Annual Report
2012 - 2013

Vivekananda Parvatiya Krishi Anusandhan Sansthan
(Indian Council of Agricultural Research)
ALMORA - 263 601, Uttarakhand
PREFACE

Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, shoulders the responsibility of carrying out research and extension to uplift the status of hill agriculture in north-western Himalayan region under the aegis of its apex body – the ICAR. In this quest, the institute has formulated 21 institutional and 31 externally funded projects. This document presents the accomplishments made in different projects during 2012-13.

During the period, two varieties of maize, viz., Vivek Maize Hybrid 45 and Vivek QPM 21, were released for Zone I and Uttaranchal, respectively. Besides, five entries, one each in rice, finger millet, barley, rice bean and groundnut, are in different stages of release. A genetic stock of wheat VW 0826 (Raj 3777/ MV-EMESE) has been identified for more number of tillers/m through All-India testing for three years. This year, 21.89 q nucleus, 236.55 q breeder, and 53.82 q truthfully labeled seed of different varieties of hill crops were produced. The farmers’ participatory seed production programme helped in procurement of 109.26 q seed produced at farmers’ fields.

The institute also commercialized its two technologies, viz., Vivek QPM 9 and VL Shyahi Hal along with small tools. Varietal demonstrations on farmers’ field and organizing more than 30 farmers’ fairs, training programmes and field days, I am sure, will go a long way in adoption of improved technologies in the region.

Sincere efforts and hard work of its scientists and other staff, with the unstinted support and valuable guidance from the Council, in general, and Division of Crop Science, in particular, have played a significant role in realizing the output. In recognition of quality of research work, institute’s scientists were honoured by different agencies.

I sincerely thank the Secretary (DARE) & DG, DDG (Crop Science) and ADG (Food & Fodder Crops), ICAR, for their generous support to VPKAS. I also express my sincere appreciation to Editorial Board, all my colleagues for their dedicated efforts and congratulate the Coordinator and staff of PME Cell for bringing out this publication in time.

Almora
July 4, 2013

(J.C. Bhatt)
Director
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EXECUTIVE SUMMARY

Enhancement in the Productivity of Major Hill Crops

During the year, an extra-early single cross hybrid maize variety Vivek Hybrid 45 was released and notified for Zone I (Uttarakhand, H.P. and J&K). A quality protein maize, Vivek QPM 21 was also released which is the second extra-early QPM single cross hybrid developed in the country through MAS. It possesses 73.5% higher tryptophan content and has 9.5% protein as compared to 8.5% in 'Vivek Maize Hybrid 21'. Besides, 5 entries in five crops are at different stages of release and notification. These include rice (V1. 31077), barley (VLB 118), finger millet (VL 348), rice bean (VRB 3), and groundnut (VLGN 13). A genetic stock of wheat VW 0826 (RAJ/3777/ME-MV-EMES) was identified for number of tiller/m. The numbers of tillers in VW 0826 were 84 as compared to 81.7 in HD 2009 (best check).

Physiological basis of drought tolerance was studied in different crops. In rice, relative water content and photosynthetic efficiency exhibited significant positive correlation with grain yield. Rice genotypes V1. 8549, V1. 8724 and VL 8732 showed significantly higher grain yield. Among eight wheat genotypes, V1. 907, VL 832 and VL 892 showed better physiological response under late sowing. Soybean genotypes exposed to drought stress during reproductive stage showed reduced activity of all physiological parameters. However, VLS 47 and VS 28018-50 exhibited significantly better physiological traits for drought tolerance.

Finger millet genotypes VL 325, VL 336, VL 341, V1. 342, VL 347, V1. 373, HR 374, VR 708, VL 333, GPHCPB 7 and GPHCPB 3 possess higher condensed tannins, total phenols, total anti-oxidant activity and crude fibre.

A total 236.55 q breeder seed of 67 released varieties/inbreds of different crops was produced. Around 21.89 q nucleus seed of 37 released varieties and 53.82 q truthfully labeled (TL) seed was also produced. In addition, 64.56 q TL seed of different crops was supplied to meet the demand of institute extension activities. Under farmers' participatory seed production programme, 109.26 q seed of various crops was produced at farmers' fields at different places.

Vivek QPM 9 developed through MAS was licensed to "M/s Hindustan Insecticide Limited, New Delhi" for commercial production and marketing. They are producing more than 1000 quintals of hybrid seed in West Bengal.

Natural Resource Management for Enhancing the Productivity

In soybean-wheat cropping sequence, phosphorus-enriched compost was found to be at par with single super phosphate in terms of system productivity, harvest index, agronomic efficiency, partial factor productivity and P recovery efficiency. Application of FYM resulted in 19 and 30% higher grain yield of lentil (1,610 kg/ha) than in INM and chemical treatments, respectively.

In colocasia-based vegetable relay intercropping systems, the system productivity and sustainable yield index was highest under colocasia-onion-french bean (57.38 t/ha) and colocasia-garden pea-french bean system (0.86), respectively. Colocasia-onion-french bean system with higher productivity improved soil fertility and enzymatic activities.
Among different finger millet varieties, VL 347 was found best for late sown condition up to 5th August.

The impact of resource conservation technologies in the rice-wheat cropping system indicated that conventional tillage in rice and zero tillage in wheat proved better in terms of grain yield. The time-trend of rice and wheat yield over a period of six years showed that rice yield has a decreasing trend while that of wheat yield has increasing trend.

Single inoculation of cold tolerant bacterial strains PBRs5 and NAIRs9 enhanced lentil yield in by 16.9 and 18.9%, respectively. Inoculation with Azospirillum sp. strain A5 enhanced shoot nitrogen uptake in rice by 24.1 and 24.7% at 30 and 60 DAT. Bacterization with Pseudomonas fragi CS11RPI significantly enhanced soybean yield by 24.6%.

Application of glyphosate through newly developed weed wiper resulted in the weed control efficiency of 78% in peas crop after 12 days of application. The wiper could cover 0.032 ha/hour with labour requirement of 31 man hours/ha. The draft observed was 10-20% higher in local hal than VL Skyahi hal.

Fescue grass Hima-14 produced the highest green forage. Among Setaria grass entries, S-25 produced significantly higher (86.409 kg/ha) green biomass. In cowpea, entry AVTC-2-3 gave significantly higher green forage. In dual purpose wheat, VL 934 produced significantly higher green forage, however, highest grain yield was recorded in VL 829. The best lopping technique for the Quercus infectoriophora grown under close plantation was found pollarding tree at 2 m for green forage production. Yield of grasses increased with the intercropping with leguminous hedge and the highest green forage (76,930 Kg/ha) was obtained from intercropping of Hybrid Napier with desmodium.

Higher rice and wheat yields and, water expense efficiency were obtained under zero tillage. Continuous application of either FYM or FYM in combination with NPK in a wheat-soybean rotation improved soil moisture capacity and organic carbon content. The LDPE film covered with cement and concrete blocks, and soil was found economical and most suitable for protecting the lining from damage.

Integrated Pest Management

Blast of rice, turcicum leaf blight and banded leaf and sheath blight of maize, F vợege leaf spot (FLS) of soybean were recorded in moderate to severe intensities. Sclerotium rolfsii of maize was observed for the first time. Yield losses in soybean due to FLS varied from 3.05% to 37.25%. Moderate infestation of aphids in finger millet, blister beetles in okra, maize, pigeonpea and french bean, fruit flies in squash, capsicum and tomato, sucking bug and soybean beetle in soybean was observed. Severe infestations of sucking pests like white flies in tomato, cucurbits and capsicum, mites and thrips in capsicum and french bean in polyhouses were noticed. A whitely predatory coccinellid, Serangium montraeousi was collected from Kausani.

Promising entries / genotypes against major diseases and insect pests were identified in different crops. Maize lines V400 and V405 were found to be resistant to Sitophilus weevill. Rice entries Raminad str 3, Tudacan and C 101 LAC were highly resistant to Pyricularia oryzae at Hazaribagh.

Adoption of IPM showed an increase of 26.5 and 7.5% in the rice yields at farmers’ fields in two villages. Fifteen new Trichoderma isolates showed in vitro antagonistic activity against soil borne pathogens. Ten isolates of Bacteriovora solanacearum were found to be of biovar 3.
Three entomopathogenic fungal isolates showed 50-100% mortality of adult blister beetles. Most of the Bacillus thuringiensis (Bt) isolates had a combination of cry IAa, IAe, IB, IC and 1D genes followed by cry IAa, IAe, IB, IC, 1D, 2A and 2B. Fifteen root nodule inhabiting Bt isolates showed the presence of 130 KDa protoxin.

A total of 18,261 white grub beetles were trapped in 11 light traps at Hawalbagh of which 78.4% were trapped in July. Amongst 22 species, Anomala dimidiata was the most predominant. VI. white grub beetle trap with anisole is found very effective in attracting male Holotrichia seticollis beetles. The attraction efficiency of anisole was up to 150 m. The female released pheromones of H. seticollis were extracted and got identified as 1,2,1,3 and 1,4 diethyl benzene isomers. Methyl eugenol and cineole were used to trap fruit flies in the polyhouse.

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

Generic stock module database was developed for 13 major hill crops. An E-book was prepared on ‘DUS Characterization of VPKAS Maize Varieties and Inbreds’. Agricultural database for major hill crops of north-western and north-eastern Himalayan states was updated. Data was collected from 60 extension personnel through a questionnaire on usage of ICT in hills. A training manual on communication methodologies was prepared and two on-farm sensitization trainings were conducted for the farmers of Mudiyani and Ron-Dal cluster of villages, on various aspects of ICT.

A document comprising of various physiological and participatory ergonomics and, nutritional methodologies was compiled for quantification of drudgery and nutritional status of hill women. A framework for ergonomic methodologies was prepared. An interview schedule was prepared and pretested on role of farm women. An interview schedule to collect data of hill women on crop cultivation, animal husbandry and poultry activities was prepared.

The study on adoption of VPKAS technologies in Kinnaur Hill's revealed that 50% of the farmers in adopted village were solely engaged in agriculture and remaining 50% were involved in other occupation along with agriculture. In non-adopted village, all the farmers were dependent upon other occupation along with agriculture. It is due to the positive impact of adoption of technologies in terms of profit earned, that farmers showed high level of economic motivation, high risk bearing ability, less constraints, high level of aspiration, higher credit utilization and higher social participation in adopted villages. The difference in the average annual income between adopted and non-adopted village was about Rs. 12,000 and the percentage of high income category was four times higher in the adopted village.

**Other Research Projects**

*Horticulture Mission for North East and Himalayan states Mini Mission-I Projects*

Under different projects in this scheme, the salient points are: (i) 1,905 kg seeds of different vegetables were produced for various groups of users; (ii) three ladder system of pruning was found to be the best for tomato as well as capsicum under protected condition; (iii) four promising hybrids were developed in gerbera and chrysanthemum; (iv) 39 trainings/ field days/field schools were conducted benefiting more than 1,200 participants; (v) 442 demonstrations were laid on off-season vegetable and mushroom production; (vi) the total number of LDPE tanks and polyhouses in farmers’ fields has reached 207 and 160, respectively; (vii) ten potential bacterial
isolates were identified for PGP traits; (viii) 62.34 and 58.76% reduction in June and July 2012 white grub reduction, with regard to corresponding populations in 2008, was observed using light traps along with entomopathogen, *Bacillus cereus* strain WGPSPS 2 in 5 villages; (ix) planned honey bee pollination increased seed yield by about 20% in different vegetables and fruit set in apple, apricot and plum; (x) significant increase in yield of fruits and seeds of vegetable crops was obtained by planned honey bee pollination of these crops; (xi) Todhra Dadvali Kisan Club formed under the project received district level best farmers club award for 2012-13; and (xii) Molecular markers linked to mitochondrial gene ‘coI’, markers *OFT* and *PstO* were used to identify sterile, true restorer and maintainer lines in onion for hybrid seed production.

**DBT Projects**

To increase the tryptophan level in maize hybrids, around 600 plants from each population were selected from respective backcross population (VQ1, VQ2 and VQ1 17) for foreground selection. The background selection was conducted on the selected plants. The selected plants were backcrossed to their respective recipient parents and the BC$_2F_1$ population was generated. The plants available for foreground selection were 547 for VQ1 1 x CML 180, 448 for VQ1 2 x CML 170 and 415 for VQ1 17 x CML 159. Subsequently, the plants available for background selection were 220, 170 and 159, respectively.

In order to incorporate durable blast resistance in V1 Dhan 207 and V1 Dhan 85, pyramiding of two or more resistant genes was done using MAS. Progenies from six crosses were used for foreground and background selections. The background selection was conducted in the BC$_3F_1$ and BC$_2F_1$ generations. Selections were made based on high recipient genome recovery, morphology of the plants and the agronomic worth of the plants. The recipient genome recovery was up to 96.15% among the crosses.

Two resistant genes *Yr5* and *Yr10* were used for pyramiding in high yielding awnless wheat variety, VL Gehun 738 to incorporate yellow rust resistance. A total about 425 seeds of each BC$_2F_1$ population were sown at Dalang Maidan. The plant having more than 90% genome recovery in case of *Yr5* and 88% in case of *Yr10*, were selected to generate BC$_2F_2$ population. Seventeen plants from *Yr5* and 21 plants from *Yr10* population were selected for the advancement of the generation. Further, 36 plants from *Yr5* population and 45 plants in *Yr10* population were selected. A total of 176 intercrosses were made between *Yr5* and *Yr10* population. After the foreground selection for both the genes using markers Xpsp3000 and S26M47 (*Yr10*) and Xwmc175 and STS7/10 (*Yr5*), 260 plants were found positive. The selected plants were sown in plant to row and foreground selection for both the genes was completed.

The selected maize lines with phenotypic contrast in respect of kernel Fe and Zn concentrations were used for developing mapping populations. The F$_{1}$$_{o}$ mapping population, V336 x CM140 was developed and used for mapping kernel Fe and Zn content. The phenotyping of F$_{1}$ seeds was done using AAS. In addition, analysis of F$_{1}$ plant harvests of four populations (V336xVQ1,1; V336xVQ2; VQ1,1xV336; VQ1,2xV336) for kernel Fe content showed several individuals with transgressive segregation. Two crosses, CM 145 x lpa1 and V334 x lpa2 were generated for transferring low phytate trait through MAS. The level of homozygosity among the best 10 plants for the cross CM 145 x lpa1 was found to be more than 95% while the same level was exhibited by 14 plants in case of V 334x lpa 2.
Among many maize genotypes evaluated, regeneration system could be standardized for VQL 2, one of the parents of Vivek QPM 9. Transformation of these embryogenic calli was done using Agrobacterium system by manipulating different factors and the transformation procedure was refined. The molecular analysis of the transgenic plants was done using PCR. The calli were induced from seed-derived nodal segment of VQL 2 for transformation and regeneration. A total of more than 100,000 seeds (approx.) of VQL 2 were placed for callus induction. The node-derived calli were cultured under 80 μMol light resulted in whole plant regeneration with excellent embryogenesis. Those calli were used for transformation. Twenty five putative transgenic plants along with 100 control plants were successfully transferred to soil and established in the transgenic green house. Various steps of agrobacterium mediated transformation were standardized and Cry 1Ab gene was validated in tobacco plants. Six plants of tobacco were observed to be expressing gus gene thereby confirming that the gene construct has a functional selectable marker.

**NaIP Projects**

The project is being executed by VPKAS as the lead centre in five districts of three North-Western Himalayan states. The area covered under improved varieties of cereals was 699 ha with horizontal expansion of 1000 ha by non-adopted villages. Cultivation of high yielding varieties of vegetables resulted in an income of Rs. 40,000 from 0.1 ha area per household per annum. An additional income of Rs. 58,751 was earned from saffron cultivation in an area of 0.1 ha. Similarly, MAPS cultivation resulted in an income of Rs. 7,985-10,335 per household per year. Out of 5839 artificial inseminations done, 1680 crossbred calves were born, in which 811 were females. More than 2500 mushroom units benefitted 250 households and the income of mushroom cultivation varied from Rs. 230 to 450 per bag. Organized 105 farmers' training in the areas of crop production, seed production, protected cultivation, fruit production and protection, vegetable production, sericulture, poultry, animal sector, apiary and fisheries benefiting 6500 farmers. Four livelihood models were suggested for higher earnings in the cluster areas.

In enabling small holders to improve their livelihoods from carbon finance project, 11,410 improved fruit saplings of various trees were planted in different villages in the grid area as carbon sequestration intervention. Thirty eight solar lanterns and 112 CFL bulbs were distributed as carbon emission reduction interventions. Reduction of about 372 kg CO₂ emission per annum was estimated by adopting solar lantern. Use of 15 watt CFL bulbs will reduce about 89 kg CO₂ emission by substituting 100 watt Edison bulb. On an average Rs. 840 per annum reduction in electricity bill per family was observed by using CFL bulb. Kerosene consumption was reduced by 18 litre per annum per family with the use of Solar lantern. Training programmes on “Climate smart agriculture practices and carbon finance” and “Society management” were organized for executive members of the project.

In the project bio-prospecting of genes and allele mining for abiotic tolerance, a significant decrease in physiological parameters under cold stress was observed in rice. Chlorophyll 'a', chlorophyll 'b', and total chlorophyll contents, total carotenoid content, photosystem II and P700/F700 were found to be reduced by 35.3, 38.6, 36.0, 12.9, 39.0 and 14.4 %, respectively. Under drought stress in maize genotypes, 25% reduction in photosystem II efficiency was recorded in stressed plants. Genotypes MGVD 38,
MGVD 10 and V 393 showed better photosystem II efficiency. Five rice genotypes viz., VL Dhan 206, VL Dhan 82, VL Dhan 86, VL Dhan 65 and VLD Bio97 were found promising for their regeneration potential. More than 200 plants for different genotypes have been regenerated and transferred to soil.

AICRP Project

An aspirator type medium capacity millet dehuller (single phase 2.5 hp electric motor driven) was designed and prototype developed for threshing and de-husking of different millets. The highest dehusking capacity of 20 kg/h and 99% efficiency was observed in case of barnyard millet at 1100 rpm and 10% moisture content in two passes.

Three fish species were stocked in different tanks at the rate of 2.5 fingerlings/ m² of water in the ratio of 30:40:30 for Silver carp, Grass carp and Common carp to identify improved aquaculture system in mid hills. Growth of fish was found better in polytanks in comparison to cement and earthen tanks.

AMAAS Projects

Single inoculation of cold tolerant bacteria Pseudomonas putida PBR85 and Pseudomonas sp strain NARs9 enhanced lentil yield by 18.9 and 16.9%, respectively, in field conditions. Bacterization with cold tolerant bacterial consortia had significantly enhanced N (1.16 to 1.69 fold), P (0.78 to 1.04 fold), K (1.94 to 2.51 fold) content and decreased Na'/K' ratio in wheat at final harvesting.

Inoculation with different bacterial consortia enhanced percent "P" content of wheat plants from 1.1 to 1.8 fold and cold tolerant "P" solubilizing bacterial consortium enhanced wheat yield under field conditions.

DUS Project

Twenty one maize inbreds, 14 hybrids and 6 composites were characterized for 28 DUS traits. Four French-bean varieties were also characterized for 21 DUS traits as per national test guidelines. A sensitization workshop on "Protection of Plant Varieties and Farmers' Rights Act (PPV&FRA), 2001" was organized by VPKAS, Almora for the hill farmers in Champawat.

CWC Project

Thirty eight multilayered cross laminated film lined tanks were dug with farmers' participation. Farmers gained good profit of Rs. 5000 per 200 m² per year by using MIS for off season vegetables along with 80% reduction in labour expenses and 75% water as compared to conventional methods. Popular NGOs were also included in the programme for site and farmer's selection during the implementation and for horizontal spread and follow up action for its sustainability.

Technology Assessed and Transferred

Under transfer of technology, more than 200 training programmes were conducted by institute and its KVKs benefitting around 5000 farmers and state officials. Under Tribal Sub Plan more than 200 farmers of tribal areas of Munsiyari and Dhanachuli were trained and exposed to latest agricultural technologies. Besides, FLDs on different crops were conducted by KVKs on more than 140 ha area benefitting more than 3800 farmers.

The Institute conducted HYV FLDs for different crops including rice (8 ha), maize (10 ha), wheat (2.04 ha), finger millet (10 ha), barnyard millet (3 ha), horsegram (2.72 ha) and soybean (1.43 ha) in different villages of Almora, Bageshwar, Champawat, Pithoragarh and Nainital districts. In all the cases, the HYVs were found superior to the local cultivars.
Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora, is a premier institution conducting agricultural research for North Western (N-W) Himalayan states of India, viz., Jammu and Kashmir, Himachal Pradesh and Uttarakhand. The growth and development of the institute over the years has been phenomenal. Being the brain-child of Professor Boshii Sen, the institute originally functioned as a ‘one man’ institute with limited resources. In 1959, the laboratory was transferred to U.P. Government, and subsequently to ICAR in 1974. The Institute headquarters is located at Almora (29°33' N and 79°39' E, 1,600 m above) in Uttarakhand. Almora district, which falls under mid-hills of N-W Himalayan region, has sub-tropical and sub-humid climate. The Research Farm is located at Hawalbagh, 13 km away from Almora on Kausani/Ramnath Road at an altitude of 1,250 m above (29°'56' N and 79°40' E). The meteorological parameters of Hawalbagh are given below:

<table>
<thead>
<tr>
<th>Rainfall (mm)</th>
<th>Temperature (°C)</th>
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<tbody>
<tr>
<td></td>
<td>Max</td>
</tr>
<tr>
<td>Kharg (May to Oct.)</td>
<td>816.5</td>
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<tr>
<td>Rabi (Nov to Apr)</td>
<td>200.6</td>
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Being a multi-crop and multi-disciplinary research institute, the research work is carried out under four divisions/sections, viz., Crop Improvement, Crop Production, Crop Protection, and Social Sciences.

The VPKAS, in the last 89 years of service to the nation, has several pioneering achievements to its credit. The most notable ones are:

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

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

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

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

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

vi. Development of completely metallic plough VL Surya Hal

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

Mandate

- Basic and strategic research
- for improving productivity and quality of important hill crops.
- on conservation and efficient utilization of natural resources.
- Development of ecologically sound and economically viable agro-production, protection and post-harvest processing technologies for different growing conditions of hills.
- Transfer of technology, research on extension methodology, organization of specialized training programmes and consultancy on hill agriculture.
Salient Accomplishments

The Institute has made outstanding contribution to crop improvement in this region, by developing more than 130 improved varieties of 25 crops. The most popular varieties are VL Gehun 616, VL Gehun 738, VL 804 and VL Gehun 829 of wheat; VL barley 1 of barley; VL Dhan 206, Vivel Dhan 62 and Vivel Dhan 82 of rice; VL Sankul Makkha 11, Vivel Maize Hybrid 9, Vivel Maize Hybrid 15, Vivel Maize Hybrid 17, Vivel QPM 9, VL Baby Corn 1 of maize; VL Mandua 146, VL Mandua 149 and VL Madina 122 of small millets; VL Soya 2, VL Soya 47 of soybean; VL Masoor 4, VL Masoor 103 of lentil; VL Agen Matar 7, Vivel Matar 8, Vivel Matar 8 of garden pea; VL Rajma 63 of rajmah and VL Ugal 7 of underutilized crop buckwheat. The Institute has won the Sardar Patel Outstanding ICAR Institution Award twice for the year 2000 and 2007 in recognition of its valuable research contributions in the development of hill agriculture.

Since 2008, 31 improved varieties of wheat (VL Gehun 892, VL Gehun 907), maize (Vivel Maize Hybrid 27, Vivel QPM 21, Vivel Maize Hybrid 33, Vivel Maize Hybrid 39, Vivel Maize Hybrid 43, Vivel Sankul Makkha 31 Vivel Sankul Makkha 35, Vivel Sankul Makkha 37, Vivel Maize Hybrid 45), millets (VL Madina 207), Pulses (VL Gahat 19, VL Matar 47, VL Masoor 129, VL Masoor 133, VL Masoor 514), oilseeds (VL Soya 59, VL Soya 63, VL Moongphali 1) and vegetables (Vivel Matar 9, Vivel Matar 10, Vivel Matar 11, VL Tamatar 4, VL Cherry Tamatar 1, VL Tamatar 5, VL Hybrid Tamatar 1, VL Hybrid Shinla Mirch 1, VL Shinla Mirch 3, VL Bean 2, VL Lahsun 2) were released. During these five years, around 1234 quintals of broccoli, 94 quintals of cucumber and 281 quintals of truthfully labeled seeds were produced for various agencies and farmers. More than 11,000 native and exotic accessions of wheat, rice, maize, small millets, pulses, oil seeds and vegetables are being maintained at the institute. Donors of resistance to biotic and abiotic stresses were identified and used.

The matching agro-techniques for realizing full potential of improved varieties of crops and managing the constraints were standardized. Cropping sequences, spring rice-wheat-finger millet-torhi attained 200% cropping intensity against 150% of the traditional spring rice-wheat-finger millet-fallow sequence in two year cropping system; and soybean-lentil, maize-pea, maize-wheat, rajmash-french bean-torhi, pigeon pea-wheat, colocasia-coriander-tomato, soybean-pea and soybean-wheat among one year crop sequences were found more remunerative. Inter cropping of soybean or groundnut in maize, soybean in finger millet and pea, lentil or torhi 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. Institute was awarded "KRISHKARI BARANI KHETI AWARD – First Prize" during 1988 for this work.

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

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

Survey of Kumaon and Garhwal regions show prevalence of yellow and brown rust, loose smut,
powdery mildew and hill bunt in wheat; stripe and covered smut in barley, blast, brown spot and false smut in rice; neck and finger blast in finger millet; turcicum leaf blight in maize; powdery mildew and white rot in pea, buckeye rot in tomato, root rot and anthracnose in bean; root rot and wilt in lentil, and frogeye leaf spot and anthracnose in soybean as the major diseases. Fuscosus blight of French bean/rajmah and zonate leaf spot of maize have been reported for the first time from this region. Virus diagnosis, based on symptoms in tomato, showed presence of nearly 50 viral diseases affecting different crops grown in hills. Indigenous Trichoderma strains have also been isolated from the N-W Himalayan region and found effective against the soil borne pathogens.

White grub, a polyphagous pest, which devastates a number of rainfed kharif crops, is the most menacing insect of the region. More than 75 species of this insect have been recorded in Uttarakhand. In addition, stem borer and leaf folder in rice and small millets, hairy caterpillar and sucking bug in soybean, leaf miner in garden pea and pod borer in pea and gram, fruit borer in tomato, blister beetle in beans and pigeon pea are other major pests. Management technologies have been evolved for major diseases and insects in important crops with emphasis on evaluation of germplasm for resistance against important pests, manipulation of cultural practices, use of locally available plant extracts and the need-based application of pesticides. The newly developed technology of insect trap and the entomopathogenic Bacillus thuringiensis are the potential alternatives to manage the white grubs.

Demonstration of improved agricultural production technology has been the major programme for agricultural development of the hilly states. More than 2,000 field demonstrations were conducted to demonstrate the benefits of latest agro-technology in the villages adopted under Transfer of Technology (TOT) Programme.

Agricultural database for N-W Himalayas were updated regularly. E-books have been created for important technological bulletins. A survey of the economics of off-season vegetables indicated that producer receives only 13-21% of consumer’s money in different vegetables and the lion’s share is siphoned to the middlemen in the prevailing marketing system, which indicates the need to develop their own marketing system by the farmers, e.g., by forming a cooperative marketing society. The investment in Almora, Bageshwar and Nainital districts are considerably short of normative investment.

The institute has to credit a technological options publication entitled, “फार्मिंग परिवर्तनीय विकास की जीत” which is very popular among farmers and extension workers. The publication was awarded prestigious Dr. Rajendra Prasad Purushottam of Indian Council of Agricultural Research in the year 2004. Vivek Thresher for pruning 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. Apart from this, 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 N-W Himalayan States. Scientists of the institute also received World Intellectual Property Organization (WIPO) Gold Medal in 2009, for development of “Eco-friendly novel technology for managing white grubs in North-West Himalayas” which was identified as the best invention of the year 2008. This work also won the Societal Innovation Award of NRDC in 2008. In 2010, the institute scientists got ICAR Outstanding Team Research Award in the subject area of Natural Resource Management. The Institute received Mahindra Krishi Samridhi India Agri Award 2012 for its outstanding contribution in the development of agricultural technologies and their popularization among farmers.

**Infrastructure Facilities**

During the period under report, following construction/renovation works at Almora and Hawalbagh Campus were completed:
1. Making provision of drainage as per IIT Roorkee advice an existing RR Masonry wall at VPKAS, Almora.
2. C/o Retaining wall in front of Administrative Building at VPKAS, Almora.
3. C/o Barbed Wire fencing of VPKAS at Mukteshwar.
4. Miscellaneous repair work at Type II, III & IV residences at VPKAS, Almora.
5. C/o Stone Masonry Dam at Khankhal Sector at VPKAS, Hawalbagh.
6. Aluminum partition in the two rooms laboratory building at Hawalbagh.

**Laboratories**

Institute has well equipped laboratories for Bio technology and Molecular Plant Pathology, Plant Physiology, Soil Science, Microbiology, Entomology and Plant Pathology. During the year a number of scientific equipments were procured to upgrade the laboratories.

**Institute Library**

During the year, the library subscribed for 25 foreign and 62 Indian periodicals. Library has a collection of 3,900 (approx.) bound volumes. A sum of Rs. 15,13,030.00 was spent for the procurement of the books/periodicals etc. during the period. Besides, many annual reports, and other miscellaneous publications were also received on gratis from various ICAR institutes and other organizations.

