna data devo Bhawa" program under Azadi ka Amrit Mahotsav during April 23-24, 2022
Dr Rahul Dev	Program on Status and prospects of Organic and Natural farming on April 24, 2022.
Drs R K Khulbe & Devender Sharma	AICRP on Seed Technology Research meeting through virtual mode on April 25, 2022
Dr J P Aditya	57th Annual Rice Group Meeting at IIRR, Hyderabad during April 25-27, 2022
Drs Rahul Dev, Hitesh Bijarniya & Mahendar Singh Bhinda	*"Kisan bhagidari, prathimikita hamari"* on millets and biofortified crops: Scientist-farmer interaction on April 28, 2022
Dr Mahendar Singh Bhinda	33rd annual group meeting of AICRP on Small Millets organized by IIMR, Hyderabad through virtual mode during April 28-29, 2022
Drs R K Khulbe, J P Aditya, Devender Sharma & Mahendra Singh Bhinda	SVT Workshop Kharif 2022 through virtual mode on April 29, 2022
Er Hitesh Bijarniya	National Conference on "Promotion of Kisan Drones" at NASC, New Delhi on May 2, 2022
Dr K K Mishra	Meeting with District Magistrate at Collectorate office in Almora on May 09, 2022

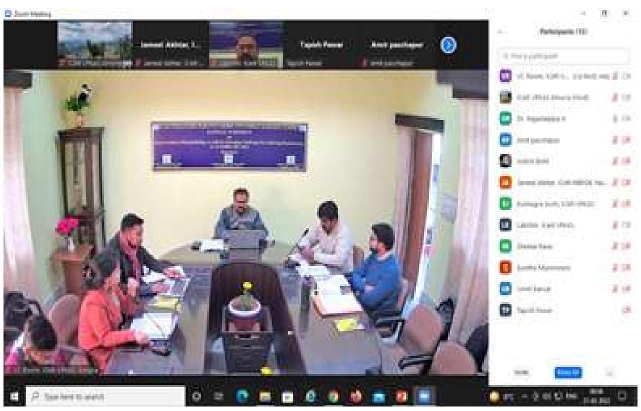
Drs R K Khulbe & Devender Sharma	AICRP on Seed Crops AGM through virtual mode during May 12-13, 2022.
Dr R K Khulbe	CRP Biofortification project review meeting through virtual mode during May 20-21, 2022
Dr R K Khulbe	CAS meeting of ICAR-IIAB, Ranchi scientists on May 21, 2022
Dr R K Khulbe	PPV&FRA programme at KVK, Kafligair (Bageshwar) and delivered lecture on Geographic Indications & Indigenous Traditional Knowledge on May 31, 2022
Dr Rahul Dev	National Conference on Underutilized Horticultural Genetic Resources: Conservation and Utilization (NCUHGR-2022) through online mode organized by Andaman Science Association (ASA), Central Agricultural Research Institute (CARI) Port Blair (Andaman) during June 03-04, 2022
Drs B M Pandey & Kushagra Joshi	Meeting of Network Project Partners organised by ICAR NIAP through virtual mode on June 09, 2022
Dr J P Aditya	International Conference on Innovative and Current Advances in Agriculture and Allied Sciences (ICAAAS-2022) through virtual mode during June 12-14, 2022
Dr K K Mishra, Rahul Dev	40th Annual group meeting of vegetable research workers during June 15-17, 2022
Dr J P Aditya	88th meeting of Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops through virtual mode on June 17, 2022.
Drs K K Mishra, Shyam Nath, Jitendra Kumar, Hitesh Bijarniya & Mahendar Singh Bhinda	Interface meeting and workshop between Scientists of ICAR-VPKAS, Almora and State officials of NEH region during June 27-29, 2022
Dr Jitendra Kumar & Hitesh Bijarniya	Demonstration of institute technologies to State officials of NEH region at farmers field in Darima, Mukteshwar on June 28, 2022
Dr K K Mishra	XXIV workshop of All India Coordinated Research Project on Mushroom at Maharana Pratap Horticultural University, Regional Mushroom Research Centre, Murthal (Haryana) during July 11-12, 2022
Dr Devender Sharma	Three-day symposium commemorating the birth bicentenary of Gregor Johann Mendel at NASC, New Delhi during July 19-21, 2022
Mr Amit U Paschapur	23rd Annual workshop of AINP on Soil Arthropod Pests organized at CSK HPKV, Palampur, Himachal Pradesh during July 20-21, 2022
Dr Devender Sharma	Refresher webinar on Fall Armyworm management in South Asia, organized by CIMMY through virtual mode on July 21, 2022
Dr R K Khulbe	Rabi Seed Meeting at Directorate of Agriculture, Dehradun on August 05, 2022
Dr K K Mishra	Pre workshop of crop protection of AICRP wheat and barley through virtual mode on August 12, 2022
Drs Lakshmi Kant, K K Mishra & N C Gahtyari	61st All India wheat & Barley workers meet at RVSKVV, Gwalior during August 29-31, 2022
Dr K K Mishra	Online meeting with Director, ICAR-IISWC, Dehradun on Sept 03, 2022
Drs Lakshmi Kant, RK Khulbe, D C Joshi, & Hitesh Bijarniya	Meghalaya Buckwheat Global Showcase Programme in Shillong during September 9-10, 2022
All scientist	XXVI meeting of Research Advisory Committee of the institute on September 15-16, 2022
Dr R K Khulbe	Monitoring of AICRP Maize Trials Kharif 2021 of Kangra, Bajaura and Dhaulakuan centres during September 21-24, 2022

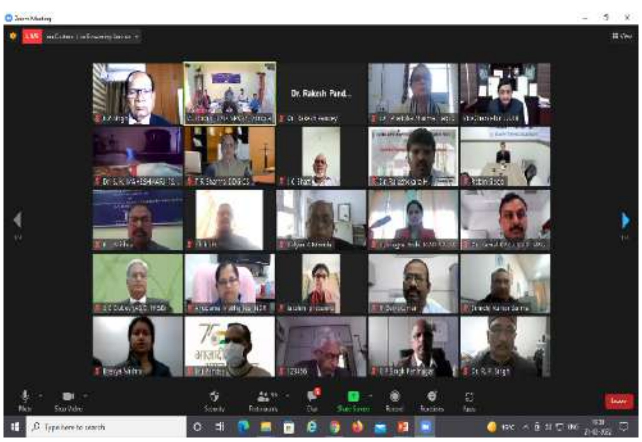
Drs K K Mishra, Shyam Nath, Jitendra Kumar & Hitesh Bijarniya, Mahendar Singh Bhinda, Rahul Dev, Tilak Mondal	Field workshop and discussion on the experiments conducted during *Kharif* on September 23, 2022
Dr J P Aditya	Soybean & Horsegram field day programme organized at Jyoli village on September 24, 2022
Dr J P Aditya	Organized Rice Field Day programme at Rawari village on September 30, 2022
Dr R K Khulbe	Monitoring of rice FLDs in Rajouri (Jammu) and interaction with Director, SKUAST-Jammu during October 7-8, 2022
Drs K K Mishra, Shyam Nath, Jitendra Kumar & Hitesh Bijarniya, Mahendar Singh Bhinda, Tilak Mondal	Institute Research Council (IRC) Meeting for Rabi 2022-23 during October 12-13, 2022
Drs K K Mishra, Shyam Nath, Jitendra Kumar, Hitesh Bijarniya & Mahendar Singh Bhinda, Tilak Mondal	Agri-start up conclave and PM *Kissan Samman Sammelan* on October 17, 2022
Dr J P Aditya	Germplasm Rice Field Day at NRRI, Cuttack on October 17, 2022
Dr J P Aditya	Virtual programme under Swachhta Campaign 2.0 on the topic "Crop Waste Management" on October 22, 2022
Dr K K Mishra	Workshop on Hill Agriculture for IAS trainees on November 03, 2022
Mr Amit U Paschapur	XVIII AZRA International Conference on Advances in Applied Zoological Researches towards Food, Feed & Nutritional Security and Safer Environment from November 10-12
Dr J P Aditya	International Conference on Global Research Initiatives for Sustainable Agriculture and Allied Sciences (GRISAAS-2022) at BAU, Ranchi during November 21-23, 2022
Dr J P Aditya	Programme on Constitution Day on 26.11.2022 at Hawalbagh.
Dr K K Mishra	Review meeting of AICRP on Mushroom on December 14, 2022
Dr R K Khulbe	Presented Almora Centre's report at AICRP on Maize QRT meeting at ICAR-IIMR Ludhiana during November 14-15, 2022
Dr Mahendar Singh Bhinda	Meeting for the International Year of Millets 2023 under the Chairmanship of DG, ICAR through virtual mode on December 15, 2022
Dr Amit Kumar	XVII Annual Group Meeting of AI-NPOF project at Ramakrishna Mission Vivekananda Educational and Research Institute(RKMVERI), Narendrapur (West Bengal) during December 28-30, 2022
Dr R K Khulbe	CAS meeting of ICAR-IIAB, Ranchi scientists on December 29, 2022