**Agricultural Knowledge Management Unit**

The Agricultural Knowledge Management Unit (formally known as ARIS Cell) is presently working with six workstations and two servers. The institute has setup a LAN consisting of about 50 nodes at Almora campus and about 30 nodes at Experimental Farm, Hawalbagh, with 2 and 1 Mbps Internet leased line connection, respectively. AKMU provides hardware, software, anti-malware and agricultural database support to the institute. AKMU also maintains institute’s website, which can be assessed at http://vpkas.nic.in.

**Staff**

The staff position of the Institute as on 31.3.2013 is given below:

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<th>Position</th>
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**Finance**

The budget outlay for 2012-13 (Rs. in lakhs) is given hereunder:

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<td>Total</td>
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**Weather and Crop Season at Research Farm (2012-13)**

The mean maximum daily temperature during kharif season (May to October) ranged from 27.3°C (October) to 35.1°C (June), and mean minimum daily temperature varied from 9.6°C (October) to 21.2°C (July). During kharif about 745.2 mm of rainfall was received. The maximum rainfall was received during July (307.5 mm) followed by August (264.2 mm). The mean maximum daily temperature during rabi season (November to April) ranged from 18.6°C (January) to 27.5°C (April), and the mean minimum daily temperature from -1.2°C (December) to 9.4°C (April), respectively. During rabi, about 268.7 mm of rainfall was received with no rainfall in the month of November. The total rainfall for entire year was 1013.90 mm.
ICAR
DIRECTOR

Institute Management Committee

Research Advisory Committee
Institute Research Council

DIVISIONS/SECTIONS
KRISHI VIGYAN KENDRAS

KenK
Uttarkashi

KVK
Bageshwar

CENTRAL FACILITIES

Administration & Accounts

Genetics & Plant Breeding;
Plant Physiology;
Agricultural Biotechnology;
Economic Botany;
Vegetable Science;
Plant Biochemistry;
Seed Science & Technology

Crop Improvement

Agronomy;
Agricultural Microbiology;
Agricultural Chemistry;
Farm Machinery & Power;
Land and Water Management Engineering;
Soil Science;
Agro-Forestry

Crop Production

Crop Protection

Plant Pathology;
Agricultural Entomology;
Nematology

Social Science

Agricultural Extension;
Agricultural Economics;
Agricultural Statistics;
Computer Application in Agriculture;
Home Science

PME Cell
RFD Cell
AKMU
Library
Research Farm
Institute Technology Management Committee
Institute Technology Management Unit

Organizational Setup, VPKAS, Almora
RESEARCH ACHIEVEMENTS

VL Maize Hybrid 45  Bacterial Strains  VL Barley 118

Blister Beetles infected with EPF  VL Shyahi Hal  LDPE Polytank
Enhancement in the Productivity of Major Hill Crops

- Genetic Improvement of Maize for higher Productivity, Quality, Biotic and Abiotic Stresses (Drs. P.K. Agrawal, S.K. Jha, Chandrashekara C. & D. Mahanta)
- Genetic Improvement of Rice for higher productivity, quality, biotic and abiotic stresses (Drs. P.K. Agrawal, J.P. Aditya, K.K. Mishra, J. Stanley, B.M. Pandey, R. Arun Kumar & Shephalika Annapali)
- Genetic Improvement of Wheat and Barley for higher Productivity, Quality, Biotic and Abiotic Stresses (Drs. L. Kant, Raghu, B.R.; S.K. Jain, D. Mahanta, R. Arun Kumar, R. S. Pal & Shephalika Annapali)
- Genetic Improvement of Small Millets and Under-utilized Crops for higher Productivity, Quality, Biotic and Abiotic Stresses (Drs. R.K. Khalbe, Salej Sood, Chandrashekara C., B.M. Pandey & Anubhuti Sharma)
- Genetic Improvement of Pulses and Oilseeds for higher Productivity, Quality, Biotic and Abiotic Stresses (Drs. G. Singh, A. Bhartiya, S.K. Jain, J. Stanley, Sher Singh & R. Arun Kumar)
- Genetic Improvement of Vegetables for higher Productivity, Quality, Biotic Stresses and Quality Traits (Drs. N.K. Hedau, Chandrashekara C., A.R.N.S. Subbarao, M.D. Turi & R.S. Pal)
- Basic and Strategic Research for Genetic Enhancement of major Hill Crops for Biotic stresses and Quality traits using Molecular Tools (Drs. N. Saini, P.K. Agrawal & B. Kalyani babu)
- Seed Production (Drs. L. Kant, N.K. Hedau – Vegetable crops)
2.1. Enhancement in the Productivity of Major Hill Crops

2.1.1. Maize

Maize is an important cereal of North-Western Himalayas. By and large, maize is cultivated during the kharif season under rainfed conditions of the North-Western Hills. Considering the short growing period and high cropping intensity in hills, the emphasis has been 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 *Sclerotium* leaf blight in particular. The accomplishments in maize research during the year 2012-13 are presented below.

2.1.1.1 Varietal Improvement

**Hybrid Identified / Released / Notified**

**Vivek Maize Hybrid 45**: Vivek Maize Hybrid 45 (FH 3483) is an extra-early single cross hybrid identified for Zone I, II, III and IV of maize growing areas of the country and subsequently the hybrid was released and notified for Zone I (Uttarakhand, H.P and J&K) as Vivek maize hybrid 45.

**Evaluation of Normal and Specialty Corn in Co-ordinated and Station Trials**

One hundred seventy-seven genotypes including 74 hybrids, 3 composites and 18 inbreds of normal maize developed at VPKAS were evaluated in thirteen trials. Besides, 108 genotypes of specialty corn including 29 hybrids, one composite and 18 lines each of pop corn and sweet corn developed at VPKAS were evaluated in 7 trials to identify superior genotypes in early and extra-early maturity normal corn and specialty corn hybrids.

Five extra-early maturity (85-90 days) multilocation trials namely AET-II (7 entries), AET-I (8 entries), IET (18 entries), Zonal 103 (22 entries) and SVT (9 entries) were conducted. Twenty-eight new normal corn hybrids, 25 new sweet corn hybrids and 18 parental lines, each of normal, sweet and pop corn were evaluated in different station trials. In AET-II (Extra early), FH 3525 (8367 kg/ha) was found to be superior to Vivek Maize Hybrid 9 (6585 kg/ha) whereas single cross hybrid FH 3513 (9955 kg/ha) followed by Sun Vaaman (4725 kg/ha) were found to be superior over the best check Prakash (4709 kg/ha) in AET-II (Early). In Extra-early trial of AET-I, FH 3556 (8811 kg/ha) recorded highest yield followed by K 75 (8367 kg/ha). These hybrids recorded higher yield than the best check Vivek Maize Hybrid 9 (8164 kg/ha). In AET-I (Early), DAS-MH-50Y recorded highest yield (9435 kg/ha).
ha) followed by HISCO 22338 (8847 kg/ha) and were found superior to the best check Prakash (8495 kg/ha). In the IET (extra-early) single cross trial, FH 3594 (11055 kg/ha), FH 3583 (9881 kg/ha) and DH 238 (9873 kg/ha) out-yielded best check Vivek Maize Hybrid 9 (9118 kg/ha). In the early maturity trials (IET early), BIO 6028 (9856 kg/ha), FH 3609 (9827 kg/ha), FH 2223 (9157 kg/ha) and FH 3605 (9827 kg/ha) were the high yielding as compared to the best check Prakash (8824 kg/ha). In Zonal Trial, VPKAS Hybrids FH 3659 (10349 kg/ha), FH 3650 (10271 kg/ha), FH 3661 (10175 kg/ha) and FH 3644 (7887 kg/ha) were superior to the best check Vivek Maize Hybrid 39 (9877 kg/ha). In the Station Trial I, FH 3664 (8938 kg/ha), FH 3669 (8490 kg/ha) and FH 3641 (8164 kg/ha) were found promising and registered 12.1-22.7% yield superiority over the best check Vivek Hybrid 39 (7281 kg/ha). In sweet corn station trial consisting of 25 new hybrids developed by VPKAS, FSCH 41 and FSCH 24 registered 19.7 and 10.3% yield superiority, respectively over check HSC I.

Development of composites
- Experimental composite VI, Pop Corn 2, synthesized involving seven elite materials, was further improved by selection for better yield, uniformity, shorter plant height and tolerance to prevailing diseases.

Development of normal and specialty corn inbred lines
- In order to develop short duration productive inbred lines, inbreeding was initiated in 26 promising materials. Of these, 43 progenies possessing early maturity, shorter plant height and resistance to prevailing diseases were retained for further inbreeding and selection.
- One hundred eighty-seven lines of different homozygosity levels (56 S, 27 S, 16 S, 21 S, 33 S, 15 S, and 19 advance generation lines) were evaluated. Of these, 153 progenies (33 S, 26 S, 14 S, 22 S, 35 S, and 23 advance stage) possessing earliness, shorter plant and ear height, good vigour, short ASI and tolerance to biotic stresses (mainly E. turicensis) were retained for further selection and inbreeding. Twelve elite lines possessing desirable traits were established and used in hybridization.
- Selection and inbreeding was continued in 27 different homozygosity inbred lines of sweet corn (14 S, 11 S, and 2 advance lines) and 56 desirable progenies (30 S, 26 and 26 advance lines) were retained for further inbreeding, selection and their potential use in hybridization.
- Hybridization, backcrossing and selecting were performed in segregating lines of normal and sweet corn crosses for development of superior sweet corn lines from normal corn.

Development of New Single cross Hybrids
- Forty-two new hybrid combinations were generated involving 25 new promising lines and 6 released parents viz. CM 212, V 335, V 341, V 346 and V 373. Seventeen new hybrid combinations of sweet corn and 15 of pop corn were generated by crossing introduced and indigenous lines. These hybrids will be evaluated in coming kharif season.

Genetic Resources: Evaluation and Maintenance
- Fifty seven indigenous/exotic inbred lines received from DMR were evaluated. Of these, 29 early-medium lines possessing desirable agronomic traits and resistance to E. turicensis leaf blight were maintained for their potential use in hybridization programme.
- Fifty five early-medium duration getroplantain received from CIMMYT, India were evaluated. Of these, 17 early materials possessing desirable agronomic traits and resistance to E. turicensis leaf blight were maintained.
- Fifteen early maturing promising lines identified during 2011 kharif were evaluated and six were retained.
- Fourteen lines each of sweet corn and pop corn were evaluated and maintained.
- Thirty-five accessions of local maize germplasm kept in mid-term gene bank were revived.
Maintenance and Seed production of Parental Lines and Hybrids

- Purification, maintenance and seed increase of 44 parental lines (0.5-1.0 Kg) of experimental hybrids were performed.
- Nucleus seed (0.5-10.0 Kg) of parental lines of Vivek Hybrid 4, Vivek Hybrid 5, Vivek Hybrid 9, Vivek Hybrid 15, Vivek Hybrid 17, Vivek Hybrid 21, Vivek Hybrid 23, Vivek Hybrid 25, Vivek Hybrid 27, Vivek Hybrid 33, Vivek Hybrid 39 and Vivek Hybrid 43 were produced.
- Nucleus seed (20.0-25.0 Kg) of released composites Vivek Sankul Makka 35, Vivek Sankul Makka 37 and VL Baby Corn 1 were produced.
- F1 seed (2.5-36.0 Kg) of 63 test hybrids for All India Coordinated and standard varietal trials were produced by controlled pollination.
- F1 seed (2.0 - 325.0 Kg) of 13 released hybrids were produced.

Sharing of Maize Germplasm and Inbred Lines with Co-ordinated Centers

Altogether 28 elite inbred lines of normal corn and 8 QPM lines were supplied to different centers of AICMIP to strengthen their extra-early maize breeding program (Fig 2.1).

2.1.1.2. Crop Protection Investigations

A total of 541 AICMIP entries and 38 station entries were screened against TLB under high disease pressure conditions. Similarly, 30 station entries were screened for Banded leaf and sheath blight (BLSB) disease under high disease pressure conditions.

In the AICMIP trial, most of the late and medium maturity entries showed resistant reaction, few entries were found to be moderately resistant to TLB. In early and extra early trial, most of the entries showed moderately resistant (MR) and susceptible (S) reaction. Under the AICMIP programme, among the 199 elite maize inbred lines screened for identification of sources of resistance against TLB, 140 lines were found to be resistant to TLB.

In the Station Trial, 13 inbreds viz., V 335, V 336, V 341, V 346, V 373, V 398, V 400, V 401, V 407, V 418, VQL 2, VQI 17 and CM 145 were found resistant to TLB. Five inbred viz., V 334, V 336, V 400, V 410 and V 414 were found to be moderately resistant to BLSB disease.

In vitro evaluation of different Trichoderma isolates against Banded leaf and sheath blight pathogen of maize

The incidence of Banded leaf and sheath blight of maize caused by Rhizoctonia solani has increased over the last few years. To manage this disease, an attempt was made to study the biocontrol activity of new Trichoderma isolates against R. solani. Among 52 isolates evaluated, the highest antagonistic activity of 81 per cent was
observed for T-202 and T-207, which was followed by T-186 (77%), T-80 (74%), T-204 (73%), T-133 (70%), T-150 (70%), T-172 (70%), and T-184 (70%) isolates. Promising isolates will be further tested under field conditions.

2.1.1.1. Agronomic Investigations

Evaluation of interactive effects of plant density, geometry on productivity of early maturity maize genotypes for rainfed conditions

The genotype Vivek QPM 9 was evaluated for different plant geometry (equal row at 60 cm and paired row of 75 cm: 45 cm), plant density (intrarow spacing of 25, 20 and 15 cm) and mulching (clean field and residue retention). The paired row (9,972 kg/ha) provided significantly higher grain yield than equal row (9,232 kg/ha). The productivity increased as the intra-row spacing decreased and the intra-row spacing of 15 cm produced significantly higher grain yield (10,607 kg/ha) than other spacings. There was no significant difference between clean field (9,508 kg/ha) and residue retention (9,697 kg/ha) in terms of grain yield. There was interaction between plant geometry and mulching. Residue retention (10,292 kg/ha) provided significantly higher grain yield than clean field (9,652 kg/ha) in paired row planting geometry.

Performance of maize hybrids to adapt rainfall changes and climatic aberrations

Vivek QPM 9 and Vivek Hybrid 25 were evaluated under different dates of sowing (5th June to 5th July at 10 days interval). Sowing on 25th June was found to be the most suitable date, which provided 7,651 kg/ha grain yield under delayed monsoon condition of 2012. The productivity of Vivek QPM 9 increased with postponement of sowing date and highest yield was recorded for 5th July sowing, while the same for Vivek Hybrid 25 was observed for the 25th June sowing.

Relative performance of pre-released genotypes of early maturity at different NPK levels

Three new genotypes i.e. FH 3513, HKH-317 and Sun Vaaman were evaluated against two checks i.e. Prakash and JH 3459 for different fertilizer levels (100:40:30, 150:50:40 and 200:60:50 kg N:P:O₃:K:O/ha). Among the new genotypes, HKH-317 produced significantly higher grain yield (7,610 kg/ha) than rest of the genotypes including the check. The fertilizer level 200:60:50 kg N:P:O₃:K:O/ha recorded significantly higher grain yield (7,134 kg/ha) than other levels.

Relative performance of pre-released genotypes of extra-early maturity at different NPK levels

Three new genotypes i.e. FH 3525, KH 9888 and FH 3510 were evaluated against two checks i.e. Vivek hybrid 9 and Vivek QPM 9 for different fertilizer levels (100:40:30, 150:50:40 and 200:60:50 kg N:P:O₃:K:O/ha). All the new genotypes, except FH 3525 (8,564 kg/ha) produced significantly lower grain yield than the best check, Vivek QPM 9 (8,777 kg/ha). The fertilizer level 200:60:50 kg N:P:O₃:K:O/ha recorded significantly higher grain yield (8,914 kg/ha) than the other levels.
2.1.2. Rice

Rice is one of the major staple food crops of the hill regions of India. The total area under hill rice in India is about 1.8-2.0 million ha, out of which 0.63 m ha is under North-Western Himalaya, producing about 1.26 million tonnes of rice. The productivity of rice in this region of hills was 2051 kg/ha in 2011-12 whereas the average national productivity was 2393 kg/ha. Rigorous efforts have been made in the institute in last few years to develop and identify the superior genotypes of rice in terms of grain yield, resistance/tolerance to prevailing biotic/abiotic stresses, quality traits and development of production technologies for their suitability under irrigated transplanted and rainfed upland conditions (spring and summer sowing).

2.1.2.1. Varietal Improvement

Varieties Identified/Recommended for Release

VL 31077: VL 30177 was identified for release in the plains of Uttarakhand. This is a basmati line, selected from CR 839. It is moderately resistant to bacterial blight and leaf blast. It yielded 3863 kg/ha in 2009-10, 3590 kg/ha in 2010-11 and 3435 kg/ha in 2011-12. It gave an overall yield advantage of 10.64% over the best check Pant Sugand 17 and 20.07% over Pusa Basmati 1. It has long slender grains and satisfies all the traits of basmati rice. At present this entry is under farmers’ trial by the SVT, Uttarakhand.

Promising lines

VL 8116: This entry has completed three years of testing in AICRP Trial and found promising for medium elevated hills of Uttarakhand under rainfed upland June sown condition. It is developed from cross VL 6446/VL 81 having long slender grain. It has recorded mean grain yield of 2246 kg/ha and surpassed the national, regional and local checks by a yield margin of 32.27%, 30.05% and 18.02%, respectively. It was recommended to be promising for the mid-hills of Uttarakhand by the AICRP (Rice).

Multi-locational Evaluation Trials

Altogether 12 trials were conducted as a part of multilocational trials. Those includes four trials under organic conditions under the ‘State Varietal Trials’ [Spring sown, June sown, irrigated (E) and Irrigated (M)], six trials under the AICRP [(AVT-E (H), IVT-E (H), AVT-M (H), AVT-M (H), AVT-U (H), IVT-U (H)], one trial under the Hybrid rice (SVT) and one trial under the Basmati rice (SVT). Two entries viz., VL 31616, VL 31618 of irrigated early and entries viz., VL 31726, VL 31611 of irrigated medium have been promoted for the third year of testing under AICRP (Rice) trials whereas four entries viz., VL 8204, VL 8302, VL 8185 and VL 31402 of rainfed upland have been promoted for the third year of testing under AICRP (Rice) trials. Similarly, under the SVT trials, VL 31618 was promoted to second year.

Station Trials

The ‘Institute Station Trial’ was conducted in three categories, viz., spring sown (rainfed upland), June sown (rainfed upland) and irrigated condition. Promising lines were selected for further evaluation and multilocational testing. Promising lines selected from advance station trials include VL 11261 (2654 kg/ha) and VL 11254 (2458 kg/ha) in rainfed upland spring sown; VL 8549 (2672 kg/ha) and VL 8732 (2639 kg/ha) in rainfed upland June sown; VL 31635 (4816 kg/ha) and VL 31609 (3385 kg/ha) in irrigated early and VL 31631 (5372 kg/ha) and VL 31546 (4630 kg/ha) in irrigated medium conditions. All these lines selected are resistant to blast and have acceptable agronomic traits like plant height, days to maturity and grain quality.

Segregating Breeding Materials

Based on the good phenotypic characters, drought tolerance, disease and insect-pest resistance, a total of 3159 progenies derived from 389 crosses were selected in F1 to F3 generations under different ecosystems viz., rainfed upland...
(Spring and June sown) and irrigated transplanted conditions (Early and Medium maturity). Under rainfall upland spring sown conditions, 204 plants were selected from 31 crosses of F₂ generation. Eighty three plant progenies from 07 crosses in F₂ generation, 89 plant progenies from 10 crosses in F₂ generation, and 384 plant progenies from 34 crosses in F₂ generation were selected for drought tolerance, blast and brown spot resistance and better yielding ability. Under June-sown rainfall upland conditions, 384 plants were selected from 38 crosses of F₂ generation. A total of 99 plant progenies derived from 11 crosses in F₂ generation, 103 plant progenies from 12 crosses in F₂ generation and 72 plant progenies from 17 crosses in F₂ generation were selected for drought tolerance, short duration, blast resistance and better grain-yielding ability. For the irrigated ecosystem, 549 plants were selected from 75 crosses of F₂ generation. Further, 121 plant progenies from 19 crosses in F₂ generation, 261 plant progenies from 35 crosses in F₂ generation and 327 plant progenies from 40 crosses in F₂ generation were selected. Emphasis was given for resistance to blast (leaf and neck) and quality traits.

In the breeding programme for quality (aromatic/sleender), 228 plants from 24 crosses of F₂ generation, 77 plant progenies from 09 crosses in F₂ generation, 71 plant progenies from 08 crosses in F₂ generation and 107 plant progenies from 10 crosses in F₂ generation were selected for fine grain aromatic traits. All of them possessed acceptable level of resistance against blast and other biotic stresses.

Genetic Resources
Among the advanced lines evaluated for blast resistance both under field condition and under ‘blast nurseries’, some of the advanced lines found resistance to blast with a score of 3.0 in a scale of 0 to 9 were: VI. 11249, VI. 11250, VI. 3040, VL. 8607, VL. 8611, VL. 8618, VL. 11028, VL. 8724, VL. 8726, VL. 8732, VL. 31546, VL. 31566, VL. 31608, VL. 31609 and VL. 31631.

International Nursery
Four international nurseries viz., IURON, IRTON, IIRON Module I and IIRON Module II with 55, 64, 60 and 40 genotypes, respectively, were evaluated under their respective ecosystem. None of the entries was found promising in IURON and IRTON. Some of the promising genotypes in IIRON Module I were MUT CEYSVONI-37-2P, IR 10A125, CT-21391-F₂, 8-1-1, IR 08N 211, KARJAT 7 whereas in IIRON Module I, the entry IR. 77186-122-2-23 (N5CIRC158) was found to be promising.

Off-season Nursery
During 2012-13, seeds of 44 F₂, 18 F₁ and 28 F₀ generations of advanced breeding populations were grown at the off-season facility at the Central Rice Research Institute, Cuttack for the advancement of generation. In addition, fourteen genotypes were raised for seed multiplication for nomination in different trials.

2.1.2.2 Crop Protection Investigations
- One hundred twenty four rice entries were evaluated under Donor Screening Nursery (DSN) against blast and brown spot. Entries VL. 8653, VL. 8657, VL. 31451, VL. 31716, VL. 31789 showed high level of resistance (1-3 score on 0-9 scale) against leaf and neck blast whereas entries VL. 8654, VL. 31615, VL. 31616 were promising against brown spot.
- In NSN-Hills rice nursery, 82 entries were screened for leaf blast, neck blast and brown spot. Entries No. 3108, 2616, 2803, 2701 were found resistant against leaf and neck blast with the score of 1-3, whereas entries 3104, 3004, 3007, 3009, 2506, 2513, RJ-2421, IR 50 were found resistant against brown spot.
- Total eighty four IRBN entries were screened for leaf and neck blast. Entries IR. 65482-4-136-2-2, IR BLSH-B, IR BLSH-S, IR BLZ-5CA/RL, C-1-4-11-7P2P1P3P1 and GBASSIN were found to be resistant against leaf and neck blast with the score of 1-3.
- In the advance breeding materials for spring sown, June sown and transplanted conditions, total 46 entries were evaluated for leaf and neck blast under artificial epiphytotic conditions. Resistant entries identified include
VL 11249, VL 8618 and VL 11028 for spring sowin, VL 8724, VL 8726 and VL 8732 for June sowin, VL 65, VL 31546, VL 31566, VL 31608, VL 31638 and VL 31631 for transplanted conditions.

- In addition, 63 VL rice lines were screened for leaf and neck blast diseases. Out of these lines, VL 8083, VL 8214, VL 8553, VL 8654, VL 8657, VL 31611, VL 31615, VL 31674 and VL 31451 showed resistant reaction.

2.1.2.3 Entomological Investigations

In National Screening Nursery (NSN-H), eighty two lines were tested and none was found to be resistant to pink stem borer and leaf folder in the field. Out of fifty five entries tested in Multiple Resistance Screening Trial (MRST), seven lines viz., TNRH 258, TNRH 222, TNRH 206, CB 07 540, Tetc, HR DRR 01, Ch 3092 772 have shown resistant reaction to pink borer in the field. Altogether, four lines viz., Tetc, RP 4918 221, RP Patho 02, RP Bio 4918-230 have shown the least damage by leaf folder in the field.

2.1.2.4 Agronomic Investigations

Nitrogen Response of Various Rice Entries (Transplanted) under High and Low Input Management

Three AVT-2 Early hill (EH - Irrigated) cultures (IET 21751, IET 21755 and IET 21756) were evaluated in comparison with high yielding check (RP-2421). No significant differences were found among various varieties and nitrogen levels. AVT-2 Medium Hill (MH, Irrigated) cultures, IET 21759, IET 21765 and IET 21766 were evaluated in comparison to two standard checks, Vivek Dhan 62 and HPR 2143, under 3 levels of N. IET 21766 (5600 kg/ha) followed by IET 21765 (5130 kg/ha) gave higher grain yields. However, no significant differences were found among nitrogen levels. Five AVT-2 Upland hill (Direct seeded) IET cultures (IET 21740, IET 21741, IET 21742, IET 21743 and IET 21744) were evaluated in comparison to standard checks (Vivek Dhan 154, and Sakardhan 1) along with one local check (VL 221). Among the cultures, mean maximum grain yield was recorded by Vivek Dhan 154 (1900 kg/ha) followed by IET 21740 (1690 kg/ha) and VL 221 (1620 kg/ha). The performance in terms of nitrogen response was maximum at 50% of RDN.

2.1.2.5 Physiological Investigations

An experiment was conducted with fourteen rice genotypes viz. VL 154, VL 221, VL 8394, VL 8412, VL 8549, VL 8551, VL 8553, VL 8559, VL 8567, VL 8590, VL 8598, VL 8608, VL 8654, VL 8657, VL 8707, VL 8853, VL 8840, VL 8214, VL 31387 and VL 31597 to study the genotype variations in physiological traits at Malhartha farm, VPKAS during kharif, 2012. The experiment was laid out in randomized block design. Differential genotypic differences were observed in physiological traits like relative water content (RWC), chlorophyll 'a', chlorophyll 'b', total chlorophyll, total carotenoid, photosystem II efficiency and photosynthesis efficiency (Fv/Fm). Differences were also recorded for days to 50% flowering, days to physiological maturity and grain yield. Genotypes VL 8549, VL 8724 and VL 8732 exhibited significantly higher grain yield compared to other rice genotypes. This could be due to better leaf pigment content along with efficient photosynthesis. Relative water content and photosynthetic efficiency (Fv/Fm) showed significant positive correlation with grain yield. These physiological traits can be used in rice breeding programme.
2.1.3. Wheat

Wheat is the most important cereal crop of rainy season in the North-Western Himalayas with the average productivity of 1,797 kg/ha, which is much below the national productivity of 2,989 kg/ha in 2010-11. It is grown over an area of 1.027 million ha in N-W Himalayas with the average productivity of 1,530; 1,535 and 2,316 kg/ha in the state of Himachal Pradesh, Jammu & Kashmir and Uttarakhand, respectively. The present status of production and productivity can be raised by the adoption of high yielding varieties having resistance/tolerance to biotic (yellow and brown rust and loose smut) and abiotic (drought and cold) stresses along with suitable production and protection technologies.

2.1.3.1. Varietal Improvement

Genetic Stock Identified through All India Coordinated Testing

VW 0826 - A Genetic Stock for high tillers/ meter: A genetic stock VW 0826 (Raj 3777/ MV-EMESE) has been identified for number of tillers/m through All India testing from 2009-10 to 2011-12. On the basis of three years of testing in Yield Component Screening Nursery (YCSN), tillers/meter in VW 0826 were 84 as compared to 81.7 in HD 2009, the best check.

Adaptability Evaluation of Newly Developed Strains

Twelve yield evaluation trials were conducted to assess the adaptability of new wheat strains with respect to grain yield, disease resistance and other desirable attributes under the rainfall early sown, rained as well as irrigated timely sown and restricted irrigation late sown conditions of Northern Hill Zone (NHZ). Under the rainfall situations, the early sown trials included thirty one entries i.e., AVT (13) and Station trial (18). None of the test entry under AVT could surpass the best check VI. Gehun 829 (1,590 kg/ha). However, HS 542 (1,460 kg/ha) and VI. 977 (1,460 kg/ha) were in the same non-significant group. In the Station Trial, one test entry viz., VW 1105 (1,123 kg/ha) yielded significantly and was superior to the best check HPW 251 (837 kg/ha). Eighty-five entries in four timely sown trials under rainfall conditions viz., AVT (8), IVT (25), SVT organic (10) and Station Trial (42), were evaluated. None of the test entry could surpass the best check HS 507 (1,680 kg/ha) in AVT, however, VI. 950 (1,580 kg/ha) was statistically at par with the best check.