19. Trainings, Workshops, Seminars, Farmers' Days Organized

National Symposium on "Recent trends in Phytopathology to address emerging challenges for achieving food security"

Institute has organized a national symposium on 'Recent trends in Phytopathology to address emerging challenges for achieving food security' during February 21-22, 2022 through virtual mode in association with the Mid-Eastern Zone chapter of Indian Phytopathological Society (IPS), New Delhi. Dr. T. R. Sharma, Deputy Director General (DDG), Crop Science, Indian Council of Agricultural Research, New Delhi was the Chief Guest of the Inaugural function. More than 100 participants including Vice-Chancellors, Directors of ICAR institutes, Professors, students, faculty members from state agricultural universities, scientists registered and attended the symposium.





Training program on *"Parvatiya Krishi Hetu Unnat Utpadan Takniki"*

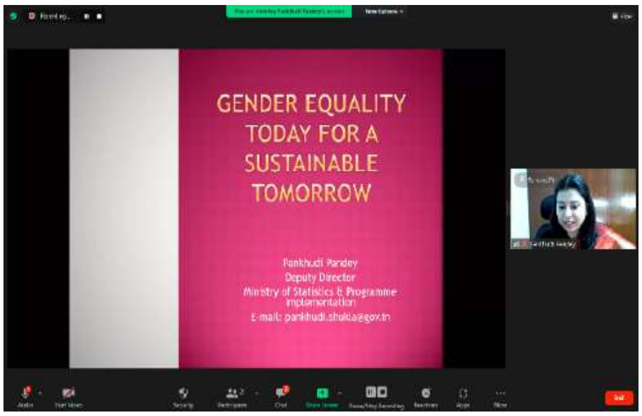
Institute organized 03 days training on *Parvatiya Krishi Hetu Unnat Utpadan Takniki* sponsored by Himotthan Society during March 7-9, 2022. A total of 28 persons including 4 progressive farmers attended the programme. During the training, the participants were appraised about various aspects of hill agriculture.

Short Course on Hill Agriculture

Institute organized three Short Courses on Hill Agriculture for 28 B.Sc. students during January 02-05, May 27-31, and June 17-21, 2022 at Experimental Farm, Hawalbagh. It was sponsored by Institute of Agricultural Sciences, BHU, Varanasi.

Organization of International Women Day

International Women's Day was organized on March 08, 2022. Smt. Reeta Durgapal, Chairperson of the Women Welfare Society was the Chief Guest on the occasion. On the occasion, three lectures were delivered by successful women in various fields and one progressive woman farmer was awarded. A total of 90 participants attended the function through online and offline modes.



Observation of Vigilance Awareness Week

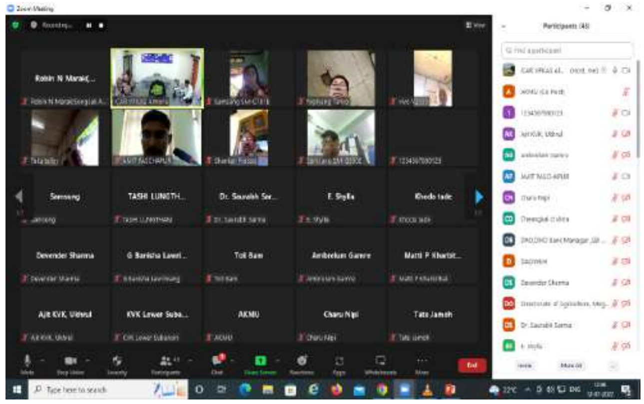
The Vigilance Awareness Week 2022 was observed from October 31-November 06, 2022 with the theme "Corruption Free India for a Developed Nation (भ्रष्टाचार मुक्त भारत– विकसित भारत) at ICAR-VPKAS, Almora. In this regard, as per the directions received from the Central Vigilance Commission and ICAR, various activities were organized at the institute.

Interface Meeting with officers of NEH region

For popularization and extension of technologies developed by the institute in NEH region, 03 days Interface Meeting was organized at ICAR-VPKAS, Almora during June 27-29, 2022. In this meeting 15 officers of NEH region and ICAR-KVKs (Meghalaya, Arunachal Pradesh, Nagaland and Mizoram) were participated.

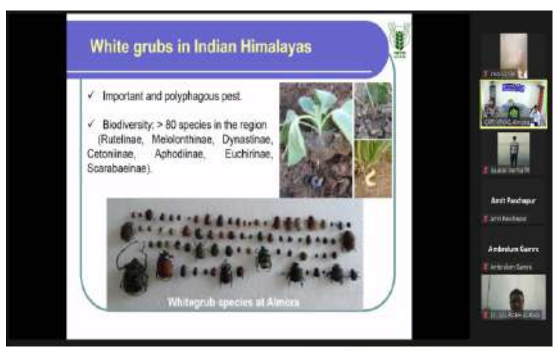
Virtual online training program on Fall Armyworm: Symptoms, Identification & Integrated Management Strategies

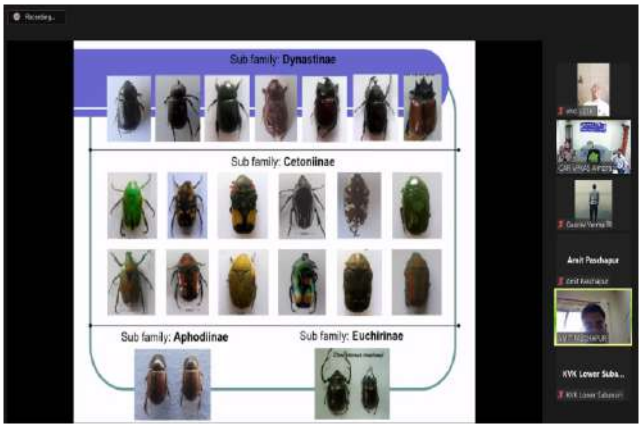
ICAR-VPKAS organized one-day virtual online training program on "Fall Armyworm: Symptoms, Identification & Integrated Management Strategies" on July 12, 2022. More than 48 officials from ICAR Institutes, state departments and KVKs of North Eastern Hill states (Meghalaya, Manipur, Mizoram, Assam, Arunanchal Pradesh, Sikkim, and Tripura) attended the training programme.



Virtual online training program on "White grubs: Symptoms of Damage and Integrated Management Strategies"

Institute has organized one-day virtual training program on "White grubs: Symptoms of Damage





and Integrated Management Strategies" on July 13, 2022. More than 51 officials from ICAR Institutes, state departments and KVKs of North Eastern Hill states (Meghalaya, Manipur, Mizoram, Assam, Arunanchal Pradesh, Sikkim, and Tripura) attended the programme.