In the IVT also HPW 380 (2,480 kg/ha) was statistically at par with the best check HS 507 (2,510 kg/ha). Test entry VW 1154 (2,125 kg/ha) numerically surpassed best check VI. Gehun 907 (1,968 kg/ha) in the Station trial. VI. 949 (1,152 kg/ha) and VI. 951 (3,022 kg/ha) in SVT were found to be at par in grain yield with the best check VI. Gehun 907 (3,317 kg/ha). Under the late sown restricted irrigation (pre-sown irrigation only) trials, 29 entries (AVT 13, Station trial 16) were evaluated. The test entry VI. 873 (2,190 kg/ha), VI. 974 (2,090 kg/ha) and HS 560 (2,060 kg/ha) yielded statistically at par with the best check VI. Gehun 892 (2,220 kg/ha) in AVT and in Station Trial, 8 test entries viz., VW 1157 (2,302 kg/ha), VW 1161 (2,210 kg/ha), VW 1159 (2,206 kg/ha), VW 1166 (2,202 kg/ha), VW 1158 (2,190 kg/ha), VW 1163 (2,089 kg/ha), VW 1165 (2,065 kg/ha) and VW 1164 (2,065 kg/ha) were found to be significantly superior in grain yield over the best check HS 490 (1,791 kg/ha). Under the irrigated conditions, 85 entries were evaluated under four timely sown trials viz., AVT (8), IVT (25), SVT organic (10) and Station Trial (42). Test entries HS 536 (6,450 kg/ha) and HPW 368 (6,340 kg/ha) were statistically at par with the best check HS 507 (6,460 kg/ha) in AVT, however, HPW 383 (6,300 kg/ha) yielded numerically higher but was statistically at par with the best check VI. 804 (6,140 kg/ha) in IVT trial, and VI. 953 (3,387 kg/ha) yielded significantly superior to the best check VI. Gehun 907 (3,048 kg/ha) in the SVT. Out of 70 new bulks generated under the institute breeding programme and evaluated in different station trials under the rained as well as irrigated
conditions, eleven promising strains were entered in different All India Coordinated Trials of northern hills zone.

**Development of New Strains**

The major objective of the programme is to develop high yielding disease resistant (yellow as well as brown rust and loose smut) genotypes suitable for rainfed early sown, rainfed and irrigated timely sown and restricted irrigation late sown conditions of NHIZ. Diverse donors of Winter and Spring wheats were used and 249 fresh crosses ([52 Spring x Spring (SxS) and 197 Winter x Spring (WxS) wheat]) including two and three way crosses were successfully made. One hundred sixty five F₁ hybrids were evaluated and 86 better performing F₁ hybrids, consisting of 33 SxS and 53 WxS, were identified for growing their F₁ generation. The breeding materials were handled following selected bulk pedigree method. The F₁ and F₂ generations were exposed to low fertility and rainfed conditions. A total of 104 F₁'s (26 SxS and 78 WxS), and 302 bulk progenies of 302 crosses (227 WxS and 75 SxS) in F₂ to F₃ generations, and 731 single plant progenies ([487 SxS and 244 WxS]) of 92 crosses in F₄ and subsequent generations were subjected to rigorous selection. Rust inoculum received from the Regional Station of Directorate of Wheat Research (DWR), Puelweardale, Shimla, (Himachal Pradesh) was multiplied under glass house conditions. The infected rows planted in and around the breeding materials were inoculated following syringe-inoculation method. In addition to this, pots with infected seedlings were also kept in the field to facilitate development of rust diseases. This facilitated selection against rust diseases. Finally, 293 bulk and 451 individual plant progenies of 357 crosses (242 WxS and 115 SxS) from F₃ generations onward and 199 bulk in F₄ and onward generations were selected for further evaluation during the ensuing season.

**Breeding for Quality Wheat**

Efforts have been made to incorporate the desirable quality traits viz., high protein content (%), high micro-nutrients, good chapati and biscuit making quality etc. through hybridization with proven donors. The donors like QLD 11, QLD 25, QLD 36, QLD 43 and Raj 4201 (for protein >14%), QLD 31, QLD 39, QLD 40 (for protein yield), VL 852 and VL 858 (for chapati quality), INS 490 (for biscuit quality), BW 5872 (for sedimentation value) have been crossed with well adapted genotypes. During 2012-13, forty six fresh crosses were attempted. In addition, 20 F₁'s were also evaluated and were retained for growing F₂ generation. Besides, 45 bulk progenies of 45 crosses and 16 single plant progenies of 4 crosses were selected in F₃ onward generation for further evaluation. Preliminary observations were taken on the newly developed strains and used as a criterion to select high protein lines. Out of 56 lines, 7 lines were having >12.0 % protein content and >36 ml sedimentation value and have been included in All India Trials (Table 2.1.1).

### Table 2.1.1. The promising strains for wheat quality

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Strain</th>
<th>Protein %</th>
<th>Moisture %</th>
<th>Starch</th>
<th>Wet gluten</th>
<th>Sedimentation value (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>VW 1131</td>
<td>12.3</td>
<td>9.9</td>
<td>66.8</td>
<td>30.5</td>
<td>37.3</td>
</tr>
<tr>
<td>2.</td>
<td>VW 1136</td>
<td>12.8</td>
<td>9.6</td>
<td>65.6</td>
<td>32.3</td>
<td>38.0</td>
</tr>
<tr>
<td>3.</td>
<td>VW 1154</td>
<td>12.4</td>
<td>9.5</td>
<td>64.6</td>
<td>26.7</td>
<td>39.9</td>
</tr>
<tr>
<td>4.</td>
<td>VW 1156</td>
<td>13.5</td>
<td>9.8</td>
<td>65.2</td>
<td>30.1</td>
<td>53.7</td>
</tr>
<tr>
<td>5.</td>
<td>VW 1157</td>
<td>13.5</td>
<td>8.5</td>
<td>66.8</td>
<td>33.0</td>
<td>42.2</td>
</tr>
<tr>
<td>6.</td>
<td>VW 1159</td>
<td>12.7</td>
<td>8.5</td>
<td>66.6</td>
<td>28.9</td>
<td>38.8</td>
</tr>
<tr>
<td>7.</td>
<td>VW 1160</td>
<td>15.1</td>
<td>9.4</td>
<td>66.0</td>
<td>30.0</td>
<td>49.2</td>
</tr>
<tr>
<td>8.</td>
<td>HPW 251 (C)</td>
<td>18.9</td>
<td>9.8</td>
<td>61.6</td>
<td>38.3</td>
<td>54.8</td>
</tr>
<tr>
<td>9.</td>
<td>VL Chenhu 901 (C)</td>
<td>12.9</td>
<td>9.4</td>
<td>65.7</td>
<td>29.2</td>
<td>50.0</td>
</tr>
<tr>
<td>10.</td>
<td>INS 490 (C)</td>
<td>13.5</td>
<td>9.3</td>
<td>66.7</td>
<td>31.4</td>
<td>43.0</td>
</tr>
</tbody>
</table>

*Annual Report 2012-2013*
New Initiatives

Pre-breeding Activities

This new initiative was taken with the major objective of tapping the newly available variability in the form of improved horto, synthetic lines and other proven component lines. A total of 358 single plant progenies arising out of 51 crosses in $F_2$ generation were evaluated under artificial epiphytic condition out of which 126 single plant progenies from 34 crosses were selected for their further evaluation. Some promising stocks like VW 0826 (tillers/meter=84) and VI 0764 (grain/spike=51) have been identified through multi-location test by the Directorate of Wheat Research, Karnal from this programme.

New Avenues for Yield Advancement: Winter × Spring Wheat Hybridization

During 2011-12 under this project, twenty five winter and facultative wheat were selected for their high grain yield, tillering, ear length, grain number per ear and disease resistance, planted in a crossing block at experimental farm, VPKAS, Havelabagh, and crossed to spring wheats known for their high yield potential, disease resistance (rust resistance in particular) and adaptation to the major wheat growing regions of the country viz., PBW 380, PBW 583, PBW 590, PBW 599, Raj 4188, HS 507, DBW 51, HS 485, HS 490, VL 892, VL 907, UP 2711, UP 2747, UP 2672, HW 5210, HPW 238 etc. Based on the rust resistance analysis, parents were further selected for attempting crosses. In addition, three way crosses were also attempted with the $F_2$'s of the previous year by crossing them with selected spring wheat. A total of 55 crosses were successfully attempted during 2011-12.

In addition to this, 50 $F_2$'s made during nahi 2010-11 were planted and 50 were retained for growing their $F_2$ generation during next crop season. A total of 55 $F_2$'s retained during last season, were raised during nahi 2011-12. The high incidence of yellow and brown rust facilitated the selection. Only negative selection was practiced in these materials. Finally 55 $F_2$'s were bulked. Fifty $F_2$ bulks were supplied during nahi 2011-12 to DWR, Karnal for further distribution to seven cooperating centers viz; GBPUAT, Patanagor, NDUAT, Faizabad, RAU, Sabour, JNKV-ZARC, Powarikeda, SDAU, Vijapur, JAU, Junagadh and UAS, Dharwad. The utilisation report from cooperating centers was 40% at JAU, Junagadh, 100% at NDUAT, Faizabad, 22% at GBPUA&T, Patanagor, 98% at RAU, Sabour, 58% at SDAU, Vijapur and 78% JNKV-ZARC, Powarikeda for yield components, morphological traits and disease resistance. Some promising lines generated under this project were put in yield trials from cross combinations UP 2572/ Wugeng 8025, 90Zhong65/UP 2572, HUW 548/MV 231-98, Lacero/Trichnia-2/ /Hunza/3/VW 9676 and UP 2425/Spartanka-kak-Hori-Doli//PHR 1010.

Preparation for Breeding for Resistance against the Black Rust race - Ug 99

With the awareness of the possible threat of Ug 99 all over the world, efforts were made to develop materials having resistance against this race so that the disease can be combated effectively during the times to come. Crosses were attempted including resistant parents namely IHS 822, VL 941, HW 5210, PBW 583 and VL 829. A total of 23 fresh crosses were attempted. In addition, 63 bulk progenies of 63 crosses and 48 single plant progenies of 10 crosses were selected for further evaluation during ensuing season.

Genetic Resources - Evaluation and Maintenance

A total of 396 entries comprising of four national nurseries were evaluated. The entries having desirable attributes have been identified for use in the breeding programme. In National Genetic Stock nursery (NGSN), the entries were selected for rust resistance (3), high grains/spike (1), high tillers and grain weight (1), high grain number and grain weight (1), rust resistance, yield components (3) and phenotypically good (1). Similarly, nine genotypes having high protein, high protein yield, good chapati and biscuit quality were selected from Quality Component Screening Nursery (QCSN). Besides this, 17 local wheat germplasm (collected through exploration in Uttar Pradesh) were evaluated and deposited for medium term storage. In addition, 32 lines were
selected from the international nurseries and 9 lines from materials selected from CIMMYT and Australia, respectively.

**Off-season Nursery**

During khairi 2012, 23 F_2's were grown at the off-season facility at Dalang Maidan, Lahaul Spiti (HP) and selections were made. In addition, 370 advance lines, one land race were planted at Dalang Maidan. Besides, 370 advance lines were also planted at IARI, RS, Wellington (TN) for screening against yellow and brown rust, respectively. In addition, Yr5 and Yr10 pyramided plants of VL Gehun 738 background were planted at Dalang Maidan and the positive plants were advanced to F_3. Out of these, lines having desirable rust reaction were selected and overall 154 were selected on the basis of rust reaction as well as grain.

2.1.3.2 Crop Protection Investigations

One thousand eight hundred forty seven wheat lines/entries were screened under artificial/natural conditions in various coordinated and station nurseries namely, Elite Plant Pathological Screening Nursery (EPPSN), Multiple Disease Screening Nursery (MDSN), Hill Bunt Screening Nursery (HBSN), Loose Smut Screening Nursery (LSSN), Powdery Mildew Screening Nursery (PMSN), Leaf Blight Screening Nursery (LSBN), VL Rust Screening Nursery (VLRSN), AAARC Wheat Disease Trap Nursery and Wheat Disease Monitoring Nursery. Promising lines in different station nurseries were identified (Table 2.1.2).

Additionally, wheat genotypes VV 0513, VV 0636, VV 0751, VV 0752, VV 0810, VV 0855, VV 0856, VV 0911, VV 0912 and VV 0954 showed immune reactions to all rusts, Karnal bunt and powdery mildew; VL 931, VL 943, VL 944 were resistant to 3 rusts, powdery mildew and flag smut. Entries VL 829, VL 971 and VL 972 were found highly resistant against leaf blight. Multi-pathotype screening at seedling stage (DWR RS, Flowerdale) showed that VL 972 was resistant to all the pathotypes of yellow rust, VV 950 to black rust and VL 971 to brown rust. In EPPSN, VV 955, VL 956 and VL 959 maintained their resistance against yellow rust at Almora. Among wheat lines evaluated against black rust race Ug99 at Kenya and Ethiopia through DWR, Karnal during 2011 crop season, VL 941 and VL 946 were resistant in Ethiopia whereas VL 957 was resistant in Kenya. Four samples of wheat yellow rust collected from Almora district were analyzed at DWR Regional Station, Flowerdale, Shimla. Pathotypes 78584 was identified in all the samples.

2.1.3.3 Agronomic Investigations

**Effect of row spacing on performance of wheat**

Row spacings of 15.0, 17.5 and 20.0 cm were evaluated against recommended spacing (22.5 cm) with three genotypes (VL 804, VL Gehun 907 and HS 240). The row spacing of 17.5 and 15.0 cm recorded significantly higher grain yield than...
recommended spacing. The 17.5 cm spacing provided the highest grain yield (4,522 kg/ha), which was at par with 15.0 and 20.0 cm. Among genotypes, VL 804 recorded significantly higher grain yield (4,552 kg/ha) than rest of the genotypes.

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

HS 526 and HPW 349 were evaluated against three checks (viz. VL 804, VL Gehun 907 and HS 507) at normal and late sown irrigated conditions. All new genotypes produced significantly lower grain yield than the best check, VL Gehun 907 (4,771 kg/ha). Normal sown condition (4,704 kg/ha) provided 22% higher grain yield than late sown condition. There was no interaction between genotype and date of sowing.

Performance of new wheat genotypes at different nitrogen levels under rainfed conditions

HS 526 and HPW 349 were evaluated against three checks (VL 804, VL Gehun 907 and HS 507) with three nitrogen levels (40, 60 and 80 kg N/ha) in rainfed condition. All new genotypes produced significantly lower grain yield than the best check, VL 804 (2,325 kg/ha). The grain yield significantly increased as the level of N increased from 40 (1,805 kg/ha) to 80 kg N/ha (2,152 kg/ha).

2.1.3.4 Physiological Investigations

Performance of wheat varieties under normal and late sown condition

A field experiment was conducted in Hawalbagh farm with 8 wheat genotypes viz VL Gehun 738, VL Gehun 802, VL 804, VL Gehun 832, VL Gehun 892, VL Gehun 907, HS 507 and HS 490 to study the physiological responses of wheat sown under late sowing with interval of one month (Nov 21–D I, Dec 21–D II, Jan 21–D III, and Feb 21–D IV). Significant variations were observed for wheat phenophases, relative water content, membrane injury index (Fig. 2.2), chlorophyll “a” content, chlorophyll “b” content, total chlorophyll content, total carotenoid content, photosystem II efficiency and photosynthetic efficiency (Fv/Fm). Among all genotypes the VL Gehun 907, VL Gehun 832 and VL Gehun 892 showed significantly better physiology under late sown condition.

![Fig. 2.2. Effect of date of sowing on membrane injury index (%) in wheat genotypes](image)
2.1.4. Small Millets and Under-utilized Crops

Small millets and other under-utilized crops are the traditional rainfed crops of North-Western Himalaya and their cultivation is an integral part of hill farming because of their ability to give assured yield even under harsh and stressed conditions. Small millets are cultivated in over 196 thousand ha in Uttarakhand and their productivity is 1321 kg/ha. Development of short duration, high yielding varieties of millets having resistance to diseases and insect-pests with improved quality will increase the area and productivity of this group of crops. Value addition to these crops is going to play a significant role in fulfilling their use and profitability.

2.1.4.1. Varietal Improvement

Varieties Identified

**VL Mandua 348:** Finger millet variety VL Mandua 348 has been developed from the cross between VL 146 (earliness, high yielding) x VL 149 (blast resistant, high yielding). VL Mandua 348 is medium duration (mean maturity: 112 days) and high yielding variety (mean yield: 1877 kg/ha in State trials). Across four locations in the State, VL 348 exhibited yield superiority of 11.99% over the check VL 324. VL 348 is moderately resistant to blast, and was identified by State Varietal Identification Committee for release in hills of Uttarakhand.

**VRB 3:** VRB 3 is a selection from local accession IC 538088 from Uttarakhand. This variety is medium maturing (120-135 days) and high yielding (mean yield: 1700 kg/ha in All India trials), is indeterminate in growth habit (average height: 136-4 cm), and moderately resistant to seed shattering. It possesses field resistance to all the major diseases of rice bean. In the trials at locations across Uttarakhand, Himachal Pradesh and Meghalaya, VRB 3 exhibited yield superiority of 11.16 per cent over the best check. PRR 1. The seed colour of VRB 3 is light greenish and 100-seed weight is 7.56 g. The protein content of VRB 3 is 20.4% compared to 19.7% in the check PRR 1. It is moderately tolerant to water stress and therefore, is an excellent variety for rainfed conditions. In the annual workshop of under-utilized crops at Rahuri, VRB 3 was identified for release for North-West and North-East Hill Regions of India.

**Varietal Trials**

Eleven varietal trials comprising of four in finger millet, three in barnyard millet, two in amaranth, one each in rice-bean and buckwheat were conducted in order to identify improved genotypes for North Western hill zone. In these trials, a total of 225 genotypes were evaluated.

**Finger Millet**

Adaptability Evaluation of Brown Grained Finger Millet Strains

One hundred and twenty six finger millet genotypes were evaluated for yield and yield contributing characters. The promising genotypes superior to checks were identified in the Advance Varietal Trial (AVT), Initial Varietal Trial (IVT), State Varietal Trial (SVT) and Station Trial. VR 988 (3196 kg/ha), KOPN 942 (3023 kg/ha), TNAU 1214 (2989 kg/ha) and KMR 118 (2939 kg/ha) in AVT; VL 375 (1679 kg/ha) in SVT under organic cultivation; and VR 561 (3837 kg/ha), VR 319 (3563 kg/ha), VR 557 (3529 kg/ha), VR 558 (3496 kg/ha), VR 559 (3492 kg/ha) and VR 563 (3348 kg/ha) in Station trial were found to be superior to checks.

Development of New Strains

During kharif 2012, forty-two new cross combinations were attempted involving released varieties/good agronomical lines: GPU 45, GPU 48, VL 330 and 1. 450 (high yielding but late in maturity); VL 347 (early maturity, high yielding); VL 146 and VL 201 (locally adapted early but blast...
susceptible); VR 485, VR 486 and VR 487 (medium maturity, white grained); GPHCPB 52, PRM 701, VL 149 (blast resistant); and GPHCPB 1, GPHCPB 30 GPHCPB 45 and GPHCPB 24, GPHCPB 25 (nutritionally superior).

In finger millet, out of 30 crosses attempted during 2011, 29 crosses were suspected to be true hybrids. In F₁ generation, nineteen crosses were planted and 117 superior plants were selected from 17 crosses on the basis of superior yield contributing characters and disease resistance. In the F₂ generation, 30 progenies of eleven crosses were grown and 45 single plants were selected involving 7 crosses. In F₂ generation, 290 progenies from 10 crosses were planted and 186 superior single plants were selected and one bulk was made. In F₂ generation, 166 progenies of 7 crosses were planted and 94 single superior plants were selected and 26 progenies showing uniformity and yield superiority were bulked. In F₃ generation, 18 single plant selections were made from 27 progenies of 3 crosses and, similarly, 7 single plant selections and 7 bulks were made from four crosses in the F₄ generation.

**Development of New Strains**

During khari’ 2012, twenty-nine fresh crosses were attempted in barnyard millet involving locally adapted materials viz., VL 172, VL 29, K 1, VL 198, VL 200, VL 207 and VL 181 and agronominical superior genotypes viz., GECH 739, GECH 271, GECH 204, ER 72, HCBMG 1011 and HCBMG 1018. The new crosses also include a cross between E. crus-galli cv. PRJ 1 and E. frumentaceae cv. ER 72.

In barnyard millet, all 21 crosses attempted during 2011 were suspected to be true hybrids. In F₂ generation, 11 crosses were planted and 63 superior single plants were selected. In F₂ generation, 59 progenies of 9 crosses were planted and 31 superior single plants were selected. In F₃ generation, 376 progenies of 13 crosses planted and 139 single superior plants showing resistance to grain smut were selected and 7 uniform progenies were bulked. Fifty-nine single plant selections and 28 bulks were made from 124 progenies of 7 crosses in F₄ generation. In F₅ generation, 3 single plant selections and one bulk was made from three crosses.

**Development of Inter-specific Hybrid between Indian and Japanese barnyard millet**

During khari’ 2011, crosses were attempted between E. crus-galli cv. PRJ 1 and E. frumentaceae cv. ER 72. In the F₁ progeny planted during khari’ 2012, 5 hybrid plants were identified. The hybrid plants were highly vigorous and exhibited higher basal tillering and culm branching. The panicles were larger in size and in number than the parents. With respect to other morphological characters, the hybrid plants were intermediate between the two parents. The hybrid plants, however, were sterile and

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**Barnyard Millet**

Forty-eight genotypes were evaluated for yield and yield contributing characters in Barnyard millet Advance Varietal Trial (BAVT), State Varietal Trial (SVT) and Station Trial, VL 239 (2501 kg/ha), DHIHMV 93-2 (2404 kg/ha), VL 232 (2258 kg/ha) and VL 234 (2202 kg/ha) in BAVT and PRB 2012-2 (1717 kg/ha), PRB 903 (1161 kg/ha) and PRB 2012-1 (1160 kg/ha) in State Varietal Trial were found superior to the checks.
failed to set seed. This is the first report of successful production of inter-specific hybrid between the two species after Yahuro (1966).

**Germplasm Evaluation**

Barnyard core collection comprising of 89 accessions obtained from ICRISAT was evaluated along with 6 check varieties in Alpha Lattice Design. The genotypes were evaluated for 17 quantitative and 8 qualitative characters. A wide range of variation was observed among accessions for days to flowering (31-68 days), maturity (58-91 days), plant height (74.9-161.6 cm), panicle length (10.4-27.3 cm), raceme number (8-51), grain weight/ear (0.42-5.32 g), 1000-grain weight (1.43-5.43 g) and grain smut resistance (0-100 per cent). The accessions identified for various traits are given in Table 2.1.3.

**Underutilized Crops**

A total of fifty-one entries were evaluated in amaranth, rice bean and buck wheat Advanced Varietal Trials (AVT) and amaranth State Varietal Trial (SVT). In amaranth AVT, highest yield was exhibited by the check Durga (1174 kg/ha) followed by VL 102 (1120 kg/ha). VL 102 was also earliest in maturity (94 days). In the SVT trials for amaranth, RD 2605 was highest yielding (738 kg/ha) and also earliest to mature (93 days). In rice bean AVT, RBHP 43 (1419 kg/ha) was the highest yielding followed by LRB 460 (1391 kg/ha) and PRR 2012-1 (1348 kg/ha). The entry PRR 2012-2 was the earliest to mature (92 days) and entry IC 563940 had highest 100 seed weight (10.0 g). In AVT trials of buckwheat, the entry IC 109728 (2163 kg/ha) was the highest yielding.

**Development of New Strains**

**Amaranth:** Two new crosses, VL 44 x PLP 1 and IC 35407 (Durga) x VL 102, were attempted during kharg 2012. In the F₁, the cross IC 42334 x PLP 2 was planted and seed of hybrid plants was bulk harvested. In F₂, two bulks in the cross VL 44 x PLP 1 were made. In F₂, one single plant selection and 8 bulks were made in the crosses VL 44 x PLP 1 and VL 44 x GA 2. In F₂, one bulk was made from the cross IC 35407 (Durga) x PLP 1.

**Genetic Resources**

**Amaranth:** Fifty amaranth accessions along with four checks viz., PRA 2, PRA 3, Durga (IC 35407) and Annapurna were evaluated in augmented block design for 11 quantitative characters. The promising accessions identified for various traits are given in Table 2.1.4.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Promising accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>50% flowering ≤ 62 days</td>
<td>IC 38375</td>
</tr>
<tr>
<td>Days to maturity ≥ 94 days</td>
<td>IC 38373</td>
</tr>
<tr>
<td>Influenzer length ≤ 60 cm</td>
<td>IC 38316, IC 38308, IC 38129, IC 38408</td>
</tr>
<tr>
<td>Yield per plant ≥ 40 g</td>
<td>IC 38373, IC 38408</td>
</tr>
</tbody>
</table>

**Rice Bean:** Twenty five rice bean accessions along with four checks viz., RBL 1, RBL 6, PRR 1 and PRR 2, were evaluated in Augmented Block Design for 9 quantitative and 8 qualitative traits. The promising accessions identified for various traits are given in Table 2.1.5.

**Table 2.1.3: Promising accessions identified in barnyard millet**

<table>
<thead>
<tr>
<th>Trait</th>
<th>Promising accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to maturity ≤ 91 days</td>
<td>IC 196, IC 178, IC 279, IC 568, IC 767, IC 360, IC 650</td>
</tr>
<tr>
<td>Panicle length ≥ 23 cm</td>
<td>IC 208, IC 383, IC 100, IC 305, IC 751</td>
</tr>
<tr>
<td>No. of racemes ≥ 48</td>
<td>IC 568, IC 229, IC 178, IC 395, IC 259</td>
</tr>
<tr>
<td>1000 seed weight ≥ 4.0 g</td>
<td>IC 552, IC 351, IC 423, IC 518, IC 537</td>
</tr>
<tr>
<td>Yield per plant ≥ 4.0 g</td>
<td>IC 330, IC 786, IC 648, IC 788, IC 364</td>
</tr>
</tbody>
</table>

**Table 2.1.4: Promising accessions identified in amaranth**

*Annual Report 2012-2013*
Table 2.1.5: Promising accessions identified in rice bean

<table>
<thead>
<tr>
<th>Trait</th>
<th>Promising accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of seeds per pod ≥ 10</td>
<td>IC 522076, IC 522084, IC 538876, IC 421817, IC 243512</td>
</tr>
<tr>
<td>1000-seed weight ≥ 9 g</td>
<td>IC 522088, IC 418659</td>
</tr>
<tr>
<td>Yield per plant ≥ 10 g</td>
<td>IC 421817, IC 418659</td>
</tr>
</tbody>
</table>

**Buckwheat**: Twenty five accessions of buckwheat along with four checks viz., Himpriya, PRB 1, VL 7 and Shrima 1 were evaluated in Augmented Block Design for 14 quantitative characters. The promising accessions identified for various traits are given in Table 2.1.6.

Table 2.1.6: Promising accessions identified in buckwheat

<table>
<thead>
<tr>
<th>Trait</th>
<th>Promising accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to maturity ≤ 60 days</td>
<td>IC 188801, IC 107631, EC 386667, EC 218631, EC 58522</td>
</tr>
<tr>
<td>1000-seed weight ≥ 35 g</td>
<td>IC 204685, IC 216631, IC 218742, IC 272442</td>
</tr>
<tr>
<td>Yield per plant ≥ 7.5 g</td>
<td>IC 202279, IC 204685</td>
</tr>
</tbody>
</table>

**Mutation Breeding in Barnyard Millet**

In M2 generation, 17 single plants of VL 207 and four of PRJ 1 were selected on the basis of phenotypic superiority and grain smut resistance.

**2.1.4.2. Biochemical characterization**

A set of 52 finger millet genotypes were evaluated for their antioxidant activity, phenolic acid, condensed tannins and crude fibre. The analysis indicated that VL 347, VL 342, VL 341, VL 372, VL 356, VL 325, HR 374, VL 708, VL 333, GPHTCB 7 and GPHTCB 3 are biochemically better as these possess high condensed tannins, total phenols, total antioxidant activity and crude fibre than other genotypes. However, few genotypes showed considerable amounts of either condensed tannins, total phenols or total antioxidant activity along with crude fibre. Genotypes with higher condensed tannins, total phenols, total antioxidant activity and crude fibre can be used for biscuit making.

2.1.4.3. Crop Protection Investigations

**Evaluation for disease resistance**

In finger millet, a total of 137 entries were evaluated for resistance against leaf, neck and finger blast in two coordinated (IVT & AVT) and one station nurseries (VL Disease Screening Nursery). Among these entries, 16 entries of AVT and 13 of AVT were resistant to neck and finger blast. In the station nursery, 4 entries were highly resistant and 55 others showed resistance against neck and finger blast.

In barnyard millet, 73 entries of AVT, Raniachauri HC28M entries and VL Disease Screening Nursery were evaluated against grain smut. BAVT-10 and BAVT-14 were highly resistant whereas BAVT-17 showed moderately resistant reaction. Among entries from Ranichauri, HCBBM-1008, HCBBM-1014, HCBBM-1016, HCBBM-1017, HCBBM-1018, HCBBM-1019, HCBBM-1020 recorded highly resistant reaction. Entry VB 519 showed moderately resistant reaction.

2.1.4.4. Agronomic Investigations

**Response of Pre-released Finger Millet Varieties to Different Nutrient Levels under Rainfed Conditions**

Two pre-released short duration entries (VL 352, PRM 9002) along with two checks (VL 708, VL 149) and 3 medium duration finger millet varieties (BIBM 10, VL 353, KOPN 393) along with check (VL 149) were evaluated at different nutrient levels (No NPK, 50% NPK, 100% NPK and 125% NPK) under rainfed condition. The check variety VL 149 (1282 kg/ha) recorded the highest yield among all varieties. Highest yield was recorded under 125% NPK in both the groups; however, significant increase in yields were found up to 100% NPK.

**Response of Pre-released Barnyard Millet Varieties to Different Nutrient Levels under Rainfed Conditions**

Three promising pre-released varieties, viz., VL 232, TNAU 149 and PRB 903 along with VL 207 (check) were evaluated at different fertility levels (No fertilizer, 50% NPK and 100% NPK). VL 207, the check variety performed best (1142 kg/ha) followed by VL 232 (1139 kg/ha). Application of 100% NPK produced the highest grain yield (1047 kg/ha).
2.1.5. Barley

Cultivation of barley is restricted to some of the traditional areas of North-Western Hills, covering only a small area of 59.7 thousand ha with an average productivity of 1,048 kg/ha (2010-11). Crop improvement work in barley is focused mainly on the development of high yielding and disease resistant varieties, suitable for rainfed conditions.

2.1.5.1. Varietal Improvement

Variety identified

VLB 118, a high yielding disease resistant barley strain was identified by varietal identification committee during 51st All India Wheat and Barley Research workers meeting held at ARS, Durgapur, Jaipur. It has an average yield potential of 3684 kg/ha. It is a 6 rowed hulled barley and has shown an overall significant yield superiority of 8.2% over the latest 6 rowed hulled check UPB 1008 under rainfed timely sown conditions during the three years of testing. VLB 118 is also significantly superior by 73.2% over 6 rowed hull less check BHS 352, and by 10.7% over 2 rowed hulled check HBL 113 under rainfed timely sown conditions during the three years of testing. VLB 118 has high degree of resistance against yellow rust under natural as well as artificial epiphytotic conditions as compared to prevalent checks.

Adaptability Evaluation of Newly Developed Strains

To identify high yielding disease resistant genotypes, 67 new barley strains were evaluated in four different trials. In AVT timely sown rainfed trial VLB 118 (2,320 kg/ha) performed significantly better than the best check UPB 1008 (2,040 kg/ha) and were in 1st non significant group. Under the SVT (organic) timely sown rainfed trial, UPB 1028 (3,665 kg/ha), VLB 130 (3,165 kg/ha), UPB 1029 (2,990 kg/ha) and PRB 902 (2,944 kg/ha) were superior to the best check PRB 502 (2,813 kg/ha). Out of 36 new bulks generated through institute breeding programme and evaluated in station trials under rainfed condition, four promising strains were nominated in the All India Coordinated Trials of Northern Hill Zone.

Development of New Strains

To develop high yielding disease resistant genotypes, 166 introduced materials were
evaluated. Thirty high yielding disease resistant genotypes were selected for their further evaluation during the ensuing season.

**Genetic Resources - Evaluation and Maintenance**

A total of 188 barley germplasm from medium term storage module of the institute were rejuvenated and maintained.

**Off-season Nursery**

During **kharif** 2012, 129 advance lines of the breeding materials were grown at the off-season facility at Daulat Maidan, Lahaul Spiti (HP) for screening against yellow rust. Out of these, 30 lines having desirable rust reaction were selected.

**2.1.5.2. Crop Protection Investigations**

Two hundred and forty barley entries of National Barley Disease Screening nursery (NBDSN) and Elite Barley Disease Screening nursery (EBDSN) were screened for yellow rust, powdery mildew and leaf blight. VLB 132 was resistant to all the pathotypes of three rusts at seedling stage when screened at Flowerdale. On the basis of multi-location testing, VLB 124, VLB 130, VLB 131 and VLB 132 were found to be highly resistant to yellow rust with ACI < 1.0 whereas VLB 118 and VLB 128 were resistant to leaf blight.

**2.1.5.3. Agronomic Investigations**

**Performance of new barley genotypes to nitrogen levels under rainfed timely sown conditions in NHZ**

VLB 118 and UPB 1008 were evaluated against two checks viz. HBL 113 and BHS 352 with three nitrogen levels (20, 40 and 60 kg N/ha) under the rainfed condition. VLB 118 (1,743 kg/ha) produced significantly higher grain yield than rest of the genotypes. The grain yield increased as the N level increased from 20 kg N/ha (1,211 kg/ha) to 60 kg N/ha (1,708 kg/ha).
2.1.6. Pulses and Oilseeds

Pulses and oilseeds are important rainfed crops for marginal lands. The total pulses production in North-Western Himalayas, is 110.4 thousand tons from an area of around 124.2 thousand hectares with an average productivity of 691.0 kg/ha as against national productivity of 882.66 kg/ha. However, the total oilseed production in North-Western Himalayas, is 19.2 thousand tons from the area of 106.8 thousand hectares with an average productivity of 782.33 kg/ha against the national productivity of 1193.0 kg/ha (DAC 2010-11). Development of high yielding varieties suitable for cropping system with matching agri-technology is a challenging area of research for increasing the area and productivity of pulses and oilseed crops in hills.

2.1.6.1. Varietal Improvement

Varieties identified

VLGN 13: VLGN 13 (2541 kg/ha) is a groundnut genotype suitable for timely sown rainfed conditions of Uttarakhand hills. It has shown significant yield superiority of 29.80% over best check VLGN 1 (1958 kg/ha) over three years of testing under organic condition in Uttarakhand hills.

Yield evaluation trials

Five hundred and ninety-eight entries of eight crops viz., lentil (179), field pea (100), soyabean (7), flax (7), soybean (178), horsegram (77), groundnut (7) and pigeon pea (42) were evaluated for yield and other characters during the rabi and kharif seasons. Efforts for development of new strains were made in lentil, field pea, soybean and horsegram.

Lentil
Varietal Adaptability Evaluation

One hundred seventy-nine entries of lentil were tested in nine trials along with suitable checks. A total of 36 entries were short listed in advance and initial Station Trials. VLM 2009-6 (1791 kg/ha), VLM 2009-4 (1198 kg/ha) and VLM 2007-24 (1198 kg/ha) were superior in advance bold seeded trial, and VLM 2010-9 (1430 kg/ha), VLM 2008-14 (1204 kg/ha) and VLM 2010-2 (1121 kg/ha) were superior in advance small seeded trial. VLM 2011-108 (1087 kg/ha), VLM 2011-103 (1463 kg/ha) and VLM 2011-101 (1407 kg/ha) were superior in initial bold seeded trial, and VLM 2011-3 (2404 kg/ha), VLM 2011-39 (1391 kg/ha) and VLM 2011-7 (1333 kg/ha) were superior in initial small seeded trial. In joint small and bold seeded SVT trial, 9 entries were evaluated. VL 142 (1130 kg/ha) and VL 143 (1114 kg/ha) were superior in small seeded and VL 521 (1006 kg/ha) in bold seeded genotypes performed well and were promoted to 2nd year of testing.

Development of New Strains

Efforts were made to transfer higher number of pods coupled with high yield from *macropersica* and bold seeded trait from *macropersica* to genotypes with better tolerance to biotic and abiotic stresses. Seventy-six fresh crosses were made involving twenty-one purposely selected parents. Seventy-four F1's and forty-two F2's crosses were advanced to next generation. 1531 progenies were selected from F2 to F4 generations. Seventy two uniform bulks were selected for further testing in term of yield and other characters.

Evaluation of Germplasm

A total of 112 lentil germplasm were grown during rabi and data was recorded on 12 characters. Twelve promising accessions were selected which exhibited variation in seed size, plant height (20-37 cm), days to 50 % flowering (104-122 days), days to maturity (142-156 days), number of pods per plant (46-86), pod length (1.02-1.2 cm), number of grains per pod (1-2) and seed yield per plant (50-360 g).

Field Pea

Varietal Adaptability Evaluation

Hundred entries of field pea were tested in seven trials along with suitable checks. A total of
16 entries were short listed in advance and initial Station Trials. VP 2009-18 (1618 kg/ha) and VP 2006-19 (1526 kg/ha) were superior in the Advance Station Trial, and VP 2011-9 (1008 kg/ha), VP 2011-12 (972 kg/ha), VP 2011-17 (935 kg/ha) and VP 2011-10 (920 kg/ha) were superior in the Initial Station Trial. IVT entry VI. 56 was promoted to AVT-I. In the SVT trial 9 entries were evaluated. VI. 55 (1571 kg/ha) showed the highest yield of 16.37% over the best check. VI. 42 (1350 kg/ha). VI. 55 was promoted to 3rd year of testing in SVT.

Development of New Strains

Efforts have been made to develop more productive and disease resistant genotypes. Twenty-three fresh crosses were made involving seven selected parents. The parents were selected on the basis of yield, yield components and resistance to biotic and abiotic stresses. Fifty-four F₁ and sixty-two F₂ crosses were selected in the second generation. 1100 progenies were selected from F₁ to F₄ generations. Thirty-three bulk progenies were selected for further testing in terms of yield and other traits.

Soybean

Varietal Adaptability Evaluation

One hundred seventy-eight entries of soybean were tested in eight trials along with suitable checks. Four entries viz., VLS 76, VLS 84 and VLS 85 were in different stages in the coordinated programme. In AVT-II, VLS 76 (2254 kg/ha) has shown significant yield superiority of 12.59% over the best check VLS 63, 14.96 % over VLS 59 and 16.5% over Bhagat in the last three years of testing. The average duration of VLS 76 was 114 days while VLS 63 matured in 117 days. Amongst the various entries tested in the early Station Trial, VS 2008-6 (1376 kg/ha), VS 2010-5 (1352 kg/ha) and VS 2009-33 (1315 kg/ha) were found superior. VLS 2008-6 showed the earliest maturity (90 days). A total of 22 entries were short listed in advance and initial station trials. VS 2010-21 (2622 kg/ha) and VS 2010 3 (2568 kg/ha) were superior in the advance station trial, and VS 2010-50 (2531 kg/ha) and VS 2010-108 (2290 kg/ha) were superior in the advance bhat station trial. A total of 35 entries were selected in the Initial Station Trials. VS 2011-15 (3259 kg/ha), VS 2011-47 (2370 kg/ha), VSB 2011-101 (1932 kg/ha) and VS 2011-50 (2326 kg/ha) were found to be superior over the best check VLS 63 (2111 kg/ha). In initial bhat station trial VSB 2011-112 (1450 kg/ha), VSB 2011-110 (1264 kg/ha) and VSB 2011-104 (1257 kg/ha) were found to be superior over the check VLS 65 (1078 kg/ha). In state varietal organic trial 12 entries were tested where VLSB 201 and VLS 77 performed well.

Development of New Strains

Fifty one fresh crosses were made involving twenty eight selected parents. The parents were selected on the basis of yield and yield components. Forty three F₁ and seventy three F₂ crosses were advanced to the next generation. 1547 individual plants were selected from F₂ to F₄ generations. Sixty-five bulk progenies were selected for further testing in terms of yield and other traits. Black soybean, popularly known as ‘Bhat’ was used in the crossing programme. Ten cross combinations were made, involving five parents. These parents were selected on the basis of yield and yield components like pods/plant, pod length, determine growth habit, stiff stem and earliness.

Evaluation of Soybean germplasm

A total of one hundred eighty soybean germplasm were grown during 2012 and data was recorded on 11 qualitative and 8 quantitative characters. The qualitative characters observed were: flower colour (White-34%, Purple-66%), leaflet colour (Light Green-84%, Green-5%, Dark Green-11%), pubescence colour (Grey-29%, Light Tawny-27%, Tawny-44%), pubescence density (Sparse-21.6%, Semispars-11.7%, Normal-3.6%, Dense-63%), pubescence type (Erect-60.4%, Semi-pressed-39.6%), seed colour (Yellowish White-24.3%, Yellow-40.5%, Green-1.8%, Buff-23.4%, Reddish Brown-7.2%, Grey-2.7%), hilum colour (Brown-52.2%, Black-47.7%), seed lustre (Shiny-24.3%, Intermediate-65.8%, Dull-9.9%), leaf shape (Broad-0.9%,
Intermediate-89.2%, Narrow-9.9%), pod colour (Light Brown-30.6%, Brown-53.2%, Dark Brown-9%, Black-7.2%) and seed shattering (Present-14.4%, Absent-85.6%). The quantitative characters observed were seed size, plant height (34-92.3 cm), days to 50% flowering (24-64 days), days to maturity (102-116 days), number of primary branches (1.3-8.0) and number of grains per pod (2-5).

Horse Gram

Varietal Adapability Evaluation

Seventy seven entries of horsegram were tested in four trials along with suitable checks. Two entries viz., VLG 33 and VLG 34 were found promising in the co-ordinated programme. A total of seventeen entries were short listed in advance and initial station trials. VLG 2010-2 (834 kg/ha) and VLG 2010-3 (721 kg/ha) were found superior in the advance station trial, and VLG 2011-12 (1093 kg/ha), VLG 2011-22 (889 kg/ha) and VLG 2011-19 (785 kg/ha) were found superior in the initial station trial. Five entries were tested in the state varietal trial under organic mode. Three entries viz., VLG 31, VLG 33 and VLG 34 are in different stages in the state varietal trial under organic mode.

Development of New Strains

Fifty fresh crosses were made involving twelve purposely selected parents. The parents were selected on the basis of yield and yield components like higher pod length, higher number of pods/plant, earliness, good market quality and resistance to diseases. Forty-three F1’s and twenty four F2’s crosses were advanced to the next generation. 1427 individual plants were selected from F2 to F4, generations. Twenty bulk progenies selected for further testing in term of yield and other traits.

Groundnut

Varietal Adapability Evaluation

Seven entries of groundnut were tested in state varietal trials under organic mode along with suitable checks. Maximum yield was expressed by GN 1906 (1462 kg/ha) followed by GN 1905 (1437 kg/ha) and GN 1904 (1457 kg/ha).

Toria

Varietal Adapability Evaluation

Seven entries were tested in state varietal trial under organic mode. None of entries performed better than the check VLT 3.

Pigeon pea

Varietal Adapability Evaluation

Forty three entries of pigeon pea were tested in four trials along with suitable checks. A total of four entries were short listed in the initial station trials. AL 201 (1772 kg/ha) and IC 2011241 (1444 kg/ha) were superior in initial NDT early station trial whereas IC 2011255 (1000 kg/ha) and IC 2011249 (875 kg/ha) were found to be superior in initial DT station trial.

Flax

Varietal Adapability Evaluation

Seven entries of flax were evaluated. JRF 4 (542 kg/ha) and JRF 2 (515 kg/ha) performed well in trial.

Sharing of Crop Genetic Resources

Exchange and sharing of genetic resources is the most effective way to faster the utilization of genetic resources. During 2012-13, 36 accessions of lentil (15), horsegram (3), field pea (4), groundnut (1), toria (1) and soybean/bhath (9) were shared with different scientists for utilization in their respective breeding programmes.

Evaluation and Maintenance of Genetic Resources

Two thousand one hundred and ten accessions of different pulse and oilseed crops were maintained during nabi and khazif (Fig. 2.3).

Fig. 3.3. Maintenance and evaluation of germplasm
2.1.6.2. Crop Protection Investigations

*Evaluation for Disease Resistance*

**Soybean**

Forty-two soybean entries of AVT I & II year were evaluated against frogeye leaf spot (*Cercospora sojina*). Yield losses due to FLS disease in soybean varied from 30.5 to 57.25% in 42 entries evaluated under protected and unprotected conditions. Five entries AMS-MB-5-18, AMS-MB-5-19, DSB 20, KDS 378, VLS 76 were categorized in resistant and high yielding group (Table 2.1.7). Out of 41 IVT soybean entries evaluated, 21 entries were resistant or moderately resistant to FLS. All the 37 entries, previously found resistant to FLS maintained their resistance including VLS 47, VLS 73, VLS 74, VLS 75 and VLS 76.

In soybean advance station trial, entries VS 2010-3, VS 2010-16, VS 2010-32 and VS 2010-40 were found resistant to FLS whereas in Bhat, VB 2010-104 and VB 2011-117 were most promising.

**Horse gram**

In the horse gram advance station trial, VLG 2010-3, VLG 2010-15 and VLG 15 were found to be most promising against anthracnose.

**Lentil and Field pea**

In the initial and advance station trials, lentil entries VLM 2009-46, VLM 2010-106, VLM 2011-104, VLM 2011-108, VLM 2011-126, VL 507, VL 514 (all bold seeded), VLM 2010-24, VLM 2011-5, VLM 2011-19, VLM 2011-37 (all small seeded) and Field pea lines VP 2010-9, VP 2010-27, VP 2011-02, VP 2011-18 were found promising against wilt and root rot complex, though the disease incidence was low in both the crops under field conditions.

2.1.5 Physiological Studies

**Physiological basis of drought tolerance in soybean genotypes**

Drought stress is commonly observed during soybean crop periods. A pot experiment was conducted during 2012 on five soybean genotypes viz. Bragg, VLS 21, VLS 47, VLS 59, VLS 63, VLS 74, VLS 75 and VLS 76. Local soybean, Local Bhat, VS 2008-50, VRF 1444 and Bhat 63 were identified to study the physiological basis of drought tolerance in soybean genotypes at reproductive stage. During reproductive stage the drought stress was imposed by withholding the irrigation and pots were shielded by polycrylon structure to avoid rainfall. Physiological observations like relative water content (RWC), membrane stability index (MSI), chlorophyll a', chlorophyll b, total chlorophyll, total carotenoid, photosystem II efficiency, photosynthesis efficiency (Fv/Fm) and grain yield were recorded after short period of drought stress. Relative water content, MSI, total chlorophyll content, total carotenoid content, photosystem II efficiency, and photosynthesis efficiency were found to be reduced under drought compared to that of irrigated (control) condition. MSI and RWC were reduced by 44 and 59%, respectively. Among genotypes, VLS 47 and VLS 2008-50 exhibited significantly better physiological traits for drought tolerance.

<table>
<thead>
<tr>
<th>Category</th>
<th>Genotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistant &amp; High Yielding (R-HY)</td>
<td>AMS MB 5-18, AMS MB 5-19, DSB 20, KDS 378, VLS 76</td>
</tr>
<tr>
<td>Resistant &amp; Low Yielding (R-LY)</td>
<td>JS 20-34, KVS 8, KVS 85</td>
</tr>
<tr>
<td>Susceptible &amp; High Yielding (S-HY) / Tolerant</td>
<td>BAUS 60, Bragg, MACS 1316, PS 1476, PS 1477, SL 958</td>
</tr>
</tbody>
</table>
Performance of lentil varieties under normal and late sown condition

An experiment was conducted during 2011-12 with five lentil genotypes viz VL 125, VL 126, VL 133, VL 507 and VL 514 to study the variations in physiological traits under normal and late sown condition. Late sown condition resulted in significant reduction in grain yield and biomass compared to that of normal sown condition. Under late sown condition, VL 514 and VL 126 recorded higher grain yield, while VL 507 recorded poor grain yield. Significant reduction in leaf relative water content (RWC), membrane stability index (MSI), chlorophyll 'a', chlorophyll 'b', total chlorophyll, total carotenoid, leaf area, leaf weight and stem weight were obtained under late sown condition. From the experimental results it can be concluded that the lentil crop can be sown up to February 3rd week.

2.1.6 Agronomic Investigations
2.1.6.1 Response of field pea varieties to different fertility levels

Three field pea varieties (VL 54, VL 55 and VL 42) were evaluated with three different fertility levels (10:30:20, 20:60:40, 30:90:60 of N: P₂O₅: K₂O kg/ha + 10 t FYM/ha) under field conditions. It was observed that VL 55 gave the highest seed yield (1,164 kg/ha) as compared to VL 42 (957 kg/ha), and was statistically at par with VL 54 (1,093 kg/ha). Similarly, all the three varieties performed best at 20:60:40 of N: P₂O₅: K₂O kg/ha + 10 t FYM/ha as compared to the other fertility levels. VL 55 at 20:60:40 of N: P₂O₅: K₂O kg/ha + 10 t FYM/ha recorded the highest grain yield (1,173 kg/ha) than all other combinations.

2.1.6.2 Evaluation of AVT-II Soybean Entries for Optimum Plant Population

The highest seed yield (2,431 kg/ha) was obtained with VLS 76 entry of soybean, which was statistically at par with VLS 47 (2,336 kg/ha). Among the plant population treatments, 0.45 M/ha recorded highest seed yield (2,242 kg/ha) followed by 0.3 (2,117 kg/ha) and 0.6 M/ha (2,013 kg/ha). Across the plant population, VLS 76 produced highest seed yield (2,574 kg/ha) at 0.45 million/ha.
2.1.7. Vegetables

Vegetable cultivation, especially off-season and temperate ones is accepted as highly viable and advantageous venture as compared to cereals, due to niche potential of hills. The total area under vegetable production in Uttarakhand is around 85.8 thousand ha with an average productivity of 12000 kg/ha, which is much below the national productivity of 17300 kg/ha (NHB 2010-11). Development of high yielding varieties and hybrids specific to quality and market demands along with package of practices and having resistance to biotic stresses is a promising area of research activity for the improvement of horticulture scenario of North-Western Himalayas.

2.1.7.1. Varietal Improvement

Variatel adaptability evaluation was undertaken in six vegetable crops, viz., garden pea, onion, garlic, french bean, tomato and capsicum. A total of 270 genotypes were evaluated in 25 trials for yield performance against suitable checks to identify the high yielding and disease resistant genotypes/strains. Development of new strains with high marketable yield and nutritional quality including disease resistance was undertaken in garden pea, tomato, capsicum and French bean.

Garden pea

Varietal adaptability evaluation

Eight field trials were conducted to evaluate 90 entries against suitable checks to identify early and medium maturing, high yielding and disease resistant genotypes. 11/PEVAR-5 (11853 kg/ha), 10/PEVAR 1 (119.92), 10/PMVAR-2 (10040 kg/ha), 09/PMVAR-2 (11380 kg/ha), VP 611 & 613 (7500 kg/ha) and VM 6 (9720 kg/ha) recorded maximum green pod yield in IET (early), AVT-1 (Early), AVT I (medium), AVT II (medium), SVT, organic mode (early) and (medium) trials, respectively. In Station Trial of garden pea, VP 1114 (15560 kg/ha) and VP 1113 (15280 kg/ha) in medium maturity group were found to be promising.

Development of new strains

Emphasis was given to develop early and medium duration genotypes with high green pod yield potential and resistance to powdery mildew. In this endeavor, 48 new F1's were made among selected parents to combine different horticultural traits like earliness, high green pod yield, high shelling percentage, attractive pod color and shape and disease resistance etc. Better performing 36 F1’s were advanced for growing their F2 generation in next season. Besides, selection was practiced in the segregating materials derived from 48 F1’s, 36 F2’s, 39 F3’s, 20 F4’s and 17 F5’s crosses. Based on desirable traits, 580 progenies derived from 73 crosses were advanced in F1 to F5 generations. 29 crosses were retained (7 F1’s, 2 F2’s and 20 F3’s) for further selection. Twenty four new bulks were also made based on phenotypic uniformity in creating crop season in early and medium maturity group.

Onion

Varietal adaptability evaluation

Three AINRP trials on long day onion were conducted with 42 genotypes to evaluate their yield performance against checks. ALRO-1109 (40160 kg/ha), ALRO-1129 (38230 kg/ha) and CLRO-1196 (42890 kg/ha) recorded maximum bulb yield in IET, AVT-I and AVT II, respectively.

Garlic

Varietal adaptability evaluation

Three AINRP trials on long day garlic were conducted with 23 genotypes to evaluate their yield performance against checks. ALROG-1101 (17780 kg/ha) in IET, BLRO-1123 (13090 kg/ha) AVT-I and CLRO-1146 (15580 kg/ha) in AVT-II recorded maximum bulb yield with big cloves.

French bean

Varietal adaptability evaluation

Two Station Trials were conducted with 35 genotypes to evaluate their green pod yield.
performance against checks viz., Arka Anoop and VI, Vear 2, VLFB 1137 and VLFB 1135 (14160 kg/ha), VLFB 1127 (13050 kg/ha) and VLFB 11408 (12500 kg/ha) recorded maximum green pod yield.

Development of new strains

Emphasis was given to develop high yielding bush type genotypes, stringless pods and resistance to angular leaf spot, root knot, anthracnose and rust. In this endeavour, 46 new F_1s were developed using diverse parents. 77 progenies derived from 22 crosses were advanced in F_2, to F_4 generations. Based on desirable traits, 6 crosses were retained (4 F_2 and 2 F_3) for further selection. Five new bulks were also made based on phenotypic uniformity in ensuing crop season.

Tomato

Vareial adaptability evaluation

Six coordinated trials were conducted to evaluate 60 entries against suitable checks to identify high yielding genotype in determinate and indeterminate group. 2011/ToDVAR-1 (39888 kg/ha); 09/ToDVAR-7(32110 kg/ha), Arka Vikas (21460 kg/ha), 2011/ToDHYB-8 (24660 kg/ha), 10/ToDHYB-10 (21998 kg/ha), 2009/ToDHYB-8 (26331 kg/ha), recorded maximum fruit yield in IET, Det., AVT-II, Det., IET, Indet. IET, Det., Hybrid AVT-I, Det., Hybrid AVT II, Det., Hybrid, respectively. In tomato station trial, promising six F_1s were evaluated along with their parent and private sector hybrids, VLTH 8 (36830 kg/ha) and VLTH 10 (34830 kg/ha) were found to be promising.

Development of new strains

Emphasis was given to develop high yielding early F_1 hybrids having market acceptability with regard to size, shape and pericarp thickness. Fifteen F_1s were made involving diverse parents with regard to yield and other desirable traits like earliness. Forty six progenies derived from 15 crosses were advanced in F_2, to F_4 generations and 3F_2, and 4F_3 were retained for further selection.

Capsicum

Vareial adaptability evaluation

Two coordinated trials were conducted to evaluate 20 entries against suitable checks to identify early maturing, high yielding and disease resistant genotype. 2009/CAPVAR-4 (25630 kg/ha) and 2011/CAPVAR-5 (31333 kg/ha) recorded maximum fruit yield in IET and AVT-II, respectively. In the Station Trial, promising eleven F_1s were evaluated along with private sector hybrids. Entries VLCP 2 X BL 1 (22750 kg/ha) and MKT X BL C 1 (21750 kg/ha) were found to be promising hybrids.

Development of new strains

In capsicum, emphasis was given to develop high yielding early maturing F_1 hybrids having market acceptability with regard to size and shape, suitable for protected cultivation and open field especially under organic conditions. Fifteen F_1s were developed involving diverse parents those will be evaluated with regard to yield and other desirable traits in next season.

Genetics Resources—Evaluation and Maintenance

Five hundred twenty four accessions of different vegetable crops are maintained in the gene bank during nabi 2011-12 and bharat 2012.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garden pea</td>
<td>210</td>
</tr>
<tr>
<td>French bean</td>
<td>30</td>
</tr>
<tr>
<td>Tomato</td>
<td>85</td>
</tr>
<tr>
<td>Cabbage</td>
<td>60</td>
</tr>
<tr>
<td>Chicory</td>
<td>40</td>
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<tr>
<td>Chilli</td>
<td>42</td>
</tr>
<tr>
<td>Onion</td>
<td>17</td>
</tr>
<tr>
<td>Cucumber</td>
<td>40</td>
</tr>
<tr>
<td>Green pepper</td>
<td>60</td>
</tr>
<tr>
<td>Radish etc.</td>
<td>324</td>
</tr>
<tr>
<td>Total</td>
<td>324</td>
</tr>
</tbody>
</table>

2.1.7.2. Crop protection Investigations

Evaluation for Disease Resistance

Among 48 onion entries screened against purple blotch in coordinated trials, 20 entries were found promising including ALRO 1106, ALRO
1109, ALRO 1113, ALRO 1196, BLRO 1115, BLRO 1127 and BLRO 1196. Similarly, 23 garlic entries of coordinated nurseries were evaluated against purple blotch in which ALRG 1109, ALRG 1117, ALRG 1120, BLRG 1123, BLRG 1125, BLRG 1136, BLRG 1129, CLRG 1143, CLRG 1146, CLRG 1153, CLRG 1155, CLRG 1120 were found to be promising.

2.1.7.3. Agronomic Investigations

Response of Pre-released Garden Pea Varieties to Different Fertility Levels

Three garden pea varieties (VL 11, VP 434 and VL 6) were evaluated with four different fertility levels (20:40:40, 20:60:40, 20:80:40 of N:P:K kg/ha + 10 t FYM/ha and 20 t FYM/ha) under field condition. It was observed that VP 434 recorded higher pod yield (15,100 kg/ha) than that of VL 11 (12,810 kg/ha) and VL 6 (11,300 kg/ha) at 20:80:40 of N:P:K kg/ha + 10 t FYM/ha.

Response of Pre-released Garlic Varieties to Different Fertility Levels

Between VGP 5 and VLG 1, VGP 5 recorded significantly higher yield (15,230 kg/ha) than VGP 1 (10,110 kg/ha). Similarly, among fertility levels, 100:50:50 NPK kg/ha resulted in significantly higher yield (13,790 kg/ha) than others. VGP 5 under 100:50:50 NPK kg/ha recorded significantly higher yield (16,780 kg/ha) than all other combinations of variety and fertility level.
2.1.8. Basic and Strategic Research for Genetic Enhancement of major Hill Crops for Biotic stresses and Quality traits using Molecular Tools

Different aspects of work carried out at VPKAS on plant biotechnology involve basic, strategic and applied research. VPKAS released the first MAS product for QPM maize namely Vivek QPM 9 in 2008. Vivek QPM 21, the QPM version of Vivek MH 21 was released by the SVRC, Uttarakhand. The other MAS products in maize (QPM), and rice (resistance against blast) are under multilocation evaluation. Besides, work at VPKAS includes transformation of maize and rice, mapping of agronomically useful genes in rice, maize and MAS in wheat (yellow rust).