Organization of Parthenium Awareness Week

ICAR-VPKAS, Almora organized 17th Parthenium Awareness Week during August 16-22, 2022. The institute made aware the farmers, school students and general public about the ill effects of *Parthenium* and its management.

Celebration of Himalayan Day

13th Himalayan Day was organized at Experimental Farm, Hawalbagh on September 09, 2022. The theme of Himalayan Day was "Himalaya: The Climate Governor". On the occasion, lectures on 'Climate resilient agriculture practices in the Indian Himalayas' and 'Insect pest scenario in changing climatic conditions of Indian Himalayas' were delivered.

Rice Field Day

Rice field day was organized on September 30, 2022 at Rawari village of Almora district to sensitize the farmers about improved varieties of rice developed by ICAR-VPKAS, Almora and also to take the feedback from the farmers for further improvement.

Organization of Agri-startup and PM *Kisan Samman Sammelan*

On October 17, 2022 Agri-startup conclave and Prime Minister *Kisan Samman Sammelan* of

Department of Agriculture & Farmers Welfare was telecasted at ICAR-VPKAS, Almora campus. On the occasion, Shri Ajay Tamta, MP, Almora was the Chief Guest and Shri Kailash Sharma, Former MP, Almora was the Guest of Honour. In the programme, a total of 350 farmers participated.

Celebration of Constitution Day

Constitution day was celebrated on 26th Nov 2022. On this occasion, a programme was organised at Experimental Farm, Hawalbagh in which students from Gyan-Vigyan Children Academy School and institute staffs were participated. Students were briefed and sensitized about the genesis of constitution day, Indian Constitution and eminent personalities involved in the development of Constitution. An oath ceremony by reading of preamble to the constitution of India was done.

National Mushroom Day

National Mushroom Day was organized at Experimental Farm, Hawalbagh of ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora on December 23, 2022. This special day is celebrated every year to promote awareness amongst farmers about the importance of mushrooms and their cultivation technologies. On the day, an interaction was organized in which scientist and farmers shared the knowledge on various aspect of mushroom production. Farmers shared their experiences and problems in mushroom farming and made the scientist aware about the problems faced by them while adopting the mushroom technologies. The farmers were encouraged about importance and benefits of scientific mushroom cultivation.

Organization of DST sponsored High-End Workshop on Plant Pest/Pathogen Diagnostics for Hill Agriculture under Accelerate Vigyan Scheme

ICAR-VPKAS, Almora organized 10 days high end workshop on "Hands-on training workshop on plant pest/pathogen diagnostics associated with hill agriculture" under Accelerate Vigyan Scheme sponsored by DST-Science and Engineering Research Board (SERB), New Delhi during December 20-30, 2022. The workshop was specifically designed for Post-Graduate and PhD students to impart contemporary pest/pathogen diagnostics technique associated with hill agriculture. The 10 days course developed with different lectures on insect pest, nematode and disease diagnostic technique followed by hands on practical by the experts. Twenty M.Sc. & Ph.D. research scholars from different states *viz*. Himachal Pradesh, Odisha, Karnataka, Telangana, Maharashtra, Uttara Pradesh, Uttarakhand, Jammu, Rajasthan are participated in the workshop. Dr. Ashish Kumar Singh, Dr. Gaurav Verma and Dr. K.K. Mishra were the coordinator of the event.