Hybrid Released

**Vivek QPM 21**: Vivek QPM 21 is the second extra-early QPM single cross hybrid developed in the country through marker assisted selection. It is the QPM version of the Vivek Maize Hybrid 21. It has 9.5% protein as compared to 8.5% in ‘Vivek Maize Hybrid 21’. It possesses 0.85% tryptophan as compared to 0.49% in Vivek Maize Hybrid 21, which is 73.5% higher over ‘Vivek Maize Hybrid 21. The mean grain yield (5631 kg/ha) in hills of Uttarakhand was at par with check ‘Vivek Maize Hybrid 21’ (5499 kg/ha) even if it is numerically superior to Vivek Maize Hybrid 21. The mean grain yield (7093 kg/ha in Zone-I, 5305 kg/ha in Zone-II and 6455 kg/ha in Zone-IV) was at par with check ‘Vivek Maize Hybrid 21’ (6620 kg/ha in Zone-I, 5687 kg/ha in Zone II and 6455 kg/ha in Zone-IV) under the AICRP maize. It produced mean grain yield of 4749 kg/ha in Zone- I, 4837 kg/ha in Zone-II and 6079 kg/ha in Zone-IV under recommended fertilizer dose (N100: P50: K50). It exhibited considerable tolerance against *S. sorghum* leaf blight.

**Pyramiding Blast Resistance Genes for Durable Resistance in Elite Cultivars VL Dhan 206 and Basmati 370**

VL Dhan 206 is a popular cultivar in the NW Himalayan region. It occupies more than 50% area for the Spring-sown rainfed ecosystem in the Kumaon region. This cultivar is susceptible to blast. In order to develop the resistant version of VL Dhan 206, marker assisted selection (MAS) was employed to pyramid *Pb* 2 and *Pb* 9 in the background of VL Dhan 206. Since the host plant resistance in VL Dhan 206 is often broken down, there was a need of employing more than one blast resistance genes with synergistic effect. *Pb* 2 and *Pb* 9 are the two proven resistance genes for which site specific markers are available. The donor used for *Pb* 2 was C101A51 and the donor for the *Pb* 9 was *O. minuta* derivative. The fixed populations of the MAS products with both these genes have been developed. The selected lines are not only resistant to the prevailing blast isolates, they are also superior in grain yield and other agronomic traits. Four lines were nominated for the SVT trials of the Uttarakhand state and they were evaluated at four locations. Based on the performance in the SVT, two entries namely VL 206 MAS 2 and VL 206 MAS 3 were promoted to the second year of testing. Since the SVT trial in 2012 failed because of climatic aberrations, those entries will again evaluated in kharif 2013.
Somaclones of VL Dhan 206: Twenty three somaclones were evaluated for agronomic traits and blast resistance. Variations were observed for different traits. Another thirty somaclones (R0) were generated which will be grown during kharif 2013.

Molecular profiling of lines generated in the background of VL Dhan 206

The DNA profiling of 46 tissue culture derived plants of VL Dhan 206 was done to know the genetic fidelity by using SSR markers. A set of 50 SSR markers were used for DNA profiling. On the comparison with the parent VL Dhan 206, all the markers were found monomorphic. None of the plants produced any non parental alleles. These plants were true to the type.

Molecular profiling of selected 45 rice genotypes with candidate genes for drought and cold

The 48 rice genotypes differing in drought and cold tolerance were screened with the molecular markers, linked with the cold and drought tolerance. Fifteen simple sequence repeat markers (SSR) which are linked with the cold and drought tolerant QTLs and explained more than 20% phenotypic variation were selected namely RM182, RM201, RM214, RM215, RM229, RM431, RM252, RM257, RM262, RM270, RM445, RM506, RM511, RM569, RM242. Significant genetic diversity was observed among these genotypes.

PCR amplification using marker RM229

QTL mapping for tryptophan content in maize

Quality Protein Maize (QPM) contains twice the amount of lysine and tryptophan as compared to normal maize endosperm. Several amino acid modifiers (aa modifiers) play a very important role in determining the level of amino acid in the maize endosperm. Two isogenic QPM inbreds derived from CM 145 significantly varying in tryptophan content were used for developing a mapping population to map QTLs responsible for the tryptophan content. During the present study two QPM inbred lines (VQL 2 and VQL8) differing greatly in the tryptophan content (0.52 and 0.92% protein, respectively) were used to develop the mapping population. Linkage map construction and QTL identification was carried out by using genomic SSRs and candidate gene based functional SSRs developed from the lysine and tryptophan metabolic pathways. Four polymorphic candidate gene (out of 27) based SSR markers developed from the GenBank accession of aspartate kinase and aspartate kinase - homoserine dehydrogenase candidate genes of lysine pathway were found. Five significant QTLs on chromosome 5, 7 and 9 (one each for chromosome 5 and 7, three on chromosome 9), with LOD values more than 2.5 were identified (Fig. 2.4).
2.1.9. Seed Production Programme

The institute produces four types of seeds to cater to the needs of its clientele. They are Nucleus Seeds, Breeder Seeds, Truthfully Labelled Seeds (TL Seeds) and Hybrid Seeds of elite hybrids. Besides the seed production of field crops, the institute also produces the seeds of vegetable crops. Production of breeder seeds of important hill crop varieties is one of the mandates of the institute. Besides, the institute also produces TL and Nucleus seed of various hill crops.

Seed production (2011-12) and supply (2012-13) data are provided in Tables 2.1.8 and 2.1.9. During the period under report, 236.55 q breeder seed of 67 released varieties/inbreds (22 varieties and 7 inbreds of cereals, 3 of finger millet, 2 of barnyard millet, 16 of pulses, 2 of oilseeds, one each of buckwheat and amaranth, and 15 of vegetable crops) was produced. Out of this, 133.455 q breeder seed was supplied to different seed producing agencies to take up further multiplication.

Around 21.89 q nucleus seed of 37 released varieties was also produced following standard methods to maintain genetic purity.

In addition to this, around 53.82 q Truthfully Labelled seed of 11 varieties of cereals, 9 of pulses, 2 of oilseeds, 12 of vegetables, 3 of finger millet, and 1 each of barnyard millet, amaranth and buckwheat was produced to meet the demand of the institute extension activities. A total of 64.56 q TL seed has been supplied. Under pre-release variety multiplication, 2.13 q of VL Jau 118 was produced and 1.80 q was supplied (Table 2.1.10).

Under farmer participatory seed production programme (Table 2.1.11), 109.26 q TL seeds of wheat varieties VL Gehun 738, VL Gehun 892 and VL Gehun 907; horsegram varieties VL Ghat 15 and VL Ghat 19; soybean variety VL Bhatt 65 and pigeon pea variety VL Azhar 1 were produced in farmers' fields at Bailpadao (Ramnagar), Chinyalaisa, Nagar and Bageshwar, respectively and a quantity of 93.44 q was supplied from the seed procured.

Table 2.1.8: Seed Production kharif 2011 and Supply during kharif 2012

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Breeder Seed</th>
<th>TL Seed</th>
<th>Nucleus Seed</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Production (q)</td>
<td>Supply (q)</td>
<td>Production (q)</td>
<td>Supply (q)</td>
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<td>VL Dhan 287</td>
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<tr>
<td></td>
<td>VL Dhan 87</td>
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<td>-</td>
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<td>VL Dhan 708</td>
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<td>2.40</td>
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<td>2.20</td>
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<td>2.00</td>
<td>1.20</td>
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<td>VL Dhan 221</td>
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<td>Maize</td>
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<td>6.00</td>
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<td></td>
<td>* Amber Popcorn</td>
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</tr>
<tr>
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<td>* QPM 9</td>
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<td>-</td>
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<td>Crop</td>
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<td>Borer Seed</td>
<td>Production (q)</td>
<td>Supply (d)</td>
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<tr>
<td>------</td>
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<td>+</td>
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<tr>
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<td>VT. Soya 63</td>
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<td>VT. Ghat 19</td>
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<td>French Bean</td>
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<td>-</td>
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<tr>
<td>Madira</td>
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<td>0.60</td>
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<tr>
<td>Amaranth</td>
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<td>0.50</td>
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<td>Summer squash</td>
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<td>4.50</td>
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<tr>
<td>Capsicum</td>
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<td><strong>Total</strong></td>
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<td><strong>65.385</strong></td>
<td><strong>9.85</strong></td>
<td><strong>19.07</strong></td>
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* Carry over stock.

Table 2.1.9: Seed Production and Supply during the year 2012-13

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Borer Seed</th>
<th>Production (q)</th>
<th>Supply (d)</th>
<th>TL Seed</th>
<th>Production (q)</th>
<th>Supply (d)</th>
<th>Nucleus Seed</th>
<th>Production (q)</th>
<th>Supply (d)</th>
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<tbody>
<tr>
<td>Wheat</td>
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<td>10.40</td>
<td>9.05</td>
<td>10.19</td>
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<td>VT. Gehun 879</td>
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<td>VT. Gehun 803</td>
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<td>-</td>
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<tr>
<td>Crop</td>
<td>Variety</td>
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<td></td>
<td>VL Musoor 103</td>
<td>1.50</td>
<td>1.50</td>
<td>0.80</td>
<td>0.80</td>
<td>1.10</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>VL Musoor 128</td>
<td>6.50</td>
<td>3.10</td>
<td>2.65</td>
<td>2.65</td>
<td>11.43</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Pea</td>
<td>VL Minor 42</td>
<td>4.03</td>
<td>1.00</td>
<td></td>
<td></td>
<td>4.03</td>
<td>1.00</td>
<td></td>
<td></td>
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<tr>
<td>Garden Pea</td>
<td>Vivek Matar 10</td>
<td>0.40</td>
<td>0.40</td>
<td></td>
<td></td>
<td>0.37</td>
<td></td>
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<tr>
<td></td>
<td>Vivek Matar 11</td>
<td>0.40</td>
<td>0.40</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Toria</td>
<td>T 3 *</td>
<td>0.07</td>
<td></td>
<td>0.11</td>
<td></td>
<td>0.11</td>
<td></td>
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<tr>
<td>Onion</td>
<td>VL PI 3</td>
<td></td>
<td></td>
<td>0.04</td>
<td></td>
<td>0.04</td>
<td></td>
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<td></td>
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<td>Radish</td>
<td>Doorangiri Local</td>
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<td></td>
<td>0.05</td>
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<td>0.05</td>
<td></td>
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<td></td>
<td>Japanese White</td>
<td></td>
<td></td>
<td>0.08</td>
<td></td>
<td>0.08</td>
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<td></td>
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</tr>
<tr>
<td>Dhaniya</td>
<td>F1 1</td>
<td></td>
<td></td>
<td>0.30</td>
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<td>0.30</td>
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<tr>
<td>Palak</td>
<td>AllGreen</td>
<td></td>
<td></td>
<td>0.36</td>
<td></td>
<td>0.29</td>
<td></td>
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<tr>
<td>Carrot</td>
<td>Narita</td>
<td></td>
<td></td>
<td>0.03</td>
<td></td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labi</td>
<td>Habibnaram</td>
<td></td>
<td></td>
<td>0.07</td>
<td></td>
<td>0.07</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Methi</td>
<td>FEB 1</td>
<td></td>
<td></td>
<td>0.37</td>
<td></td>
<td>0.33</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turnip</td>
<td>PTWG</td>
<td></td>
<td></td>
<td>0.03</td>
<td></td>
<td>0.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>109.26</td>
<td>93.44</td>
<td>43.99</td>
<td>43.49</td>
<td>16.27</td>
<td>4.16</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

*Carry over stock
**EVX produce

Table 2.1.10: Pre-release variety multiplication

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Production (q)</th>
<th>Supply (q)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>VL Jmt 118</td>
<td>2.13</td>
<td>1.60</td>
</tr>
</tbody>
</table>

Table 2.1.11: Farmers' Participatory seed production

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Seed Produced (q)</th>
<th>Seed Supplied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>VL Gobai 917</td>
<td>38.00</td>
<td>32.00</td>
</tr>
<tr>
<td></td>
<td>VL Gobai 892</td>
<td>32.60</td>
<td>32.60</td>
</tr>
<tr>
<td></td>
<td>VL Gobai 738</td>
<td>10.87</td>
<td>1.05</td>
</tr>
<tr>
<td>Horsegram</td>
<td>VL Gobai 15</td>
<td>0.61</td>
<td>0.61</td>
</tr>
<tr>
<td></td>
<td>VL Gobai 19</td>
<td>0.66</td>
<td>0.66</td>
</tr>
<tr>
<td>Soybean</td>
<td>VL Bhart 65</td>
<td>2.41</td>
<td>2.41</td>
</tr>
<tr>
<td>Pigeon pea</td>
<td>VL Achan 1</td>
<td>34.11</td>
<td>24.11</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>109.26</td>
<td>93.44</td>
</tr>
</tbody>
</table>
Natural Resource Management for Enhancing the Productivity

- Soil Health Management for Enhancing Productivity of Hill Crops (Drs. H. Biswas, P.K. Mishra, B.L. Mina, D. Mahanta & M. D. Tuti)
- Utilization of Plant Growth Promoting Bacteria (PGPB) for Enhancing Crop Productivity in Hill Agriculture (Drs. P.K. Mishra, K. Jeevanandam, Gyanendra Singh, H. Biswas & J.K. Bisht)
- Mechanization of Hill Agriculture through Development of Suitable Farm Implements and Machineries (Ex. Sukhbir Singh, Drs. D.C. Sahoo, Sher Singh & M. D. Tuti)
- Podder Production Management with Special Reference to Utilization of Marginal and Wasteland (Drs. J.K. Bisht, P.K. Mishra, B.M. Pandey, D.C. Sahoo, B.L. Mina & R.P. Yadav)
2.2. Natural Resource Management for Enhancing the Productivity

Basic and strategic research pertaining to the farming systems and operational management of inputs for harnessing sustainable production was carried out. It included tillage, water harvesting, intensive cropping, long term fertility management, IPMS, weed management, forage and grassland management, farm machinery and post harvest technology and application of plastics for sustainable production in hilly region.

2.2.1 Soil Health Management for Enhancing Productivity of Hill Crops

Utilization of Rock Phosphate as a Source of P in Soybean-Wheat Cropping System

Application of phosphorus (P) through SSP resulted in the highest grain yields (2280 and 4720 kg ha\(^{-1}\) in soybean and wheat, respectively) (Fig. 2.5), which was comparable with P enriched compost (2230 and 4590 kg ha\(^{-1}\) in soybean and wheat, respectively) and P enriched compost + SSP (2220 and 4260 kg ha\(^{-1}\) in soybean and wheat, respectively), and significantly higher than rock phosphate (1760 and 3940 kg ha\(^{-1}\) in soybean and wheat, respectively) and control (1570 and 3570 kg ha\(^{-1}\) in soybean and wheat, respectively). Response to applied P varied from 11.7 - 43.9 % over the P unfertilized plot in case of soybean and 10.4 - 35.3 % in case of wheat, indicating a higher response to applied P by the former crop.

Agronomic efficiency of applied phosphorus was higher in wheat than soybean, and was highest under SSP followed by P enriched compost among the different P sources (Table 2.2.1). Similar was the case with partial factor productivity and phosphorus recovery efficiency (with the slight exception in soybean). The highest P harvest index was recorded under P enriched compost + SSP in soybean, and under SSP in wheat.

Soil organic carbon, available N and P content significantly improved with all treatments over control (Table 2.2.2). Highest soil organic carbon content was recorded with P enriched compost while highest available N and P were obtained under SSP treated plots. However, maximum available K content was recorded with rock phosphate followed by SSP.

Fig. 2.5: Effect of different P sources on grain yield of soybean and wheat

<p>| Table 2.2.1: Effect of different P sources on agronomic efficiency (AE), Partial factor productivity (PFP), phosphorus recovery efficiency (PFE) and P harvest index (PHI) in soybean and wheat |
|-----------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Treatment                         | Soybean        | Wheat          |</p>
<table>
<thead>
<tr>
<th></th>
<th>AE (kg grain/</th>
<th>PFP (kg grain/yield/kg P applied)</th>
<th>PFE (%)</th>
<th>P harvest index (%)</th>
<th>AE (kg grain/yield kg P applied)</th>
<th>PFP (kg grain/yield kg-1 P applied)</th>
<th>PFE (%)</th>
<th>P harvest index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSP</td>
<td>9.2</td>
<td>30.8</td>
<td>19.8</td>
<td>71.2</td>
<td>36.9</td>
<td>1015.6</td>
<td>38.5</td>
<td>57.6</td>
</tr>
<tr>
<td>Rock phosphate</td>
<td>7.4</td>
<td>83.2</td>
<td>6.3</td>
<td>71.8</td>
<td>10.4</td>
<td>178.0</td>
<td>10.2</td>
<td>55.6</td>
</tr>
<tr>
<td>P enriched compost</td>
<td>16.6</td>
<td>98.7</td>
<td>13.1</td>
<td>72.2</td>
<td>31.4</td>
<td>184.7</td>
<td>32.2</td>
<td>57.3</td>
</tr>
<tr>
<td>P enriched compost + SSP</td>
<td>11.9</td>
<td>94.2</td>
<td>15.0</td>
<td>72.9</td>
<td>31.3</td>
<td>187.0</td>
<td>33.5</td>
<td>53.8</td>
</tr>
</tbody>
</table>

Annual Report 2012 - 2013
Table 2.2.2: Effect of different sources of phosphorus on soil fertility status in soybean-wheat cropping system.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Soil pH</th>
<th>Organic carbon (%)</th>
<th>Available N (kg/ha)</th>
<th>Available P (kg/ha)</th>
<th>Available K (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>5.4</td>
<td>0.58</td>
<td>369</td>
<td>12.6</td>
<td>109</td>
</tr>
<tr>
<td>Rock phosphate</td>
<td>5.5</td>
<td>0.60</td>
<td>425</td>
<td>14.0</td>
<td>125</td>
</tr>
<tr>
<td>P enriched compost</td>
<td>5.5</td>
<td>0.82</td>
<td>399</td>
<td>14.7</td>
<td>117</td>
</tr>
<tr>
<td>SSP+ Compost</td>
<td>5.5</td>
<td>0.71</td>
<td>359</td>
<td>14.8</td>
<td>118</td>
</tr>
<tr>
<td>SSP</td>
<td>5.4</td>
<td>0.66</td>
<td>452</td>
<td>17.6</td>
<td>125</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>NE</td>
<td>0.83</td>
<td>22.6</td>
<td>0.57</td>
<td>4.66</td>
</tr>
</tbody>
</table>

**Phosphorus Management in Soybean-Wheat Cropping System for Yield Maximization**

Soybean and wheat yields increased with increasing levels of P applied through rock phosphate along with biofertilizers. Highest grain yield of soybean was recorded with 150 % RP + PSB + VAM (2980 kg ha⁻¹), which was at par with SSP (2870 kg ha⁻¹), 150 % RP + PSB (2920 kg ha⁻¹), 150 % RP + VAM (2880 kg ha⁻¹) and 125 % RP + PSB + VAM (2870 kg ha⁻¹). Highest grain yield of wheat was recorded with SSP (5040 kg ha⁻¹) which was at par with 150 % RP + PSB + VAM (4740 kg ha⁻¹), 150 % RP + PSB (464 kg ha⁻¹), 150 % RP + VAM (4550 kg ha⁻¹), 125 % RP + PSB (4590 kg ha⁻¹) and 125 % RP + PSB + VAM (4690 kg ha⁻¹).

Bio-stimulation of phosphorus solubilizing (PSB) and mobilizing micro-organism (VAM) in soybean—wheat cropping system increased grain yield of soybean and wheat by 4.56–8.98 and 3.33–9.52%, respectively.

Phosphorus applied through SSP (T₁) resulted in higher agronomic efficiency and partial factor productivity (PFP) than 100, 125 and 150% of P applied through rock phosphate alone and along with PSB and VAM in both the crops (Fig. 2.6). Agronomic efficiency and PFP of applied phosphorus was higher in wheat than soybean.

**Evaluation of Magnesite Waste as Nutrient Supplement to Enhance the Productivity of Hill Crops**

Application of magnesite waste along with recommended dose of NPK elicited response up to 100 kg Mg ha⁻¹ from both bharif and nab crops in three different cropping sequences. The responses to magnesite waste application were 29.6, 18.2 and 12.6% for finger millet, rice, and soybean, respectively, during bharif, and 10.8, 19.8 and 36.2% for wheat, toria and lentil, respectively.
in rabi season. There was significant difference among different crops and the equivalent yields were highest in soybean and wheat during kharif and rabi, respectively.

In another similar study at KVK, Kafligiair (Bageshwar), continuous application of fertilizers or manures alone and along with lime to different crops under magnesite waste-deposited soil improved soil pH, soil organic carbon and available NPK as compared to control (Table 2.2.3) after two crop cycles.

**Evaluation of P Enriched Compost and Biofertilizers under Soybean Based Cropping System**

Increasing levels of P enriched compost along with biofertilizers increased crop yield of rabi and kharif crops (Table 2.2.4). Highest soybean and wheat equivalent yields were recorded with 125% P enriched compost + bio-fertilizers, which was comparable with SSP and 100% P enriched compost + bio fertilizers.

**Performance of Lentil and Finger Millet Varieties in Organic, INM and Chemical Modules**

Three nutrient sources, viz. organic (FYM @ 40 kg P, O, ha⁻¹ and FYM @ 40 kg N ha⁻¹ for lentil and finger millet, respectively), INM (50% of recommended dose of fertilizer (RDF) + FYM @ 20 kg P, O, ha⁻¹ and 50% of RDF + FYM @ 20 kg N ha⁻¹ for lentil and finger millet, respectively) and chemical (RDF for lentil and finger millet) in main plot and five varieties in sub plot were evaluated. Organic source of nutrient produced significantly higher seed yield of lentil (1,610 kg/ha), which was 19 and 30% higher than INM and chemical, respectively. There was significant interaction between nutrient source and genotype for seed yield of lentil. The performance of lentil genotypes VL 133, VL 514 and VL 516 under organic condition was significantly superior to other sources in terms of seed yield. Highest finger millet grain yield was also recorded under organic plots (3,998 kg/ha).

**Nutrient Management in Gardenpea - French bean Cropping System**

A field experiment was conducted to study the effect of different organic manures viz., FYM @ 17.5, 34.9, 52.4 and 69.9 kg P/ha, poultry manure @ 17.5 and 34.9 kg P/ha, vermicompost @ 17.5 and 34.9 kg P/ha against recommended NPK, INM (recommended NPK + FYM 10 t/ha) and

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Soil pH</th>
<th>Organic Carbon (%)</th>
<th>Available N (kg/ha)</th>
<th>Available P (kg/ha)</th>
<th>Available K (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>7.32</td>
<td>1.03</td>
<td>498</td>
<td>18.5</td>
<td>157</td>
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<tr>
<td>FYM</td>
<td>7.33</td>
<td>1.18</td>
<td>471</td>
<td>33.9</td>
<td>168</td>
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<tr>
<td>NPK + Lime</td>
<td>7.58</td>
<td>1.18</td>
<td>474</td>
<td>25.7</td>
<td>159</td>
</tr>
<tr>
<td>NPK + FYM + Lime</td>
<td>7.38</td>
<td>1.29</td>
<td>496</td>
<td>26.6</td>
<td>185</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>NS</td>
<td>NS</td>
<td>22.0</td>
<td>5.5</td>
<td>60.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nutrient management</th>
<th>Soybean yield (kg/ha)</th>
<th>Wheat equivalent yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSP</td>
<td>1650</td>
<td>2620</td>
</tr>
<tr>
<td>50% P enriched compost + bio fertilizers</td>
<td>1990</td>
<td>2380</td>
</tr>
<tr>
<td>75% P enriched compost + bio fertilizers</td>
<td>1340</td>
<td>2580</td>
</tr>
<tr>
<td>100% P enriched compost + bio fertilizers</td>
<td>1660</td>
<td>2830</td>
</tr>
<tr>
<td>125% P enriched compost + bio fertilizers</td>
<td>1740</td>
<td>2900</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>208</td>
<td></td>
</tr>
</tbody>
</table>
control in fixed plots. Application of FYM @ 69.9 kg P/ha recorded significantly higher green pod yield of garden peas (5,352 kg/ha) and French beans (15,326 kg/ha) compared to control and INM, respectively.

**Effect of Biofertilizers on Growth and Yield of Finger Millet-Lentil Cropping System**

Three biofertilizers viz., Azospirillum (Rhizobium for lentil), PSB and VAM (Glomus fasciculatum) inoculated individually and in combination with FYM @ 7.5 t/ha were evaluated against FYM @ 10 and 7.5 t/ha, and control in finger millet-lentil cropping system. Combination of three biofertilizers with FYM @ 7.5 t/ha produced more grain (3,100 kg/ha) than FYM @ 10 t/ha (2,793 kg/ha).

**Effect of Long Term Fertilization on Weed Diversity in Soybean Crop under Soybean-Wheat Cropping System**

The effect of various fertilization levels on weed species composition, aboveground biomass and weed seed bank were investigated in experimental plots of rained soybean-wheat cropping system established 40 years ago at Haveli Bagni farm, in a sandy loam soil. Every year, the nutrients were applied to the soybean crop and wheat was grown without addition of any external nutrient sources (residual wheat). Major dominant weeds included *Cyperus rotundus, Eragrostis ciliaris* and *Oryza sativa* in soybean (Table 2.2.5). The population of *C. rotundus* in control (22/m²), N+P (38/m²), N+K (52/m²) and N+P+K (77/m²) was higher compared to N+FYM (11/m²) and NPK+FYM (8/m²) at 45 days after sowing. However, *A. ciliaris* population was higher in FYM applied plots i.e. N+FYM (16/m²) and NPK+FYM (23/m²) than in control (2/m²). Similar trend was also observed with respect to total weed dry matter. Total weed seedling density was higher in the 0-15 cm soil layer than in 15-30 and 30-45 cm (Fig. 2.7). In N+FYM and NPK+FYM plots, about two-thirds of the total weed seedlings emerged from 0-15 cm, compared to other treatments. Maximum yield of soybean (2,870 kg/ha) was obtained in the plots under NPK+FYM treatment. Results suggested that although integrated nutrient management enhanced the system productivity of soybean-wheat cropping system, it changed weed composition, which needs to be addressed through integrated weed management.

![Fig. 2.7: Percent vertical distribution of weed seeds in soil after harvesting of soybean under different treatments](image)

#### Table 2.2.5: Weed species abundance (%) in soybean crop under different treatments

<table>
<thead>
<tr>
<th>Weed species</th>
<th>Control</th>
<th>NP</th>
<th>NK</th>
<th>NPK</th>
<th>N+FYM</th>
<th>NPK+FYM</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cyperus rotundus</em></td>
<td>39</td>
<td>49</td>
<td>44</td>
<td>55</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td><em>Agrostis ciliaris</em></td>
<td>13</td>
<td>16</td>
<td>20</td>
<td>17</td>
<td>62</td>
<td>87</td>
</tr>
<tr>
<td><em>Oryza sativa</em></td>
<td>52</td>
<td>22</td>
<td>18</td>
<td>14</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Others</td>
<td>16</td>
<td>13</td>
<td>18</td>
<td>14</td>
<td>14</td>
<td>11</td>
</tr>
</tbody>
</table>
constraint in limiting the productivity and sustainability of farming in north-western Himalayas. To find out a sustainable vegetable-based cropping system in this region, a three-year colocasia-based vegetable intensive experiment was conducted on a sandy clay loam soil. Seven colocasia-based cropping systems viz., colocasia-onion-frenchbean, colocasia-garden pea-frenchbean, colocasia-wheat-okra, colocasia-radish-potato, colocasia-cabbage-frenchbean, colocasia-curriander-cauliflower-frenchbean, colocasia-coriander-tomato were compared with rice-wheat system under recommended package of practices. The system productivity in terms of colocasia equivalent yield was highest under colocasia-onion-frenchbean (52,380 kg/ha) system. Sustainable yield index was highest with colocasia-garden pea-frenchbean system (0.86). After 3 years, total soil organic carbon (0-5%), available N (2-22%), P (-7 to 14%) and K (3-15%) concentrations increased in all cropping systems except rice-wheat system, where negative balance of available P (7%) was observed over that of initial soil. Colocasia-onion-frenchbean system significantly increased soil carbohydrate, dehydrogenase (Fig. 2.8), protease and, acid and alkaline phosphatase activity (Fig. 2.9). Apart from colocasia-onion-frenchbean system, colocasia-garden pea-frenchbean and colocasia-curriander-tomato systems also significantly influenced soil enzymatic activities than those of other cropping systems. Both, acid and alkaline phosphatase activities were negatively influenced by addition of chemical fertilizer due to four crop-based vegetable cropping systems (colocasia-curriander-cauliflower-frenchbean). The results suggest that colocasia-onion-frenchbean system with higher productivity improves soil fertility and enhances enzymatic activities.

**Effect of Seshbania Mulching on Productivity of Finger Millet**

An experiment was conducted to assess the effects of Seshbania application under 4 nutrient levels, [FYM (5.0 t/ha), FYM (50%) + RDF (50%), RDF i.e. 40:20:20 NPK and control] on yield of finger millet and succeeding wheat crop under rained condition. No significant differences in grain yields of finger millet and succeeding wheat were recorded due to Seshbania mulching. Application of FYM (50%) along with recommended dose of fertilizer (50%) gave the highest grain yield (853 kg/ha) of finger millet which was at par with other levels except control.