20- jktHkk"kk lEcU/kh xfrfof/k;k¡

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
- डॉ0 प्रियंका खाती– वैज्ञानिक, सदस्या (01.06.2022 से)
- 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 बैठक प्रत्येक तिमाही में की जाती है। वर्ष 2022 के दौरान समिति की बैठकें क्रमशः 26.03.2022, 27.06.2022, 22.09.2022 एवं 28.12.2022 को आयोजित की गयी। राजभाषा वार्षिक कार्यक्रम की विभिन्न मदों में 'क' एवं 'ख' क्षेत्र के साथ हिन्दी पत्राचार के लिए 100 प्रतिशत का लक्ष्य रखा गया है तथा 'ग' क्षेत्र के साथ 65 प्रतिशत का लक्ष्य रखा गया है। संस्थान द्वारा 'क' क्षेत्र के साथ लगभग 80–82 प्रतिशत 'ख' क्षेत्र साथ 70–72 प्रतिशत तथा 'ग' क्षेत्र के साथ 65–70 प्रतिशत पत्र व्यवहार किया जा रहा है। राजभाषा अधिनियम की धारा 3(3) का अनुपालन सुनिश्चित किया जा रहा है। वार्षिक कार्यक्रम में नोटिंग के लिए 75 प्रतिशत का लक्ष्य रखा गया है, जबकि संस्थान द्वारा 95 प्रतिशत से अधिक नोटिंग का कार्य हिन्दी में किया जा रहा है। संस्थान द्वारा संचालित सभी प्रशिक्षण कार्यक्रमों में व्याख्यान हिन्दी में तैयार किए जाते हैं तथा सभी प्रशिक्षण कार्यक्रम हिन्दी में ही सम्पन्न होते 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 2022 से 30 सितम्बर 2022 तक 'हिन्दी पखवाड़ा' का आयोजन किया गया। पखवाड़े के दौरान अनेक कार्यक्रम जैसे कि हिन्दी टिप्पण एवं प्रारूप लेखन प्रतियोगिता, हिन्दी निबंध प्रतियोगिता, कम्प्यूटर पर यूनिकोड में हिन्दी टाइपिंग प्रतियोगिता, स्वरचित हिन्दी काव्य पाठ प्रतियोगिता आदि का आयोजन किया गया। हिन्दी पखवाड़ा के दौरान दिनांक 14.09.2022 को हिन्दी दिवस समारोह एवं 30.09.2022 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 की छमाही बैठकें निर्धारित समय पर आयोजित की जाती हैं। वर्ष 2022 के दौरान ये बैठकें 27.07.2022 एवं 21.12.2022 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 हैं। 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

- Shri Lokesh Agarwal, Member of Indian Science Congress & Student Agriculture, BHU visited institute on January 04, 2022.
- Shri Honey Mishra, IAS, BHU visited institute on January 04, 2022.
- Swami Suhitananda, Vice President, Ramakrishna Math and Mission, Belur Math, visited institute on May 13, 2022.
- Dr. A.K. Singh, Director, ICAR-Indian Agricultural Research Institute, New Delhi visited institute on July 03 - 04, 2022.
- Shri S.K. Ghosh, Devotee of Swami Vivekananda, Bandra, Mumbai visited institute on November 8, 2022.
- Dr. W.S. Lakra, Former Vice Chancellor, CIFE, Mumbai visited institute on November 19, 2022.
- Dr. Ashok Kumar, Director, Fisheries, ICAR Head Quarter, New Delhi visited institute on November 20, 2022.
- Dr. B.P. Mohanty, ADG (Fisheries), ICAR, New Delhi visited institute on November 20, 2022.
- Dr. K. M. L. Pathak, Former DDG (AS) & Vice Chancellor, DUVASU, Mathura visited institute on November 20, 2022.
- Prof. Jeet Ram, Dean, Agriculture & Agroforestry, Kumaun University, Nanital visited institute on November 25, 2022.

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

Dr. Jay Prakash Aditya, Sr. Scientist (Plant Breeding)

Dr. Anuradha Bhartiya, 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. Navin Chander Gahtyari, Scientist (Genetic & Plant Breeding)

Dr. Devender Sharma, Scientist (Genetic & Plant Breeding)

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. Tilak Mondal, Scientist (Agricultural Chemistry)

Dr. Vijay Singh Meena, Scientist (Soil Science) (on deputation *w.e.f.* 26.05.2020)

Dr. Amit Kumar, Scientist (Agronomy)

Dr. Shyam Nath, Scientist (Farm Machinery & Power)

Dr. Jitendra Kumar, Scientist (Soil and Water Conservation Engineering)

Dr. Manoj Parihar, Scientist (Soil Science) (upto 23.12.2022)

Dr. Rajendra Prasad Meena, Scientist (Agronomy)

Er. Utkarsh Kumar, Scientist (Land & Water Management Engineering) (on study leave)

Dr. Priyanka Khati, Scientist (Agricultural Microbiology)

Er. Hitesh Bijarniya, Scientist (Farm Machinery & Power)

Crop Protection Division

Dr. K.K. Mishra, Principal Scientist (Plant Pathology) & I/c Head

Dr. Gaurav Verma, Scientist (Plant Pathology)

Dr. Ashish Kumar Singh, Scientist (Nematology)

Mr. Jeevan B., Scientist (Plant Pathology) (upto 03.09.2022)

Mr. Amit Umesh Paschapur, Scientist (Agricultural Entomology)

Social Science Section

Dr. B.M. Pandey, Principal Scientist (Agronomy) & I/c

Dr. Renu Jethi, Scientist (Home Science Extension) (upto 31.05.2022)

Dr. Kushagra Joshi, Scientist (Home Science/ FRM)

Coordinators/ In-charge

Library

Dr. P.K. Mishra

AKMU

Dr. Renu Jethi (upto 31.05.2022)

Dr. Kushagra Joshi (*w.e.f.* 01.06.2022)

PME Cell

Dr. J.K. Bisht, In-charge

Experimental Farm

Dr. K.K. Mishra, Pr. Scientist-Farm Coordinator

Shri D.C. Mishra, ACTO, Farm Superintendent (upto 26.04.2022)

Dr. G.S. Bisht. ACTO, Senior Farm Superintendent (*w.e.f.* 27.04.2022)

Shri Narayan Ram, TO, Junior Farm Superintendent (*w.e.f.* 27.04.2022)

Vehicle

Mr. Lalit Mohan Tewari, Asstt. Administrative Officer

Guest House

Dr. K.K. Mishra, Pr. Scientist

Shri Sanjay Kumar Arya, ACTO

Shri Keshav Nautiyal, Technical Asstt. (*w.e.f.* 02.11.2022)

Maintenance

Mr. Lalit Mohan Tewari, Asstt. Administrative Officer

Krishi Samridhi Radio Programme

Dr. Kushagra Joshi

Technical Staff

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. J.K. Arya, STO

Shri. O.P. Vidhyarthi, TO

Shri. C.S. Kanwal, TO

Shri Ramesh Singh Kanwal, TO

Shri. Narayan Ram, TO

Shri Vijay Pal Singh, TO (Pump Operator)

Shri Neeraj Kumar Pandey, STA

Shri Manoj Bhatt, STA

Shri Jaiprakash Gupta, STA

Shri Saleem, STA

Shri Keshav Nautiyal, TA

Shri Sachin Singh Pawar, TA

Shri Omkar Pratap, ST

Shri Rajendra Prasad, ST

Shri Devendra Singh Karki, Technician

Shri Ajit Bisht, Technician

Shri Surendra Singh, Technician

Shri Mohan Chandra Bhatt, Technician

Shri Ramesh Chandra Pant, Technician

Shri Shiv Kumar, Technician

Administration and Finance

Senior Administrative Officer

Mr. R.S. Negi

Assistant Administrative Officers

Mrs. Radhika Arya

Mr. Lalit Mohan Tewari

Finance & Accounts Officer

Mr. R.S. Negi, I/c FAO

Store

Shri Sanjay Kumar Arya

Managerial Staff at KVK, Chinyalisaur

Dr. Chitrangad Singh Raghav, Pr. Scientist-cum-Head

Dr. Pankaj Nautiyal, CTO/ T-9, Horticulture

Ms. Manisha, ACTO, Home Science

Managerial Staff at KVK, Bageshwar

Dr. Kamal Kumar Pandey, ACTO, Horticulture

Dr. N.K. Singh, ACTO, Veterinary Science

Dr. H.C. Joshi, ACTO, Plant Protection

Shri. Medni Pratap Singh, Farm Manager/T-6 (upto 04.11.2022)