**Screening of Suitable Finger Millet Varieties for Contingent Crop Planning**

Five finger millet varieties, viz., VL 146, VL 149, VL 315, VL 324 and VL 347 were evaluated across 4 dates of sowing (5 July, 15 July, 25 July and 5 August) under rained condition for contingent crop planning in case of late onset of monsoon. Sowing on July 5 (1449 kg/ha) gave...
the highest grain yield followed by July 25 (928 kg/ha), August 5 (746 kg/ha) and July 15 (689 kg/ha). The poor germination due to heavy rainfall after sowing on July 15 led to lower grain yield of all the varieties (Fig. 2.10). The highest yield was recorded with VL 347 when sown on July 25 (1918 kg/ha) followed by VL 146 (1529 kg/ha) and VL 149 (1501 kg/ha) when sown on 5 July. VL 146 (1529 kg/ha) and VL 149 (1301 kg/ha) were found to be the most suitable varieties for sowing on 5 and 15 July, respectively, however, VL 347 performed better when sown on 25 July (1918 kg/ha) and 5 August (1130 kg/ha). VL 892 of wheat was found suitable for a rotation with finger millet crop sown on all above dates (1027-1130 kg/ha).

Fig. 2.10: Effect of different sowing dates on grain yield of finger millet varieties

Fig. 2.11: Effect of tillage, weed residue and sowing methods on grain yield of rice (a) and wheat (b) in rice-wheat cropping system

of six years showed that rice yield has a decreasing trend while wheat yield has increasing trend irrespective of tillage, residue management and sowing methods. The above findings suggest that wheat crop is more suitable for resource conservation technologies in the long run than rice crop.

Evaluation of Different Crops/Cropping Systems for Productivity Enhancement under Different Farming Situation

There are tremendous variations in the crop growing conditions of the hill agriculture. Cultivated lands in mountain terrains present 360° variation to the sun. Steep slopes, foot hills and narrow lands are the contiguous part of hill agro-ecosystems. The productivity of crops in hill region is governed by slope, exposure to sunlight, moisture status, nutrient regime, etc. The three selected sites at experimental farm, Hawalbarg, namely, Khakal, Atthadar and Kannigere differ widely in these parameters and each has been accordingly divided into poor, moderate and favourable type of crop growing conditions. The performance of different crops showed that there was increase in yields of all the crops with improvement in the crop growing conditions. In case of crops, Kannigere site proved better for kharg crops while Atthadar for nahi crops.

2.2.3 Enhancing Crop Productivity with Special Emphasis on Conservation Agriculture

Effect of Different Tillage, Crop Residue and Sowing Methods on Productivity of Rice-Wheat Cropping System

The impact of resource conservation technologies in the rice-wheat cropping system indicated that conventional tillage in rice and zero tillage in wheat proved better in terms of grain yield (Fig. 2.11). The crop residue (stubbles) of previous crop retained at 15 cm height resulted in higher yield as compared to those retained at 5 and 10 cm height in both rice and wheat. The performance of sowing methods was almost similar in both the crops with normal sowing having little edge over bed sowing. The time-trend of rice and wheat yield over a period
(VL Masoor 514) dry shoot biomass (1.4 to 13.2%) and dry root biomass (7.1 to 35.7%) over non-bacterized control. Maximum (1.42 fold) enhancement in number of pods/plant in lentil crop was recorded with *Pseudomonas* sp. NARS9 inoculation followed by *Pseudomonas* sp. PGERs17 (1.2 fold) over un inoculated control. Enhanced total chlorophyll (4.9 to 22.0%), physiologically available iron (14.1 to 24.5%) and decrease in Na+/K+ ratio was also observed in single cold tolerant bacterial inoculated lentil plants at 60 DAS under field conditions. Inoculation with cold tolerant *Pseudomonas* significantly enhanced lentil Zn content (5.8 to 39.0% except PBRs5. NFRs3 and PFRs4). Inoculation with NFRp15 recorded maximum Zn content (39.0%) followed by NARS9 (24.3%) as compared to uninoculated control. Single inoculation of cold tolerant bacterial strains PBRs5 and NARS9 enhanced grain yield by 16.9 and 18.9%, respectively, over uninoculated control (1232 kg/ha) except PFRs4 inoculation under field conditions (Fig. 2.12).

**Fig. 2.12:** Evaluation of cold tolerant *Pseudomonas* on lentil yield at field conditions (T1-Control, T2- P. sp. PGERs17, T3- P. sp. PFRs4, T4- P. putida PBRs5, T5- P. putida PGRs1, T6- P. tarda NFRp15, T7- P. tarda NFRs3, T8- P. sp. NARS9, T9- P. fluorescens PFRs4)

**Effect of Cold Tolerant 'P' Solubilizing Bacterial Consortia to Enhance 'P' Uptake and Growth of Pea (Pisum sativum L.)**

Carrier based formulation of eight cold tolerant 'P' solubilizing bacterial consortia were tested for growth and P uptake in pea (VL47) under pot conditions. Bacterization with cold tolerant 'P' solubilizing bacterial consortium significantly (P<0.05) improved pea root length (6.7 to 23.3%), shoot length (14.6 to 30.9%), dry shoot biomass (1.22 to 2.09 fold) and dry root biomass (1.2 to 2.2 fold) over non-bacterized control. Enhanced total chlorophyll (13.4 to 36.8%), physiologically available iron (1.2 to 2.4 fold) and decrease in membrane injury electrolyte leakage and Na+/K+ ratio was also observed in cold tolerant bacterial consortia (combination of different strains, C3-C8) inoculated pea plants at 60 DAS (Fig. 2.13). Maximum (3.7 fold) enhancement in 'P' uptake was recorded with consortium C5 (consisting of three *Pseudomonas* strains CS11R1H1, NS12R1H2), CS11R3) over uninoculated control (0.36 mg/plant). Inoculation with bacterial consortia enhanced percent P content of pea plants in the range of 4.4 to 25.4%. Maximum P uptake was recorded by consortium C3 (25.3%) followed by consortium C7 (22.4%) over uninoculated control (0.67%) at final harvesting (Fig. 2.14).

**Fig. 2.13:** Effect of cold tolerant P solubilizing bacterial consortia on growth and physiological parameters at 60 DAS (T1-Uninoculated Control, T2- C1, T3- C2, T4- C3, T5- C4, T6- C5, T7-C6, T8- C7, T9- C8)

**Fig. 2.14:** Effect of cold tolerant P solubilizing bacterial consortia on percent P content of pea (VL47) at final harvesting (T1-Uninoculated Control, T2- C1, T3- C2, T4- C3, T5- C4, T6- C5, T7-C6, T8- C7, T9- C8)

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*Agricultural Research 2012-2018*
Evaluation of *Azospirillum* spp. Isolates on Rice Crop

Six *Azospirillum* spp. isolates were evaluated on rice (VL 63) crop. Inoculation with *Azospirillum* sp. AS enhanced the shoot (15.5 vs 23.2%), root length (30.1 vs 69.2%), available Fe content (24.0 vs 38.6%), and chlorophyll content (66.3 vs 47.4%) at 30 and 60 days after transplanting (DAT), respectively, over the uninoculated control. The treatment *Azospirillum* sp. AS enhanced shoot nitrogen uptake in the rice plants by 24.1 and 24.7%, respectively, at 30 and 60 DAT.

Evaluation of *P* Solubilizing Pseudomonads on *P* Uptake of Soybean

Carrier based formulation of *P* solubilizing bacterial strains were tested for *P* uptake in soybean (VL Soy 47) under field conditions. At 60 DAS cold tolerant *P* solubilizing bacterial inoculants enhanced soybean *P* content in the range of 11.5 to 24.6%. *Pseudomonas* sp. RD2RF1(2) exhibited maximum *P* content (24.6%) followed by *Pseudomonas* sp. CS11RF1, *Pseudomonas* sp RT6RF (18.03%) and *P. poae* NS12RF2 (13.1%) over the uninoculated control (2.68%). Under field conditions, *P. fragi* CS11RF1, *P. poae* NS12RF2(1) and *Pseudomonas* sp. NAR69 significantly enhanced soybean yield by 24.8 and 23.5%, respectively, over uninoculated control (1500 kg/ha) (Fig. 2.15).

2.2.5 Mechanization of Hill Agriculture through Development of Suitable Farm Implements and Machineries

Design and Development of Prototype of Manual/Bullock Multicrop Planter

A single row manual/bullock multi-crop planter was designed and a prototype developed for sowing of different crops. Specification of planter is given in Table 2.2.6. The power and pull requirement is 74.6 W and 12 kgf, respectively. The prototype was tested at Institute farm and farmers’ field. The effective field capacity was 0.0378, 0.05, 0.058 and 0.056 ha/b in wheat, lentil, mustard and pea, respectively. Under poor residual moisture (3.3%) conditions, sowing of wheat with multi-crop planter resulted in highest emergence.

![Fig. 2.15: Evaluation of *P* solubilizing bacterial inoculants on soybean yield at field conditions](image)

![Prototype of multi-crop planter](image)

![Testing of multi-crop planter](image)

Table 2.2.6: Specification of the multi-crop planter

<table>
<thead>
<tr>
<th>Particular</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall dimensions LxWxH (mm)</td>
<td>530x580x310</td>
</tr>
<tr>
<td>Type of furrow opener</td>
<td>Shovel &amp; Inverted T</td>
</tr>
<tr>
<td>Ground wheel diameter, mm</td>
<td>260</td>
</tr>
<tr>
<td>Seed metering mechanism</td>
<td>Cell type roller made of nylon</td>
</tr>
<tr>
<td>Type of cots on roller</td>
<td>6</td>
</tr>
<tr>
<td>Roller diameter &amp; length, mm</td>
<td>64 &amp; 380</td>
</tr>
<tr>
<td>Fertilizer metering system</td>
<td>Plastic roller made of Aluminum</td>
</tr>
<tr>
<td>Power transmission to metering device</td>
<td>From ground wheel (through rope, wire and chain)</td>
</tr>
<tr>
<td>Depth of sowing</td>
<td>Adjustable up to 80 mm</td>
</tr>
</tbody>
</table>

![Revised Hindi Text: K라도가 향상된 다목적랜덤 시스템](image)
non-selective herbicides. The herbicide solution is continuously supplied from main pipe to small plastic pipe (16 mm diameter) and then over to the spongy roller at a controlled rate. The solution is then applied to the weeds as the unit wipes over them.

The capacity of wiper was observed 0.032 ha/h in pea crop with 31 man·h/ha labour involvement and weeding efficiency 78% after 12 days of herbicide application @ 2.16 litres glyphosate in 432 litres of water, without any injury to pea crop.

**Ergonomic Evaluation of VL Shyahi Hal**

The draft observed was 10-20 % higher in local hal than VL Shyahi hal. Study showed that operator feels comfortable (HR: 68-72 beats/min) as compared to local hal (72-76 beats/min) after one hour of operation. At the same time, bullocks also showed some fatigue with local hal as the pulse rate (70-72 beats/min), respiration rate (25-32 breath/min) and body temperature (102.2°F) were higher as compared to VL Shyahi hal (58-65 beats/min, 22-26 breath/min, 101.2°F, respectively). Physical behavior symptoms of bullocks (e.g. uncoordination, inhibition of forward movement) start after 1 h of operation in local, and 1.5 h after in VL Shyahi hal. The effective field capacity was 0.026 ha/h with VL Shyahi hal, while it was 0.02 ha/h with traditional hal.

**Animal Drawn Pant-ICAR 6 in 1 Tillage Outfit**

Pant-ICAR 6 in 1 tillage outfit was tested for ploughing at 3 different locations in villages of Almora and Bageshwar districts. The draft observed was 54-56 kgf and the energy expenditure rate of the operator was 55-69% and 160-167% higher after 2nd & 3rd hour of operation.
Testing of Pant-ICAR 6 in 1 village outfit

than after 1st hour of operation. Due to speed reduction after 1st and 2nd hours of operation, the effective capacity of the ploughing reduced significantly from 0.026 ha/h to 0.018 ha/h. Seed drill was tested for sowing of wheat (0.034-0.036 ha/h) & lentil (0.041 ha/h). The digging capacity of potato digger was 0.042 ha/h and mechanical damage observed was 0.5-1.5%. The capacity of ridge making by the ridger was 0.05 ha/h.

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

Adaptability and Evaluation

Winter Grasses

In winter Fescue grass Hima-14 produced the highest green forage (38,669 kg/ha) followed by Hima 1.

Evaluation of Grasses under Wasteland Condition

Setaria Grass

Under wasteland condition, six entries of Setaria grass were evaluated. Out of these entries, S-25 produced significantly higher (86,409 kg/ha) green biomass than others.

Evaluation of Cultivated Fodder

Cowpea

In cowpea, entry AVTC-2-3 gave significantly higher green forage (17,199 kg/ha) except AVTC-2-4 & 5. However AVTC-2-4 produced the highest dry fodder.

Maize

In dual purpose maize entries/varieties from VPKAS, FHQ-38 (23,840 kg/ha) produced significantly higher green fodder than VL babycorn-1, Vivek QPM-9 and Dhari local. However, in case of green cob production Vivek-H-38 (16,390 kg/ha) produced significantly higher green cob than VL babycorn-1.

Dual Purpose Wheat and Barley

Bacterial and Chemical Fertilization on the Dual Purpose Wheat

Dual purpose wheat which gives grain and green forage during winter period can be a suitable option for fodder production in hilly. To obtain maximum yield from these varieties after green forage cut, proper fertilization is essential to overcome the stress of crop after cut. Due to higher prices of nitrogenous fertilizer some other alternative sources are required. Application of PGFR can be a good option. Wheat variety VL 829 and a genotype VL 934 were grown under different N fertilization with bacteria and its consortia i.e. C1 = Un cut Normal N, C2 = Cut with additional 20 kg N/ha after cut, C3 = Cut +B1 (Azotohancer), C4 = Cut +B2 Pseudomonas sp (PGFRa-17) and C5 = cut +B1 +B2. VL 934 produced significantly higher green forage (7,550 kg/ha) than VL 829, which in turn produced higher grain yield (5,080 kg/ha) than VL 954. Green forage yield was not affected significantly with different levels/sources of fertilization (Fig. 2.17). However, application of consortia of two bacteria gave the highest green forage (7,677 kg/ha). Grain yield was significantly higher in no cut with normal N (5440 kg/ha) than application of bacteria. Grain yield difference was non-significant between uncut and cut with additional 20 kg (C2) N/ha after cut.

Fig. 2.17: Effect of bacterial and chemical fertilization on the dual purpose wheat
Evaluation of Different Dual Purpose Barley Genotypes under Rainfed Mid Hill Condition

To find out the suitable dual purpose barley under rainfed situation, twenty genotype/strains were evaluated for green fodder production along with grain production. Green fodder and grain yield of these strains differed significantly. NHDBZ-17 gave the highest green forage (2034 kg/ha) with 744 kg/ha grain.

Fodder Production Potential of Grasses

Grassland Management

Fodder trees *Quercus laevischephalus*, *Grewia optiva*, *Morus alba*, *Bauhinia retusa* and *Melia azedarach* along with four grasses viz., *Stevia khasangali*, *S. nandi*, Congo signal grass and broad leaf *Paspalum* were tested under silvi-pastoral system. *Q. laevischephalus* yielded (10,675 kg/ha) the highest green biomass followed by *B. retusa*. The lowest green biomass was harvested from *G. optiva*. During rainy season, *S. nandi* produced the highest green forage (4398 kg/ha) out of three cuts.

Inter Cropping of Grasses with Legume

In hill region, farmers do not apply inorganic fertilizer in grasses under wasteland situation. To increase the yield of grasses, intercropping of legumes in grasses can be a beneficial option. Keeping this in mind, three grasses were grown with *desmodium* (legume) under 1:1 combination. Yield of grasses increased with the intercropping and the highest green forage (76,930 kg/ha) was obtained from intercropping of *Hy. napier* with *desmodium*.

Establishment and Cutting Management in Fodder Trees

*Kachnar (Bauhinia retusa)* Plantation Studies on Sloping Lands

In hilly region during winter months the dependence on fodder trees is very heavy as trees are the only source of green fodder under rainfed conditions. For growing trees we have to utilize the wastelands. This provides an opportunity to exploit such lands for production of forage and fuel to cater the ever increasing demand. The establishment and survival of fodder trees on sloping and degraded lands is very poor due to poor land support. Two planting methods i.e., improved and traditional pit with different fertilization treatments viz., control (T1), soil + FYM mix (T2), soil + FYM lower part (T3), T2 + 25 kg N/ha I year + 12.5 kg N/ha II year + 12.5 kg N/ha III (T4), T2 + stone mulching (T5), T2 + grass mulching (T6) and T2 + Lower half part of pit is covered with black polythene (T7) were studied for the proper development of *Bauhinia retusa*. During seventh year after planting, improved pit showed significantly higher plant height (145.17 cm) than traditional pit (Fig. 2.18). Similarly, improved pit produced significantly higher plant girth (5.87 cm) and green forage (0.49 kg/tree) than the traditional planting.

![Fig. 2.18: Effect of different planting methods and fertilization on the plant height of Kachnar (Bauhinia retusa) tree](image)

Cutting Management of Trees

For the proper tree canopy management of eleven year old oak plantation, four lopping techniques were applied. The four lopping treatments were coppicing (whole tree is cut off close to the ground level), local (removal of leaves and tender twigs at random just above the bifurcation of branches), pollarding tree at 2 m height (tree cut back near the trunk, so as to produce a dense mass of branches) and lopping of tree leaving top 1/3 portion undisturbed. In *Quercus laevischephalus* coppicing of tree was not successful just like *Grewia optiva* during initial years. Pollarding at 2 m yielded the highest forage (11,807 kg/ha) followed by coppicing. Similar trend was recorded in case of fuel yield (Fig. 2.19).
Agroforestry

Agri-horti System

Presence of pecan nut tree in the field could not bring any significant reduction in the grain yield of soybean, finger millet, wheat and lentil. However, grain yield of these crops was numerically higher in the fields without pecan nut tree. Above and below ground carbon stock of pecan nut based agroforestry system was estimated at 23,920 kg/ha from lentil and 25,300 kg/ha from wheat. Litterfall (2143 kg/ha) of pecan nut contributed potential nutrient return of C (901.91 kg/ha), N (57.44 kg/ha), P (3.21 kg/ha), and K (43.29 kg/ha). The average concentration of C, N, P and K in litterfall was 42.08, 2.68, 0.15 and 2.02%, respectively.

In fruit based agri-horti system four fruit crops, hill lemon, pear, plum and apricot were planted with soybean in kharif and dual purpose wheat during rabi season. During initial years no significant effect on grain yield was observed with the presence of different fruit trees. Green forage yield varied from 5000 to 5700 kg/ha in different treatments. The highest carbon stock was recorded in pear (12,700 kg/ha) followed by apricot (7300 kg/ha), plum (5780 kg/ha) and lemon (3790 kg/ha).

Silvi-horti System

Two varieties of turmeric (Pant Pitab and Swarna) were grown under Grewia optiva, Quercus leucotrichophora, Bauhinia variegata and Celtis australa. The highest rhizome yield was obtained under Q. leucotrichophora (19,182 kg/ha) followed by C. austalis (Fig 2.20). Pant Pitab gave significantly higher yield (16,099 kg/ha) than Swarna.

2.2.7 Integrated Water and Soil Management for Enhancing Production and Input Use Efficiencies

Irrigation Requirement of Wheat-Rice Rotations in Relation to Tillage Alterations

There was a significant increase in rice and wheat yields with increasing levels of irrigation. Highest yields of both the crops were obtained with four irrigations, which was at par with three irrigations (Table 2.2.8). The net returns and net returns per unit applied water in both the crops were higher in zero tillage. Higher profile moisture depletion occurred under conventional tillage in comparison to zero tillage.

Soil Moisture and Nutrient Dynamics in Wheat Soybean Rotation under Irrigated Conditions

Wheat was grown under fertilized condition and soybean was grown on the residual fertility, barring one treatment where it was grown with recommended NPK. Application of recommended NPK+10 t FYM recorded the highest wheat grain yield (5930 kg/ha) followed by N+FYM (5000 kg/ha). Further, FYM application gave higher yield (2650 kg/ha) in comparison to N alone (2470 kg/ha). The lowest grain yield was obtained under control (1480 kg/ha). Water use efficiency (WUE), gross
Table 2.2.6. Grain yield and water use of wheat as influenced by tillage and irrigation levels

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Grain yield (kg/ha)</th>
<th>FMC (%)</th>
<th>WUE (mm)</th>
<th>Net returns (Rs/ha)</th>
<th>Net return (per mm applied water)</th>
<th>Grains yield (kg/ha)</th>
<th>FMC (%)</th>
<th>WUE (mm)</th>
<th>Net return (Rs/ha)</th>
<th>Net return (per mm applied water)</th>
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<tr>
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<tr>
<td>Zero</td>
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<td>148</td>
<td>2200</td>
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<td>148</td>
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<td>22.2</td>
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<td>-18.2</td>
<td>70</td>
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<td>31.8</td>
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<tr>
<td>CD (P=0.05)</td>
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<td>NS</td>
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<td>NS</td>
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<td>NS</td>
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<td>NS</td>
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</tr>
<tr>
<td>Per</td>
<td>2200</td>
<td>-17.8</td>
<td>70</td>
<td>17.1</td>
<td>137</td>
<td>2200</td>
<td>-17.8</td>
<td>70</td>
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<td>137</td>
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<tr>
<td>Per+CFR</td>
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<td>-17.8</td>
<td>70</td>
<td>22.2</td>
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<td>2200</td>
<td>-17.8</td>
<td>70</td>
<td>22.2</td>
<td>31.8</td>
</tr>
<tr>
<td>Per+CFR+CF</td>
<td>2200</td>
<td>-17.8</td>
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<td>Frosted+CF</td>
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<td>-17.8</td>
<td>70</td>
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</tr>
</tbody>
</table>

The average profile moisture was higher due to FYM application in comparison to control and sole application of fertilizer. Soybean yield was affected significantly due to residual effects of fertilization. The highest grain yield (2130 kg/ha) was recorded under NPK + FYM and lowest (650 kg/ha), under sole N. The residual effect of NPK + FYM, N= FYM, FYM was higher than direct effect of NPK + NPK (700 kg/ha).

Water Storage Dynamics in Run-off fed LDPE Lined Water Tank and Effective Utilization of Harvested Water

The LDPE lined tank remained dry from 151°
day up to the 185th day. Runoff started flowing into the tank during July 2012, from 186th day onwards till the tank was full on the 217th day. The water level was maintained up to 266 days, after which it declined (Figs. 2.21 and 2.22).

Supplementary irrigation through the harvested water resulted in more than 94 and 20% rise in wheat and soybean yields, respectively, as compared to rainfall condition. The highest yields in case of both the crops were obtained with the application of FYM @ 10 t/ha + recommended NPK followed by application of FYM @ 10 t/ha + 50% recommended NPK (Table 2.2.9). Similar trends were observed for gross returns, gross returns per mm water use, water expense efficiency (WEE) and water use efficiency (WUE). In soybean, yield trend was similar to that obtained in wheat.

Artificial Recharging Techniques for Hill Springs

The discharge and rainfall relationship was worked out including the data before the treatment.
Table 2.2.9 Grain yield and water use of wheat and soybean under supplementary irrigation

<table>
<thead>
<tr>
<th>Irrigation</th>
<th>Grain yield (kg/ha)</th>
<th>WUE/WUE (kg/ha/m3)</th>
<th>Grain returns (000 Rs/ha)</th>
<th>Grain returns (per mm water use in Rs/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate Irr.</td>
<td>800</td>
<td>4.9</td>
<td>13.6</td>
<td>95.4 (1290) 7.3 33.2 48.5</td>
</tr>
<tr>
<td>Supplementary</td>
<td>2580</td>
<td>3.9</td>
<td>26.4</td>
<td>108.5 (1540) 5.9 42.0 20.6</td>
</tr>
<tr>
<td>CD (P = 0.05)</td>
<td>1.72</td>
<td>0.83</td>
<td>3.11</td>
<td>NS (1.42) 3.26 3.89 3.10</td>
</tr>
</tbody>
</table>

Fertilizer treatments
- Control: 600 3.7 11.6 52.1 440 1.1 11.4 16.3
- FYM 10 t/ha in both seasons: 1130 5.7 22.0 179.3 1850 4.8 42.7 75.2
- FYM 10 t/ha + NPK in both seasons: 1680 7.8 32.3 1410.3 1540 5.5 53.7 61.9
- FYM 10 t/ha + 50% NPK in both seasons: 1370 6.0 24.7 122.4 1420 4.8 38.1 72.7

In both seasons:
- NP 6 t/ha + NPK in both seasons: 940 4.2 17.5 77.6 540 1.3 13.6 14.9
- (28 FYM in block + NP in sub) 1000 7.7 23.3 102.9 1040 4.0 48.7 59.4

CD (P = 0.05) 2.94 1.44 3.38 38.09 2.46 0.63 6.05 8.65

Reference: Rate: 105.3 mm, Effective rainfall: 105.3 mm, block: 1000, sub: 105.3 mm, rate: 105.3 mm.

Inception and after the treatment imposition, there was a better correlation between discharge and rainfall after application of treatment (Fig. 2.23).

Studies on the Suitability of Locally Available Covering Material to Protect Pond Lining Material from UV Radiation and Physical Damages

Different types of materials and their combinations were tried at the Research Farm, considering their cost-effectiveness and lining-protection efficiency. Among the different combinations, the LDPE film covered with cement and concrete blocks (made locally) + soil was found to be very economical and most suitable. The concrete and concrete blocks do not require technical know-how and can be easily made by farmers.

Demonstration of LDPE Film Lined Tank and MIS System at Farmer’s Field

The total capacity of water resources developed by harvesting surface as well as run-off water in a participatory mode reached up to 1977 m³ in two villages of Almora district. The MIS system has been installed at five farmers fields with an area of around 3021 m².

Fig. 2.23: Rainfall and discharge relationship (a) prior and (b) after the application of treatment

![Graph 1: Rainfall vs Discharge](image1)

![Graph 2: Rainfall vs Discharge](image2)
Integrated Pest Management

- Management of Major Soil Borne Pathogens under Different Vegetable Cropping Sequences (Drs. Chandrashekara, C. and K.K. Mishra)
- Integrated Pest Management (IPM) for Chewing Pests in Major Hill Crops (Mr. A.R.N.S. Subban, Drs. J. Stanley and Jeevanandam)
- Development of cost effective management strategies for Major Diseases and Insect-pests under protected cultivation (Drs. K.K. Mishra, J. Stanley, Chandrashekara, C. and Hedau, N.K.)
2.3. Integrated Management of Diseases and Pests of Hill Crops

Crop protection activities have significant importance in reducing the yield losses caused by diseases and insect pests. Development of environmentally safe and integrated methods of management assumes importance in hill ecosystem. Thus, major thrusts have been on biological control, identification and characterization of native microbial agents, organic amendments, varietal resistance and use of safer pesticides besides undertaking survey for major diseases and insect pests of hill crops.

2.3.1 Disease and Insect-Pest Scenario

During the year, blast and brown spot of rice, turmeric leaf blight and banded leaf and sheath blight of maize were recorded in moderate to severe intensities. Sclerotium rot of maize (Sclerotium nodorum) was observed for the first time. Moderate to severe occurrence of Frogeye leaf spot (FLS) was observed in September and October with the infection index of up to 88.9% in some entries. Yield losses in soybean due to FLS varied from 3.05% to 37.25%. In wheat disease monitoring nurseries, C306, VL892 were found free from yellow rust whereas 80-90% severity recorded in susceptible lines. Powdery mildew and leaf blight incidence was low during 2011-12 crop season. Wilt in pea and lentil, powdery mildew of pea and purple blotch in onion appeared in low to moderate intensities.

Among insect pests, infestation of aphids in crucifers during February and March, red pumpkin beetle (Aulacophora foveicollis) in summer squash during April-May and moderate incidence of sucking bug (Chauliognathus foveicollis) and soybean beetle (Phyllognathus hystrix) in soybean during 2012 were observed. Moderate infestation of aphids in finger millet, blister beetles (Melanotus sp.) in okra, maize, pigeonpea and French bean, fruit flies (Bactrocera sp.) in squash, capsicum and tomato were also noticed.

Field monitoring of virulence of rice blast pathogen

Monitoring of virulence pattern of Pyricularia oryzae (rice blast pathogen) was conducted in a nursery comprising of 26 entries under field conditions. Entries like Raminrud str 3, Taducan and C 101 LAC were highly resistant, however, C 101 A51, BL 245, and A57, RIL 29, O. minuta showed R to MR reactions to prevalent population at the experimental farm, Hawaiagah.

Evaluation of IPM and non-IPM modules for rice cultivation under farmer's field conditions

As a collaborative programme with NCIPM, New Delhi, a trial consisting of IPM components and corresponding non IPM/ farmers' practices were undertaken at villages Raulshera and Bajinath under irrigated transplanted conditions in kharif 2012 to evaluate the effect of IPM practices in rice production. The IPM components were applied on varieties, VL, Dhan 85, Taichung, Thapachini and a local variety in Raulshera and varieties, VL, Dhan 62, VL, Dhan 82, VL, Dhan 56 and VL, Dhan 85 in Bajinath. The IPM interventions consisted of in situ green manuring with dhaincha (Sesbania), balanced fertilizer application, collection and destruction of egg masses/infested plant parts, seedling root dip with chlorpyrifos @ 0.02%, affixing of trichocards and harvesting close to the ground. During the crop season, two sprays with tricyclazole (600g/ha) at mid-tiller and panicle initiation stage and one with mancozeb (2.5 kg/ha) at panicle initiation stage for control of blast and brown spot, respectively, were done. A light trap was also installed to monitor the photo active insect pests.

The insect pest severity was comparatively low in all the varieties in IPM package as the prophylactic measures like collection and destruction of infested plant parts, release of trichocards were effective in managing the stem borers in the early stages itself. However, among
the varieties, the improved ones, VL Dhan 85, VL Dhan 62, VL Dhan 82, VL Dhan 86 and VL Dhan 65 were less susceptible to pests and diseases in comparison to Taichung, Thapachini and local variety grown by the farmers. Data of non-IPM fields shows that the traditional varieties were quite susceptible to diseases and insect pest attack.

The maximum yield gain of 8.0 q/ha was observed in varieties Thapachini and local variety in Raulshera village (Table 2.3.1) and in VL Dhan 65 (4.0 q/ha) in Bainath village. The comparison between average yields showed an increase of 26.5 and 7.5 % in IPM implemented fields over non-IPM fields in villages Raulshera and Bainath, respectively.

2.3.2. Management of Major Soil Borne Diseases under Different Vegetable Cropping Sequences

Isolation and in vitro evaluation of native Trichoderma isolates

To identify the effective antagonist Trichoderma isolates against soil borne pathogens, 52 new *Trichoderma* isolates collected from the different region of Uttarakhand were evaluated in *vitro* against *Rhizoctonia solani*, *Sclerotium rolfsii* and *Sclerotinia sclerotiorum*. Fifteen isolates showed reasonably good antagonistic activity with 40 to 83 % radial growth inhibition (Table 2.3.2).

In vitro evaluation of plant extracts/botanicals on soil-borne fungal pathogens

Different botanicals/plant extracts were tested against *Fusarium oxysporum* (tomato), *Rhizoctonia solani* and *Sclerotinia sclerotiorum* at different concentrations in *vitro*. Batain seed kernel extract (BSKE) inhibited the growth of *Fusarium* and *R. solani* by 41.7% and 37.1%, respectively, at 15% conc. which increased with higher concentration, whereas it did not show effectiveness against

<table>
<thead>
<tr>
<th>Variety</th>
<th>Disease and Insect-pest status</th>
<th>leaf blast (%)</th>
<th>Neck blast (%)</th>
<th>Brown spot (%)</th>
<th>Stem borer (no./m²)</th>
<th>Leaf folder (no./m²)</th>
<th>Grain yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taichung</td>
<td>IPM</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>38</td>
</tr>
<tr>
<td>Thapachini</td>
<td></td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>38</td>
</tr>
<tr>
<td>VL Dhan 85</td>
<td></td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>42</td>
</tr>
<tr>
<td>Local</td>
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<td>3</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>28</td>
</tr>
<tr>
<td>Non-IPM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taichung</td>
<td></td>
<td>6</td>
<td>15</td>
<td>15</td>
<td>2</td>
<td>1</td>
<td>31</td>
</tr>
<tr>
<td>Thapachini</td>
<td></td>
<td>8</td>
<td>15</td>
<td>17</td>
<td>2</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>VL Dhan 85</td>
<td></td>
<td>4</td>
<td>8</td>
<td>10</td>
<td>1</td>
<td>0</td>
<td>36</td>
</tr>
<tr>
<td>Local</td>
<td></td>
<td>10</td>
<td>20</td>
<td>20</td>
<td>2</td>
<td>1</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 2.3.2: Promising local Trichoderma isolates against 3 fungal pathogens

<table>
<thead>
<tr>
<th>Isolate</th>
<th><em>R. solani</em></th>
<th><em>S. rolfsii</em></th>
<th><em>S. sclerotiorum</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>T-80</td>
<td>73</td>
<td>63</td>
<td>61</td>
</tr>
<tr>
<td>T-81</td>
<td>71</td>
<td>57</td>
<td>57</td>
</tr>
<tr>
<td>T-82</td>
<td>74</td>
<td>63</td>
<td>65</td>
</tr>
<tr>
<td>T-97</td>
<td>71</td>
<td>56</td>
<td>55</td>
</tr>
<tr>
<td>T-133</td>
<td>71</td>
<td>62</td>
<td>74</td>
</tr>
<tr>
<td>T-136</td>
<td>71</td>
<td>62</td>
<td>63</td>
</tr>
<tr>
<td>T-138</td>
<td>55</td>
<td>71</td>
<td>71</td>
</tr>
<tr>
<td>T-142</td>
<td>64</td>
<td>67</td>
<td>70</td>
</tr>
<tr>
<td>T-147</td>
<td>66</td>
<td>73</td>
<td>79</td>
</tr>
<tr>
<td>T-148</td>
<td>68</td>
<td>76</td>
<td>74</td>
</tr>
<tr>
<td>T-150</td>
<td>75</td>
<td>81</td>
<td>79</td>
</tr>
<tr>
<td>T-151</td>
<td>74</td>
<td>83</td>
<td>76</td>
</tr>
<tr>
<td>T-156</td>
<td>66</td>
<td>40</td>
<td>73</td>
</tr>
<tr>
<td>T-199</td>
<td>67</td>
<td>35</td>
<td>83</td>
</tr>
<tr>
<td>T-207</td>
<td>61</td>
<td>64</td>
<td>74</td>
</tr>
</tbody>
</table>
Sclerotinia sclerotiorum. Oxalis leaf extract inhibited the growth of Fusarium spp. completely and of R. solani by 82.8% at 50% concentration (Fig. 2.24).

Biovar determination of *Ralstonia solanacearum* isolates

The biovar determination of 10 isolates of *Ralstonia solanacearum* causing wilt on tomato and capsicum was carried out based on the utilization of the disaccharides and the oxidation of the hexose alcohols. All ten isolates utilized disaccharides (cellobiose, lactose, maltose) and oxidized the hexose alcohols (dulcitol, mannitol and sorbitol). Based on the Hayward’s classification (Hayward, 1964), all 10 isolates were classified as biovar 3.

### 2.3.3. Integrated Pest Management (IPM) of Chewing Pests in Major Hill Crops

**Isolation of entomopathogenic fungi from environment samples**

With a view of isolating new strains of entomopathogens, a total of 66 environmental samples including soil, leaf and water samples were collected from different areas of Uttarakhand. An extensive screening of these samples by insect bait technique using *Coccinella septempunctata* as bait insect yielded a total of 10 entomopathogenic fungal isolates (Table 2.3.3). Single conidial cultures of each isolate were established and maintained in -20°C as 20% glycerol stock for further studies.

#### Table 2.3.3: Details of entomopathogenic fungi

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Fungal isolate</th>
<th>Area of collection</th>
<th>Shape of conidia</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VLF 2</td>
<td>Govindpur</td>
<td>Elongated oval</td>
</tr>
<tr>
<td>2</td>
<td>VLF 3</td>
<td>Maman</td>
<td>Elongated oval</td>
</tr>
<tr>
<td>3</td>
<td>VLF 4</td>
<td>Daulali</td>
<td>Elongated oval</td>
</tr>
<tr>
<td>4</td>
<td>VLF 5.2</td>
<td>Sirmauli</td>
<td>Elongated oval</td>
</tr>
<tr>
<td>5</td>
<td>VLF 6</td>
<td>Maman</td>
<td>Leon</td>
</tr>
<tr>
<td>6</td>
<td>VLF 10</td>
<td>Bitra</td>
<td>Leon</td>
</tr>
<tr>
<td>7</td>
<td>VLF 11</td>
<td>Bitra</td>
<td>Leon</td>
</tr>
<tr>
<td>8</td>
<td>VLF 37</td>
<td>Champawat</td>
<td>Oval</td>
</tr>
<tr>
<td>9</td>
<td>VLF 37</td>
<td>Muniyani</td>
<td>Oval</td>
</tr>
<tr>
<td>10</td>
<td>VLF 68</td>
<td>Muniyani</td>
<td>Oval</td>
</tr>
</tbody>
</table>

#### Bioefficacy studies of entomopathogenic fungi against blister beetle

Three new isolates of entomopathogenic fungi (EPF) viz., VLF 37, VLF 57 and VLF 68 were evaluated for their toxicity against field collected adult blister beetles, *Mylabris phalerata*. Each isolate was cultured for 15 days on potato dextrose agar at 25°C and conidia were harvested and conidial suspension was prepared in 0.03% Triton X-100. The individual adult beetles were dipped for 30 seconds in different conidial concentrations and kept in boxes containing okra pieces as feed. Mortality of beetles was recorded daily for 15 days and the dead beetles were incubated at 25°C for conidial development (Fig. 2.25) to confirm the infection. The isolate VLF 37 was found to be highly pathogenic at $1 \times 10^6$ conidial concentration with 100% mortality within seven days of treatment (Table 2.3.4). The remaining two isolates, VLF 57 and VLF 68 showed mortality of 60 and 50%, respectively.

#### Table 2.3.4: Bioefficacy of EPF isolates against blister beetle

<table>
<thead>
<tr>
<th>EPF Isolate</th>
<th>Concentration (Conidia/ml)</th>
<th>Per cent mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VLF 37</td>
<td>$1 \times 10^6$</td>
<td>73.6</td>
</tr>
<tr>
<td></td>
<td>$1 \times 10^5$</td>
<td>100.0</td>
</tr>
<tr>
<td>VLF 57</td>
<td>$1 \times 10^6$</td>
<td>45.0</td>
</tr>
<tr>
<td></td>
<td>$1 \times 10^5$</td>
<td>60.0</td>
</tr>
<tr>
<td>VLF 68</td>
<td>$1 \times 10^6$</td>
<td>35.0</td>
</tr>
<tr>
<td></td>
<td>$1 \times 10^5$</td>
<td>50.0</td>
</tr>
</tbody>
</table>
Profile of cry genes in Bacillus thuringiensis (Bt) isolates

Cry gene profile indicates the combination of insecticidal genes present in a particular Bt isolate. This gives appropriate information relevant to toxicity magnitude of the Bt isolate and its pathogenicity distribution among different insect orders because of the specificity of the cry genes. Keeping this in view, the Bt isolate collection was subjected to PCR screening with specific family primers (cry 1, 2, 3, and 8) and gene primers (cry 1Aa, 1Ab, 1Ac, 1B, 1C, 1D, 2A and 2B). Based on toxicity against six major insect pests, eighty Bt isolates were selected for cry gene profiling. Most of the isolates (28 isolates) showed a combination of cry 1Ab, 1Ac, 1B, 1C and 1D followed by a combination of cry 1Ab, 1Ac, 1B, 1C, 1D, 2A and 2B in 16 isolates (Table 2.3.5).

Among individual genes, the most frequently occurring gene were cry 1, cry 1Ab, cry 1C and cry 2 (Fig. 2.26). No isolate was found positive for cry 1Aa, cry 3 and cry 8. However, with respect to cry 2 genes, 44 isolates were found positive to family primers but not with gene specific primers, cry 2A and cry 2B. Only one isolate, VLBk 27 was found positive to cry 2B but not cry 2A.

Table 2.3.5: Cry gene combinations in different B. thuringiensis isolates

<table>
<thead>
<tr>
<th>S.No.</th>
<th>cry gene combinations</th>
<th>Number of isolates</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1Aa, 1Ac, 1B, 1C, 1D</td>
<td>28</td>
<td>35.6</td>
</tr>
<tr>
<td>2</td>
<td>1Aa, 1Ac, 1B, 1C, 1D, 2A, 2B</td>
<td>16</td>
<td>20.0</td>
</tr>
<tr>
<td>3</td>
<td>1Aa, 1Ac, 1B, 1C, 2A, 2B</td>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td>4</td>
<td>1Aa, 1Ac, 1C</td>
<td>1</td>
<td>1.25</td>
</tr>
<tr>
<td>5</td>
<td>1Aa, 1Ac, 1C, 1D</td>
<td>16</td>
<td>20.0</td>
</tr>
<tr>
<td>6</td>
<td>1Aa, 1Ac, 1C, 1D, 2A, 2B</td>
<td>7</td>
<td>8.75</td>
</tr>
<tr>
<td>7</td>
<td>1Aa, 1Ac, 1C, 2A, 2B</td>
<td>4</td>
<td>5.00</td>
</tr>
<tr>
<td>8</td>
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<td>1.25</td>
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<td>9</td>
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<td>1</td>
<td>1.25</td>
</tr>
<tr>
<td>10</td>
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<td>2</td>
<td>2.5</td>
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<tr>
<td>11</td>
<td>1Aa, 1C, 1D</td>
<td>1</td>
<td>1.25</td>
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<tr>
<td>12</td>
<td>1Aa, 1C, 1D, 2A, 2B</td>
<td>3</td>
<td>3.88</td>
</tr>
<tr>
<td>13</td>
<td>1Aa, 1C, 1D, 2A, 2B</td>
<td>1</td>
<td>1.25</td>
</tr>
<tr>
<td>14</td>
<td>2A, 2B</td>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>

Fig. 2.26: Distribution of cry genes in B. thuringiensis isolates

Studies on cry toxins of Bacillus thuringiensis isolates

The crystal proteins of fifteen root nodule inhabitant Bt isolates were partially purified and studied for their molecular mass. The acetone powder formulation prepared for each isolate was used for purification of crystal protein (Protoxin). The SDS-PAGE analysis of protoxins revealed that all 15 root nodule inhabitant Bt isolates were producing 130KDa protoxin (Fig. 2.27).
Light Trap Catches of Different Species of White Grubs

A total of 18,261 beetles were trapped in eleven light traps installed at the experimental farm, Hawalbagh. A maximum of 78.42% of total catch was recorded during the month of July. Diversity of beetle catches comprised of 22 species of which 63.1% was the predominant species, Anomala diadipta. Other species viz., Aphidius sp., Maladera sp., Xyleborus gideon and Anomala triops were of 8.9, 3.9, 2.7 and 2.7 % of the total catch, respectively.

Studies on Pheromonal Attraction of Scarabaeid Beetles

The attraction efficiency of anisole is found to be up to 150 m to attract male beetles of Holotrichia seticollis in the field. The emergence of beetles started in the third week of May and continued up to 4th week of July. Peak emergence was noted during May last to first fortnight of June, 2012. WL whitegrub beetle trap with anisole is found very effective in attracting and capturing male H. seticollis beetles. The female released male attractive pheromones were extracted using a hand held air entrainment apparatus in the field itself using Porapak Q and got identified as 1,2, 1,3 and 1,4 diethyl benzene isomers through GC-MS.

Comparison of Helicoverpa armigera moth catches in light and pheromone traps

A comparison was made on the trapping efficiency of light traps and pheromone traps on Helicoverpa armigera moths. Since pheromone traps attract only male moths and light trap catches both the sexes, the total catches on light traps were made half for comparison. Overall moth catches in pheromone traps were higher than light traps at experimental farm, Hawalbagh. H. armigera catch increased progressively from II week of March and peaked by 1st week of April and became zero by 3rd week of May onwards in both light and pheromone traps (Fig. 2.28). The peak catch of H. armigera was noted during 1st week of April with trap catch of 57 and 209 moths per week in light and pheromone traps, respectively.

Screening of maize entries for storage pest Sitophilus weevil

A total of 41 maize lines/ genotypes were screened for their susceptibility to the important storage pest, Sitophilus weevil in the laboratory. Two lines viz., V400 and V405 were found resistant to the weevil damage registering negligible weight loss of grain after two months of infestation. Some of the lines viz., V346 and V372 were highly susceptible compared to others by supporting the weevil growth and reproduction which is revealed by more number of weevils reproduced with less number of mortality and more weight gained by the weevils. Specialty corns (popcorn and sweet corn) were also found susceptible to the pest damage. Much variation was not found between Vivek QPM 9 and Vivek hybrid 9, so as CM212 and CM145 with that of VQ1.1 and VQ1.3, respectively (Table 2.3.6).
Table 2.3.6: Screening of maize genotypes for storage pest, Sitophilus sp.

<table>
<thead>
<tr>
<th>Genotypes</th>
<th>Initial wt</th>
<th>Final wt</th>
<th>Wt Loss</th>
<th>Frass wt</th>
<th>Burn*</th>
<th>Dual</th>
<th>wt gained</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM212</td>
<td>24.9</td>
<td>23.6</td>
<td>1.3</td>
<td>0.080</td>
<td>29</td>
<td>24</td>
<td>0.029</td>
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<tr>
<td>CM145</td>
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<td>25.6</td>
<td>1.4</td>
<td>0.070</td>
<td>28</td>
<td>26</td>
<td>0.030</td>
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<td>VQL-2</td>
<td>22.2</td>
<td>20.1</td>
<td>2.1</td>
<td>0.046</td>
<td>23</td>
<td>22</td>
<td>0.024</td>
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<tr>
<td>VQL-1</td>
<td>24.9</td>
<td>23.3</td>
<td>1.7</td>
<td>0.068</td>
<td>29</td>
<td>28</td>
<td>0.045</td>
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<tr>
<td>V 338</td>
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<td>22.0</td>
<td>0.9</td>
<td>0.028</td>
<td>2</td>
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<tr>
<td>V335</td>
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<td>23.7</td>
<td>1.1</td>
<td>0.023</td>
<td>12</td>
<td>25</td>
<td>0.002</td>
</tr>
<tr>
<td>V346</td>
<td>24.1</td>
<td>21.1</td>
<td>3.0</td>
<td>0.230</td>
<td>68</td>
<td>9</td>
<td>0.126</td>
</tr>
<tr>
<td>V372</td>
<td>23.6</td>
<td>21.2</td>
<td>2.4</td>
<td>0.210</td>
<td>29</td>
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<td>1.6</td>
<td>0.060</td>
<td>65</td>
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</table>

* Burn after introduction excluding the introduced 30 beetles.

2.3.4. Development of Cost Effective Management Strategies for Major Diseases and Insect-Pests under Protected Cultivation

**Disease and insect-pest status in polyhouses**

In various polyhouses /net houses of Experimental farm, Hawelboigh and at farmer’s places in Domagiri, Mundiyani, Dharanaj and Chaffy areas, disease incidence and severity were recorded. Diseases like damping-off and foot rot (5-8%), buckeye rot (15-20%), fusarium wilt (25-30%), early blight (15-18%), powdery mildew (40-50%) and bacterial wilt (18-20%) were the major diseases in tomato. In capsicum, bacterial wilt (8-10%), fusarial wilt (20-25%), and powdery mildew (60-66%) were recorded.

Severe infestations of sucking pests like whiteflies in tomato, cucumber and capsicum, mites and thrips in capsicum, French bean and ornamental crops in polyhouses were noticed. Mite infestation in tomato was noticed for the first time in polyhouse.

**Attraction potential of cue lure and methyl eugenol on fruit flies**

Fruit fly traps, both methyl eugenol and cue lure were installed in polyhouses and open conditions. Three species of fruit flies were trapped in methyl eugenol traps viz., *Bactrocera dorsalis*, *B. tabaci* and *B. diversi* in the ratio of 3:1.5:1 whereas in cue lure, the fruit flies species *B. tabaci*, *B. cucurbitae* and *B. lat* in the ratio of 1:4:3:1 were trapped.

**Management of whiteflies in polyhouse**

Yellow sticky traps were found effective in managing the whitefly adults only when they are present in very low levels of >3 per three leaves in tomato. A whitefly predatory cucinellids, *Syringa montrouzieri* was collected from Kusaani area during expeditions made along with scientist of National Bureau of Agriculturally Important Insects (NBAII), Bengaluru.
Socio-economic Studies
Transfer of Technology and Information Technology

- Information Communication Technology and Knowledge Management in Agriculture
  (Dr. Mukesh Kumar, Mr. K.K.S. Bisht, Drs. Manik Lal Roy, Pratibha Joshi, Mr. Athasepalla G.A. and Dr. Nirmal Chandra)

- Assessment of Drudgery Prone Activities and Nutritional Status of Hill Farm Women
  (Drs. Pratibha Joshi, Reenu Jethi, Mukesh Kumar, Manik Lal Roy, Mr. Athasepalla G.A. and Dr. Nirmal Chandra)

- Study on Socio-economic Aspects of Hill Farming and Extension Methods
  (Dr. Nirmal Chandra, Dr. Manik Lal Roy, Mr. H. L. Kharbikar, Dr. Pratibha Joshi and Mr. Athasepalla G.A.)
2.4. Socio-Economic Analysis and Transfer of Technology Research

Socio-economic analysis 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.

2.4.1. Information Communication Technology and Knowledge Management in Agriculture

Genetic stock module database was developed for maize, wheat, oilseeds (mustard, onion and groundnut) and pulses (black gram, chick pea, field pea, pulses, lentil, pigeon pea, soybean and blackgram) crops. The user can retrieve the information on the following parameters: sample location, collection year, accession number, rack number, partition number, tray number etc. Data entry module was created for rainfall data.

E-book was created on 'DUS Characterization of VPKAS Maize Varieties and Inbreds'. This e-book provides the following information: (i) passport and distinguishing characters of each maize variety and inbred, (ii) key for identification of each notified maize variety and inbred, and (iii) grouping of maize varieties and inbred on the basis of essential DUS characters. This e-book intends to help the user for the selection of most similar maize variety and inbred for carrying out the DUS trials.

Moving average time series analysis of crop production showed that (i) in J&K, rice and wheat showed an increasing trend initially, then declined followed by an increase in recent years. Maize and millet showed increasing and decreasing trends, respectively; (ii) in HP, rice, wheat and maize showed increasing trends whereas millets showed decreasing trend; (iii) in Uttar Pradesh, rice and wheat yields showed increasing trends, maize showed a declining trend after 1985 and millet is nearly static after 1995.

The contents of the institute’s website were maintained and updated whenever required. About 800 photographs were added to the digital photo repository. Personnel Management Information System (PERMISnet) database of the institute was updated regularly. Information about the three personnel, who joined during the reported period, was added to the database. PIMISCAR database was updated and monitored. AKMU provided hardware, software, anti-malware, intranet and Internet support to the institute.

A questionnaire was prepared and finalized for data collection on usage of ICT in hills. Data were collected from 60 extension personnel. First draft of training manual on communication methodologies has been prepared covering the following chapters: (i) Fundamentals of communication, (ii) Training: The concept, (iii) Training methodology, (iv) Extension training methods: (a) Experienced lectures, (b) Role-playing and Simulation games, (c) Case study, (d) Critical incident technique, (e) Demonstration Method and Result, (f) Focus group discussion, (g) Facilitation skills, (h) Cyber Training: Concept, Models and Roles; (v) Training need assessment, (vi) Formulation of training objectives, (vii) Course-curricula development of a training programme, (viii) Planning training programmes, (ix) Modulating training sessions, (x) Implementation of a training programme, (xi) Evaluation and follow-up of extension training and (xii) Constraints in organizing effective extension training programme. Two on-farm sensitization trainings were conducted for farmers of Muddiyani cluster and Ron-Dal village, on various aspects of ICT like online information delivery services, provided by government and other agencies through Internet in agriculture. The same aspects were covered in two off-farm trainings at Hawalbough.
2.4.2. Assessment of Drudgery Prone Activities and Nutritional Status of Hill Farm Women

Rural women in our country share abundant responsibilities and perform a wide spectrum of duties in running the family, maintaining the household, attending to farm, attending domestic animals and extending a helpful hand in rural assistantship and non-farm activities. While doing so the women adopt many unnatural postures like bending, stretching of different body parts which leads to increase in cardiovascular stresses. These tasks not only demand considerable time and energy but also are sources of drudgery for rural women which are not yet precisely identified and quantified. Widespread ignorance and belief that women in the rural areas do not participate in the economic development because they are confined to household and unaccounted farm and non-farm activities. Hitherto conditions of women in the plains and easily accessible areas have been explained by scholars concerned with the development of women, but the hilly and backward areas, however, have been neglected for a long time. Their work is also not recognized in any statistical terms.

- Conducting basic ergonomic task analysis process by using ergonomic checklist, questionnaire and worksheets.
- Identifying work related musculoskeletal disorders and postural analysis.

This document provides specific user information to ensure proper integration of the main-system interface requirements with those of other ergonomic disciplines. Anthropometric data are used for proper design of workstation, equipment, furniture and so on in order to decrease awkward postures and stresses on human body due to improper design. Mismatch between anthropometric dimensions and consumer products may cause such health problems in human body as musculoskeletal disorders, concentration deficit, and so on. The manual containing information on ergonomics, anthropometry, physical fitness index, OWAS (O), QUC, TCCW, CCW, VO2.max, Washington State Caution Zone and/or Hazard Zone Checklist, job strain index, NIOSH lifting equation, LUBA, Snook Tables 24 Hour recall method, Body Mass Index for Participative ergonomics and Nutritional assessment.

For the quantification of drudgery and nutritional status, a document of various physiological & participatory ergonomics and nutritional methodologies was compiled. It will help the researchers in understanding the step-by-step process of ergonomic evaluation of any activity and will help in

- Workout basic analysis of any activity to identify ergonomic issues
- Ergonomics and Nutritional Manual for Practitioners

An interview schedule has been prepared and pretested on role of farm women. It has been structured to collect data about role of farm women in following segments: (i) Crop cultivation: Here 15 major activities related to crop cultivation were covered. (ii) Animal husbandry: This part was divided into activities related to dairy, goasery
and poultry and each division was further subdivided into daily as well as occasional activities. In case of dairy, 10 daily activities and seven occasional activities were taken into account. Likewise in case of gowery and poultry, these figures were [4, 3] and [6, 3], respectively. (iii) Decision making pattern: Besides the decision making pattern of farm women in crop, animal husbandry and household activities were also included in the interview schedule and the domains covered under each section were 12, 11 and 12, respectively.

Under the project, reviews have been collected on nutritional status of women, food consumption pattern, nutritional deficiency, nutritional knowledge and nutritional assessment methodology. Questionnaire for assessment of nutritional status of hill farm women, consisting of socio-economic status, 24 hrs recall sheet and food frequency table, and anthropometric measurement chart was prepared. Nutritional assessment methodologies were incorporated in Ergonomic and nutritional practical manual.

A framework for ergonomic for methodologies manual and database was designed and a draft of ergonomic methodologies was prepared.

2.4.3. Study on Socio-economic Aspects of Hill Farming and Extension Methods

A comparative study was undertaken at an adopted village, Bhagartola and non-adopted village, Maniyagar in Almora district to study the role of socio-personal, socio-economic and socio-psychological attributes of farmers in adoption of improved agricultural technologies. The data was collected on 15 independent variables viz. age, education, occupation, landholding, farming experience, annual income, material possession, social participation, constraints, credit utilization pattern, change proneness, level of aspiration, economic motivation and risk bearing ability of the farmers.

It was found that majority of the respondents in both adopted and non-adopted villages were in medium-age category (31-53 yrs) (76.66 % and 63.33 %, respectively). The average age of the respondents in adopted and non-adopted villages was 44 years and 40 years, respectively. It is an indication that the rate of migration to towns for alternate occupation was lesser in adopted village than in non-adopted village, which reflects the impact of modern agricultural technologies on agriculture in the former case.

Majority of the respondents in both adopted and non-adopted villages belonged to the middle-level of educational qualification (56.67 % and 70.00 %, respectively) but the farmers with higher education were 20 % in adopted village as compared to the non-adopted village (10%). It is an indication that the modern agricultural technologies are creating interest among the higher educated individuals to get engaged in farming as occupation.

Majority of the respondents from both adopted and non-adopted village had medium level of social participation (76.00% and 80.00%, respectively). While respondents from adopted village showed some percentage of high social participation (16.67%) it was nil in non-adopted village. This also shows the positive impact of adoption of modern agricultural technologies on social participation of the farmers.

Majority of farmers from adopted as well as non-adopted village were medium earners (43.33% and 65.67%, respectively). The difference in average annual income between adopted and non-adopted village was about Rs. 12,000/- and the percentage of high income category was four times higher in adopted village than that of non-adopted village.

Level of credit utilization and level of adoption of modern agricultural technology by the farmers were positively correlated because no farmer from the non-adopted village was found to have a high level of credit utilization whereas 23.33% farmers from the adopted village had a higher level of credit utilization. Although majority of the farmers from both adopted and non-adopted villages were found having medium level of credit utilization (76.67% and 93.33%, respectively), the intensity of credit utilization was higher in adopted village than the non-adopted village.
Majority of the population from both adopted and non-adopted villages was faced with medium level of constraints (66.67% and 86.67%, respectively), which are very common in complex, diverse and risk-prone hill agriculture but the intensity of constraints was lesser in adopted compared to non-adopted village.

In adopted village, 50% farmers were solely engaged in agriculture and remaining 50% indulged in agriculture and other occupation, while in non-adopted village all the farmers were engaged in agriculture and other occupation (100%).

In adopted villages majority of farmers had high and medium level of change-proneness, whereas all the farmers in non-adopted villages had low or medium level of the same.

Majority of the respondents in both adopted and non-adopted village were having medium level of aspiration (56.67 % and 70.00 %, respectively). But the mean scores differ significantly between adopted and non-adopted village (17.47 and 12.33, respectively). No farmer from the non-adopted village was found having high level of aspiration while 33.33% of farmers from the adopted village was reported having high level of aspiration.

Majority of the respondents in adopted village were found having medium as well as high level of economic motivation (46.67% each) whereas most of the respondents in non-adopted village were found having medium level of economic motivation (66.67%). No farmer from the non-adopted village was found having high level of economic motivation while 46.67% of farmers from the adopted village were reported having high level of economic motivation. It is due to the positive impact of adoption of VPKAS technologies in terms of profits earned which increased the level of economic motivation among the farmers of adopted village.

The level of risk bearing ability and level of adoption were directly correlated, because no farmer from the non-adopted village was found having high level of risk bearing ability where 36.66% farmers from the adopted village were reported having high level of risk bearing ability. Though majority of the farmers from both adopted and non-adopted villages were found having medium level of risk bearing ability (56.67% and 70.00%, respectively) but the tendency of taking risks was realized higher in adopted village compared to non-adopted village.
Other Research Projects

Horticulture Mission for North East & Himalayan States Projects

- Production of Quality Seed and Planting Material (Vegetables) (Dr. N.K. Hedau)
- Quality seed production of capsicum and squash under protected condition (Dr. M. D. Tuli)
- Multiplication of Quality Planting Material of Important Cut Flowers of Uttarakhand (Dr. N.K. Hedau)
- Purification and Seed Multiplication of Underutilized Important Hill Vegetables (Dr. N.K. Hedau)
- Standardization of Improved Vegetable Production Technologies under Protected Cultivation (Dr. N.K. Hedau)
- Standardization of Organic Nutrient Management for Major Vegetable Crops (Dr. B.L. Mina)
- On Farm Sustainable Production and Dissemination of Fruits and Vegetables Based Farming System (Dr. J.K. Bisht)
- Efficient Water Management through Micro-Irrigation System in Terraced Land for Growing Vegetables (Dr. D.C. Sahu)
- Dissemination of Growing Off-Season Vegetable Technology under Protected Environment (Mr. K.K.S. Bish)
- Refinement and Dissemination of Mushroom Production Technologies (Dr. K K Mishra)
- Evaluation and Mass Multiplication of Plant Growth Promoting Bioinoculants to Enhance Vegetable Production (Dr. P.K. Mishra)
- Deployment of Entomopathogens and Light Traps for the Management of Scarabaeids in Uttarakhand Hills (Dr. J. Stanley)
- Planned Honey Bee Pollination for Improvement in Horticultural Crop Production (Dr. J. Stanley)
- Status of Horticulture and Market Opportunities in the state of Uttarakhand (Dr. Renu Jethi)
- Training in Mechanization of Horticulture (Ex. Sakkbir Singh)
- Assessment and Refinement of Available Methods/Devices to Check Wildlife Damage in Hill Crops (Dr. M.L. Roy)
- Purification of A, B and R lines in Onion for Parental and Hybrid Seed Production using Molecular Tools (Dr. N. Saini)
**DBT funded Projects**

- Rapid Conversion of Normal Maize Inbreds to Quality Protein Maize and Further Enhancement of Limiting Amino Acids in Elite Inbreds through Marker Assisted Selection *(Dr. P.K. Agarwal)*
- Pyramiding Multiple Resistance Genes using MAS for Durable Resistance against Blast in the North West Himalayas *(Dr. P.K. Agarwal)*
- Genetic enhancement of Wheat by Pyramiding of Rust Resistance genes through molecular approaches in Northern hills in India *(Dr. N. Saini)*
- Development of Micronutrient Enriched Maize through Molecular Breeding - Phase II *(Dr. P.K. Agarwal)*
- Network Project on Transgenics *(Dr. P.K. Agarwal)*

**AMAAS Projects**

- Development of a Bacterial Consortium to Alleviate Cold Stress *(Dr. P.K. Mishra)*
- Development of a Cold Tolerant Phosphate Solubilizing Bacterial Inoculant *(Dr. P.K. Mishra)*

**NAIP Projects**

- Enhancement of Livelihood Security through Sustainable Farming Systems and Related Farm Enterprises in N-W Himalaya *(Dr. P.K. Agarwal)*
- Enabling small holders to improve their livelihoods and benefit from carbon finance *(Dr. D. Mahanta)*
- Bio-prospecting of Genes and Allele Mining for Abliotic Stress Tolerance (Rice and Maize) *(Dr. P.K. Agarwal)*

**All India Coordinated Research Projects**

- Use of Plastics in Agriculture Particularly in Protected Cultivation, Water Harvesting and Packaging *(Dr. D.C. Sahoo)*
- AICRP on Post Harvest Technology *(Dr. Sukhbir Singh)*

**DUS Project**

- DUS Project on Maize, Soybean and French bean *(Ms. Shehalika Annapoli)*

**CWC Project**

- Demonstration of Storage and Application System for Efficient Water Utilization in Major Crops of Uttarakhand Hills through Participatory Approach *(Dr. B.M. Pandey)*
2.5. Externally Funded Projects

The projects under Horticulture Mission for North East and Himalayan States (HIMHSS), Department of Bio-technology (DBT) funded projects, Network Project Transgenics, National Agricultural Innovation Project (NAIP), All India Coordinated Research Projects (AICRP), Application of Micro-organisms in Agriculture and Allied Sectors (AMAAS), Distinctness Uniformity and Stability (DUS) and Farmers Participatory Action Research Programme of Central Water Commission (CWC) are the driving force for the diversification of institute research activities. The funds received under these projects are utilized to complement existing resources and augment the research capability of the institute.

2.5.1. Horticulture Mission for North East & Himalayan States Projects

2.5.1.1. Production of Quality Seed and Planting Material (Vegetables)

During the year 2012-13, a total of 1905.10 kg quality seeds of vegetables, viz., garden pea, French bean, tomato, okra, onion, and garlic were produced against the target of 1889.0 kg and thirty thousand seedlings of VL Pia 3 (long day onion) were produced.

2.5.1.2. Quality Seed Production of Capsicum and Squash under Protected Condition

Total 6.1 kg of capsicum and 35.0 kg of squash seeds were produced under protected condition. Quality seed production of french bean (var. VL Banni Bean 1 and 2) was taken in the May season inside the polyhouses. The total french bean quality seed produced was 55.0 kg.

2.5.1.3. Multiplication of Quality Planting Material of Important Cut Flowers of Uttarakhand

- Mother blocks of gerbera, chrysanthemum & carnation were developed and maintained.
- 1230 plants including other annuals were multiplied, supplied and distributed to different projects, institutes and farmers.
- Four promising hybrids were developed in gerbera and chrysanthemum.

2.5.1.4. Purification and Seed Multiplication of Underutilized Important Hill Vegetables

- Seeds obtained from twenty diverse lines of Dhamagiri radish (local type) were grown separately.
- Four local types Brassica sp. (leafy type) were grown for purification and maintenance.
- Forty eight lines of colocasia and three local type Dolicos were grown and evaluated.

2.5.1.5. Standardization of Improved Vegetable Production Technologies under Protected Cultivation

- Mulching with polyethylene (silver black) performed the best among the six mulch treatments. It gave the highest marketable fruit yield 256.65 q/ha whereas, minimum fruit yield was recorded in control (131.85q/ha).
- Four pruning systems were evaluated in tomato and capsicum under protected conditions. The three-leader system gave maximum marketable fruit yield in both the vegetables (470 and 318 q/ha, respectively).

2.5.1.6. Standardization of Organic Nutrient Management for Major Vegetable Crops

- An experiment was laid out to study the effect of different organic manures on yield of garden pea-french bean-potato cropping system. Application of different organic manures (FYM/poultry manure and vermiculture) increased the yield of all the crops with increasing levels of organic manures. Highest pod yield of garden pea...
(97.2 q/ha) was recorded with recommended dose of NPK+FYM @10 t/ha, which was statistically at par with vermicompost @ 15 & 20 t/ha, FYM @ 20 t/ha and poultry manure @ 9 and 12 t/ha. However, vermicompost (20 t/ha) gave the highest yield of French bean (101.7 q/ha) and potato (255.0 q/ha).

The traditional agriculture was improved by the intervention of high yielding varieties, seed drill sowing and mechanized threshing. Soybean, maize, barnyard millet, finger millet, wheat and lentil were main crops that covered a total area of 9.6 ha.

Animal husbandry component was also taken up for the integrated farming system development. Under which deworming of 220 animals was done along with feed supplementation to enhance milk production.

2.5.1.8. Efficient Water Management through Micro-Irrigation System in Terraced Land for Growing Vegetables

Water storage capacity of 747 m³ (15 tanks) was created in Dooragiri and Shitikhet villages and MIS was installed in 0.1 ha in the farmers fields. Four gravity-fed micro-irrigation systems (inline drip, PC emitter type, micro-tube and micro-sprinkler) along with plant-to-plant manual irrigation through pipe were evaluated for cabbage. There was not much difference in growth and yield of the crop among treatments due to frequent rain during the crop period. Four training-cum-demonstration programs were conducted at different villages in Almora and Bageswar districts in which a total of 132 farmers participated.

2.5.1.9. Dissemination of Growing Off-Season Vegetable Technology under Protected Environment

This project has been functional in Dwarahat block of Almora district and Dhari, Ramgarh and Bhimtal blocks of Nainital district. A total of 395 demonstrations (16.97 ha) were taken up and the data show that the protected cultivation of tomato gave 221% increase in yield over the tomato grown...
in open. The french bean yield was recorded 25-
30% lower than the normal because of low and
high rainfall during March and August 2012,
respectively, for the correspondingly sown bean
crop (Table 2.5.1). Besides, seven low-cost
crops, covering approximately 700 square
polyhouses, were constructed and three
training cum-exposure programmes for farmers
were conducted for the adopted villages, in which
175 farmers, farm and women participated.

2.5.1.10. Refinement and Dissemination of
Mushroom Production Technologies

The anti-oxidative activities of Pleurotus
ostreatus, P. djamor, P. eryngii, P. flabellatus,
P. florida, P. cinctus, P. sajor-caju and Hypsizygus
ulmarius (blue oyster mushroom) were determined.

Total phenolics in edible oyster mushrooms: Among
the studied species, P. eryngii had the highest
content of phenolics (21.67 mg TAE/g of
mycelium), followed by P. djamor (18.88 mg TAE/g
of mycelium) while other species had lower
phenolic contents, with H. ulmarius showing the
lowest amount (5.94 mg TAE/g of mycelium).

Radical Scavenging Activity on DPPH of edible
mushrooms: RSA of different edible mushroom
species varied from 13.63 to 69.67% and increased
with the increase in concentration. It was higher
for P. eryngii, P. djamor and P. flabellatus (67.4-
69.67% at 100% mycelial extract concentration)
in comparison to standards, i.e., vitamins C and
E, while H. ulmarius, P. sajor-caju and P. florida
showed comparatively lower RSA (41.99-43.88% at
100% mycelial extract concentration).

Ascorbic acid content and metal chelating activity:
The ascorbic acid content was significantly higher
in P. cinctus (6.76 mg/g) and P. ostreatus (6.55
mg/g), followed by P. eryngii (5.88 mg/g), while
H. ulmarius, P. sajor-caju, P. flabellatus and P. florida
showed significantly lower ascorbic acid content,
i.e., 4.20, 4.15, 3.89 and 3.76 mg/g, respectively.
All the studied species had higher metal chelating
activity in comparison to EDTA (53.46% at 100
ppm). The chelating activity of P. cinctus
(82.71%) was significantly higher followed by P.
djamor (71.9%) and P. eryngii (70.82%) while
lowest was shown by P. sajor-caju (69.94%) and P.
flabellatus (69.25%). However, it was 65.42% in
case of H. ulmarius.

Trainings and demonstrations

A total of eight training programmes on
different aspects of mushroom cultivation were
organized at farmers’ fields as well as at
Hawallah farm in which one hundred twenty one
farmers got training.

Eleven demonstrations of oyster and 36 of
button mushrooms were conducted at farmers’
sites. The biological efficiency of oyster mushroom
varied from 50-72.50%, however, it was 13.21% for
button mushroom at different sites.

Table 2.5.1: Detail of demonstration conducted during 2012-13

<table>
<thead>
<tr>
<th>Vegetable (polyhouse)</th>
<th>Demonstrations</th>
<th>Area (ha)</th>
<th>Average yield (kg/ha)</th>
<th>Average price (Rs./kg)</th>
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<tbody>
<tr>
<td>Tomato (polyhouse)</td>
<td>8</td>
<td>0.18</td>
<td>56200</td>
<td>24</td>
</tr>
<tr>
<td>Tomato (open)</td>
<td>27</td>
<td>1.38</td>
<td>17500</td>
<td>23</td>
</tr>
<tr>
<td>Capsicum (polyhouse)</td>
<td>6</td>
<td>0.12</td>
<td>21000</td>
<td>43</td>
</tr>
<tr>
<td>Cabbage (open)</td>
<td>55</td>
<td>3.06</td>
<td>41000</td>
<td>5</td>
</tr>
<tr>
<td>Cucumber (polyhouse)</td>
<td>11</td>
<td>0.05</td>
<td>52200</td>
<td>24</td>
</tr>
<tr>
<td>S. Squash (open)</td>
<td>9</td>
<td>0.05</td>
<td>31700</td>
<td>15</td>
</tr>
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<td>Cauliflower (open)</td>
<td>5</td>
<td>0.16</td>
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<td>French bean (open)*</td>
<td>7</td>
<td>0.26</td>
<td>7121</td>
<td>25</td>
</tr>
<tr>
<td>French bean (open)**</td>
<td>97</td>
<td>4.00</td>
<td>7600</td>
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<tr>
<td>Ps (open)**</td>
<td>160</td>
<td>7.73</td>
<td>3400</td>
<td>25</td>
</tr>
</tbody>
</table>

* - March sown  ** - August sown  *** - November sown
2.5.1.11. Evaluation and Mass Multiplication of Plant Growth Promoting Bioinoculants to Enhance Vegetable Production

A total of 255 bacteria were isolated from vegetable rhizosphere/ rhizoplane/endophyte and phytoilane. Isolated bacteria were screened for four PGP traits (P solubilization, IAA, siderophore and HCN production) under in-vitro condition at 28°C and finally ten potential isolates were selected for further studies. Qualitative estimation of phosphatase activity by bacterial isolates revealed that at 28°C out of 45, five isolates ORs1, ORs6, ORs10, LRs3 and LERS18 showed

strong phosphatase. Bacterial isolates LRp10 and LRp9 showed the highest IAA production (60.8 μg ml⁻¹) and (60.5 μg ml⁻¹) after five days of incubation at 28°C while LRs3, LRs1, ORs43, and ORP5 had shown IAA production 55.3, 54.6, 52.5 and 44.3 μg ml⁻¹, respectively.

2.5.1.12. Deployment of Entomopathogens and Light Traps for the Management of Scarabacids in Uttarakhand Hills

White grubs (Coleoptera: Scarabacidae) are polyphagous insect pests causing severe damage to crop plants in the hill ecosystem. Both adult beetles and immature grubs cause damage to plants. The grubs are of subterranean habitat feeding extensively on the roots and the adults defoliate the plants. A two pronged strategy involving an efficient, light based insect trap for capturing the adults and an entomopathogen, Bacillus cereus strain WGPSB-2 for the management of grubs was developed. Large scale deployment of the above technology was done on community basis in 12 villages of low, mid and high altitudes including two in experimental farms of Uttarakhand hills. Seven villages were selected to demonstrate the technology with 102 light traps (VL, White Grub Beetle Trap-1) installed at strategic locations which trapped a total of 0.68 lakhs beetles during 2012. The pit samplings of white grub population/fm² done in the cropped fields at different intervals during June and July (peak period) showed a reduction of 67.34 and 58.76% with respect to June and July, 2008.

Besides, talc based formulation of B. cereus strain WGPSB-2 (57 kg) was prepared for
demonstrations at farmers' fields. Besides these, exhaustive surveys were made throughout the state for collection of diseased white grubs for isolating the associated entomopathogens. So far, 52 local strains of entomopathogens have been isolated from diseased white grubs and being studied for their efficacy. Both the cost effective and environmentally safe technologies have gained popularity and advancement under the network project initiated in November 2005 at three centers located at low, mid and high altitudes of Uttarakhand state. More than 1300 farmers in low, mid and high altitudes were benefited through the deployment of scab resistance management technologies.

2.5.1.13. Planned Honey Bee Pollination for Improvement in Horticultural Crop Production

Insect pollinators are essential for proper pollination and fruit set in cross-pollinated crops. Keeping this in view, honeybee boxes were provided to the interested farmers of adopted village. The villagers were trained at the institute and their respective farms regarding honeybee monitoring and management of bee colonies during daphth. To assess the impact, crops from the adopted villages were compared against the respective crops from distant villages (at least 2 km away) having no bee colonies nearby.

Because of planned honey bee pollination, an increase in the crop yield was realized in the adopted villages. The average increase in seed yield of fenugreek, coriander, cauliflower and onion at Hairalbargh was found to be 19.2, 25.7, 18.8 and 17.9%, respectively, in planned honey bee pollinated crops over naturally pollinated crops. Besides vegetable crops, honeybees were found to play a major role in increasing the fruit set of apple, apricot and plum. In Darim, with the introduction of honeybees, a substantial increase was noticed in fruit set to the tune of 25.0% in apple, 20.9% in apricot.

2.5.1.14. Status of Horticulture and Market Opportunities in the State of Uttarakhand

Primary data were collected from 84 farmers of three clusters of villages, viz., Bhagartola, Dubkhari and Dunagiri. Figs. 2.31, 2.32 and 2.33 represent the area allocated by farmers to various vegetables crops in the three clusters.

![Land use pattern of Bhagartola](image)

**Fig. 2.31:** Share of different vegetables in Bhagartola cluster

![Land use pattern of Dunagiri](image)

**Fig. 2.32:** Share of different vegetables in Dunagiri Cluster

![Land use pattern of Darim-Dubkhari](image)

**Fig. 2.33:** Share of different vegetables in Dubkhari Cluster

Yields under protected condition in the case of cucumber, tomato and capsicum were recorded to be 651, 552 and 383 q/ha which were 77, 372 and 251% higher than those under open condition. The benefit cost ratio was highest for cucumber (2.5) followed by capsicum (2.3).
The yields of cucumber, cabbage, potato, cauliflower, radish, tomato, capsicum, french bean and pea were 368, 196, 136, 128, 118, 117, 109, 93 and 84 q/ha under open condition with benefit cost ratio 2.4, 1.5, 1.02, 1.8, 1.4, 1.3, 1.7, 1.4 and 1.6, respectively (Fig. 2.34). Due to wild boar problem, the area under potato crop has reduced from 58% in 2010-11 and 53% in 2011-12 to 48% in 2012-13 in Bhagatulia cluster.

Four farmers' clubs, seven self-help groups and one retail outlet started for farmers' club are maintained and monitored regularly. Todhra Dudho Kisan Club formed under the project received district level best farmers club award for 2012-13.

![Fig. 2.34: Productivity of different vegetables under open and protected field condition](image)

### 2.5.1.15. Training in Mechanization of Horticulture

- Five 3-day training programmes on mechanization of horticulture were organized at Haukabagh and KVK, Kailigain, in which 71 farmers were participated.
- Twenty demonstration-cum-training programmes (one day each) were organized at different villages of Almora, Patheraghah, Chamoli, Champawat and Bageshtwar district in which improved tools such as scaceuta, pruning saw, rake, khuri, sickle, digging hoe, *kaali*, VL Syahi Hal, mini tiller, line maker and sprayer (hand and power operated) were demonstrated to the 706 farmers.
- Improved tools developed by the institute were also exhibited/demonstrated at farmers' fairs, etc.
- More than 2500 improved tools were purchased by the farmers from the institute.
- Nine improved small tools (VL Syahi Hal, line maker, garden rake, hand rake, hand hoe, hand fork, kulka, khuppi, darai-big, darai-small) have been commercialized and the license given to M/s Himalayan Hi-tech Nurseries, Haldwani (Nainital) for fabrication/multiplication.

#### 2.5.1.16 Assessment and Refinement of Available Methods/Devices to Check Wildlife Damage in Hill Crops

The growth phases of rice, maize, finger miller, barnyard millet and potato which are most vulnerable to damages by wild boar were studied and ranks were given on the basis of severity of damage found in experimental farm at Haukabagh and farmers' fields (Table 2.5.2).

### Table 2.5.2: Crop Growth Phases Vulnerable to Wild Boar Damage

<table>
<thead>
<tr>
<th>Crop</th>
<th>Growth phase</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>Scudding</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td>Tillering</td>
<td>II</td>
</tr>
<tr>
<td></td>
<td>Milking</td>
<td>III</td>
</tr>
<tr>
<td>Maize</td>
<td>Scudding</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td>Silking</td>
<td>II</td>
</tr>
<tr>
<td></td>
<td>Soft doughs</td>
<td>III</td>
</tr>
<tr>
<td>Finger millet</td>
<td>Seedling</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td>Tillering</td>
<td>II</td>
</tr>
<tr>
<td></td>
<td>Milking</td>
<td>III</td>
</tr>
<tr>
<td>Barnyard millet</td>
<td>Seedling</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td>Tillering</td>
<td>II</td>
</tr>
<tr>
<td></td>
<td>Milking</td>
<td>III</td>
</tr>
<tr>
<td>Potato</td>
<td>Seedling</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td>Stover formation</td>
<td>II</td>
</tr>
<tr>
<td></td>
<td>Tuber formation</td>
<td>III</td>
</tr>
</tbody>
</table>

Maize seedlings damaged by wild boar
Yield losses in different vegetable and fruit crops at Bhagartola village by various wild animals are presented in Tables 2.5.3 and 2.5.4.

Table 2.5.3: Yield Losses of Different Vegetable Crops at Bhagartola Village due to Wild Animal Damage

<table>
<thead>
<tr>
<th>Crops</th>
<th>Yield losses % (kg/200 m²)</th>
<th>Species causing damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potato</td>
<td>37.85</td>
<td>Wild boar</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>26.53</td>
<td>Monkey</td>
</tr>
<tr>
<td>Pea</td>
<td>15.99</td>
<td>Monkeys</td>
</tr>
<tr>
<td>Radish</td>
<td>10.46</td>
<td>Wild boar</td>
</tr>
<tr>
<td>Pumpkin</td>
<td>5.22</td>
<td>Monkey</td>
</tr>
<tr>
<td>Tomato</td>
<td>2.69</td>
<td>Monkey, Partridge</td>
</tr>
<tr>
<td>Bean</td>
<td>0.59</td>
<td>Monkey</td>
</tr>
</tbody>
</table>

Table 2.5.4: Yield Losses of Different Fruit Crops at Bhagartola Village due to Monkey and Bird Damage

<table>
<thead>
<tr>
<th>Fruit crop</th>
<th>Yield losses % (per tree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>26.54</td>
</tr>
<tr>
<td>Pea</td>
<td>41.62</td>
</tr>
<tr>
<td>Apricot</td>
<td>17.43</td>
</tr>
<tr>
<td>Peach</td>
<td>8.34</td>
</tr>
<tr>
<td>Citrus</td>
<td>9.17</td>
</tr>
</tbody>
</table>

A herbal product was tested at Howalbagh to repel wild boar. However, no satisfactory result was obtained.

2.5.1.17. Purification of A, B and R lines in onion for parental and hybrid seed production using molecular tools

Heterosis breeding provides an opportunity for improvement in productivity, earliness, uniformity and yield attributing characters in onion. To exploit the heterosis for yield is first identification of superior combination and second to economize the cost of hybrid seed production. In onion, two types of cytoplasmic male sterility (CMS) have been utilized for hybrid cultivar development in onion, viz. CMS-(S) and CMS-(T). The majority of hybrid onion cultivars produced till date have used S cytoplasm as a source of male sterility. The male-sterile plants produced flowers with light green anthers which were easily detected in the field, however it is not a full proof method. Onion is a biennial plant and usually, 4 to 8 years are required to determine a cytoplasm type by test-crossing to identify sterile cytoplasm and Ms alleles. Mitochondrial gene "cob" is polymorphic between normal and sterile cytoplasm. The marker linked with cob gene was used to identify the sterile and fertile cytoplasm. The fertility is restored in CMS-(S) by single nuclear dominant gene (Ms/mS). The fertility restorer gene (Ms/mS) linked markers i.e. OPT and PstD markers was used to identify true restorer and maintainer. Four populations were used to identify the true A, B and R plants, i.e. VL F1st 67, VL F1st 3, M population and KR population. About 300 plants were selected as putative sterile plants in three populations. Out of these 300 plants, 144 were found to have sterile cytoplasm while 156 plants had normal cytoplasm. These plants were also screened for fertility restorer gene locus. Out of these plants, 201 plants were having dominant homozygous alleles (Ms/Ms) of nuclear fertility...
restorer gene, while 81 plants had heterozygous allele (Ms/ms) and 18 plants had recessive homozygous (ms/ms) allele. On comparing the cytoplasm and nuclear fertility restorer gene locus, 12 plants were found to be completely sterile having sterile cytoplasm and having recessive homozygous (ms/ms) allele in two population, VLPiaz-3 and KR, while none of the plants were found in the population of VL Piaz 67. The pollen viability test of the selected sterile plants was done based on molecular markers using acrocarmine stain (0.5%) (Fig. 2.35). The pollen viability test was completely coincided with the molecular marker test. Sterile plants can be identified on the basis of anther colour but to identify the maintainer line (B line) is a tedious job. In all the three populations, only one plant had a normal cytoplasm and recessive homozygous (ms/ms) gene in VL Piaz-3 population. This plant was treated as maintainer and used to pollinate the completely sterile plants and also selfed to get the seeds. In KR population, seven plants were found having normal cytoplasm and heterozygous allele (Ms/ms). These plants were used to pollinate the sterile cytoplasm and also selfed. The F1 plants and selfed plants were also screened to get the true A and B type plants.

2.5.2. DBT Funded Projects

2.5.2.1. Rapid Conversion of Normal Maize Inbreds to Quality Protein Maize and Further Enhancement of Limiting Amino Acids in Elite Inbreds through Marker Assisted Selection

Maize ranks third in India after rice and wheat, both in area and production. It is one of the major sources of calorie and protein. However, it is deficient in essential amino acids viz., lysine and tryptophan. Quality protein maize (QPM) with opaque-2 gene along with associated modifiers contains twice as much lysine and tryptophan and 30% less leucine than the normal maize. The reduced level of zein further improves the nutritional quality of the QPM.

Three maize inbreds viz., VQI 1, VQI 2 and VQI 17, parents of two elite maize hybrids, Vivek QPM 9 and FQH 38 were selected and were crossed with QPM donors CML 180, CML 170 and CML 189 respectively in order to improve the nutritional quality and to further enhance the tryptophan and lysine level of the selected elite inbreds. The BC F1 populations were grown in kharif 2011 at Hauz Khas farm of VPKAS, Almora. More than 500 plants were used for foreground and background selection. A set of 100 polymorphic primers were identified earlier for the background selection. A set of 50 primers out of this set were used in this generation for background selection. This set along with earlier used primers completes the whole set of 100 evenly distributed polymorphic markers for the background selection. The genome recovery ranged from 70% to 95%. Plants with more than 85% genome of the respective recipient parents, with higher tryptophan content were selfed to generate the BC F2 generation. The BC F2 plant populations were grown at the Winter Nursery of the Directorate of Maize Research, Hyderabad. Around 600 plants of each population were used for foreground selection. The background selection was conducted on the selected plants after the foreground selection. The selected plants were backcrossed to their respective recipient parents and the BC F3 population was generated. The BC F3 generation was raised in the kharif 2012 at VPKAS Almora. More than 600 seeds were sown for each cross. After proper plant stand, the plants available for foreground selection were 547 for VQI 1 x CML 180, 448 for VQI 2 x CML 170, and 416 for VQI 17 x CML 189. The plants available for background selection, after the foreground selections were 220, 170 and 159, respectively.
2.5.2.2. Pyramiding Multiple Resistance Genes using MAS for Durable Resistance against Blast in the North West Himalayas

Rice is one of the major staple food crops of the hill regions of India. The total area under hill rice in India is about 1.82.0 million ha, out of which 0.62 m ha is under North-Western Himalaya, producing about 1.23 million tonnes of rice. Among many rice cultivars grown in this region, two elite cultivars are, VL Dhan 207 and VL Dhan 85 cover a large area in the hills of NW Himalayan region. Although, both these cultivars were resistant when released, they have become susceptible at some locations. Hence, there is a need to induce resistance in these cultivars by pyramiding two or more resistance genes using MAS so that the cultivars may have durable resistant against the blast isolates prevalent in this region. The project aimed to pyramid more than one gene in the background of VL Dhan 207 and VL Dhan 85. Accordingly the following crosses were planned to pyramid Fv1, Fv9 and Fkko.

VL Dhan 207 x O. minuta derivative (Fv9)
VL Dhan 207 x C 1010 lac (Fv1)
VL Dhan 207 x MAS 73Q179 (Breeding line carrying Fkko)
VL Dhan 85 x O. minuta derivative (Fv9)
VL Dhan 85 x C 101 lac (Fv1)
VL Dhan 85 x MAS 79 (Breeding line carrying Fkko)

Parental polymorphism between the recipient and donor parents were completed for Fv9, Fv1 and Fkko in the beginning of the project. The marker for Fv9 is available right within the gene where as Fv1 and Fkko are highly close to the gene of interest. Foreground selection was successfully conducted using linked markers like RM 206 for Fkko, P 28 and NBS LRR markers for Fv9, and RM 206 for Fkko. A set of more than 500 DNA markers were used to identify polymorphic markers between respective recipient and donor parents. The PCR condition for all the polymorphic markers were standardized. The background selection was conducted in the BC1,F1 and BC2,F1 generations. Selections were made based on high recipient genome recovery (RGR), morphology of the plants and the agronomic worth of the plants. The RGR in different crosses ranged up to 95%. The BC1,F1 and BC2,F1 generations were grown in khairi 2012. In order to achieve the expected level of recipient genome recovery, the number of crosses/ seeds in the earlier generation were made to be more than 1000 and the number of plants were more than 500 per cross. The recipient genome recovery was up to 96.15% among the crosses