Smt. Nidhi Singh, Prog. Asst. (Lab Technician) T-6

Retirement

Sh. Prahlad Singh, Senior Technician - 31.01.2022

Sh. Umed Singh, Skilled Supporting Staff - 31.01.2022

Sh. Krishna Lal, Technical Officer - 31.05.2022

Sh. Harish Chandra Upadhyay, Skilled Supporting Staff - 31.05.2022

Sh. Kailash Singh, Skilled Supporting Staff - 31.07.2022

Sh. Pramod Kumar Chaudhary, Private Secretary - 30.11.2022

Obituary

Sh. Vinod Lal Balmiki, Skilled Supporting Staff - 06.03.2022

Transfer

Ms. Usha Birdi, Assistant to ICAR-IIMR, Ludhiana 05.04.2022

Dr. Renu Jethi, Sr. Scientist to ICAR-DCFR, Bhimtal 31.05.2022

Dr. Jeevan B., Scientist to ICAR-NRRI, Cuttack (Odisha) 03.09.2022

Sh. M. P. Singh, Farm Manager/T-6 to KVK, ICAR-CIAE, Bhopal 04.11.2022

Dr. Manoj Parihar, Scientist to ICAR-CAZRI, Jodhpur 23.12.2022

Promotion

Dr. Dibakar Mahanta, Senior Scientist (Research Level -13A) *w.e.f.* 01.07.2020

Dr. Dinesh Chandra Joshi, Senior Scientist (Research Level -13A) *w.e.f.* 15.12.2021

Dr. Renu Jethi, Senior Scientist (Research Level -13A) *w.e.f.* 15.12.2021

Dr. Jay Prakash Aditya, Senior Scientist (Research Level -13A) *w.e.f.* 07.01.2022

Dr. Kushagra Joshi, Senior Scientist (Research Level-12) w.e.f. 01.01.2022

Dr. Mahipal Chaudhary, Scientist (Research Level-11) *w.e.f.* 01.07.2020

Dr. Manoj Parihar, Scientist (Research Level-11) *w.e.f.* 05.07.2021

Sh. Jagdish Kumar Arya, Senior Technical Officer *w.e.f.* 17.01.2021

Sh. Vikram Singh, Technical Assistant/T-3(Driver) *w.e.f.* 28.01.2020

Sh. Mohan Chandra Bhatt, Technician/T-1 *w.e.f.* 28.01.2022

Sh. Surendra Singh Gwal, Technician/T-1 *w.e.f.* 28.01.2022

Sh. Ramesh Chandra Pant, Technician/T-1 *w.e.f.* 28.01.2022

Sh. Shiv Kumar, Technician/T-1 *w.e.f.* 28.01.2022

Sh. Charu Chandra Joshi, Private Secretary (Level -7) *w.e.f.* 12.12.2022

Study Leave

Mr. Utkarsh Kumar, Scientist, Land & Water Management Engineering

23. Human Resource Development (HRD)

A. Physical targets and achievements

Category	Total No. of Employees	No. of trainings planned for 2022 as per ATP	No. of employees undergone training during Jan-June 2022	No. of employees undergone training during July to December 2022	Total no. of employees undergone training during January to December 2022	% realization of trainings planned during 2022
1	**1**	**3**	**4**	**5**	**6 (4 + 5)**	**Col. 6*100/ Col. 3 = 7**
Scientist	31	14	03	01	04	28.57
Technical	29	09	04	06	10	111.11
Administrative & Finance	14	03	00	01	01	33.33
SSS	36	0	00	00	00	0.00
Total	110	26	**07**	**08**	**15**	**57.7**

B. Financial targets and achievements (All employees)

RE 2022 for HRD (Rs.)	Actual Expenditure up to December 31, 2022 for HRD (Rs.)	% Utilization of allotted budget
1	**2**	**2*100/1=3**
2,00,000.0	**81,912.0**	**41.0**

भाकृअनुप
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch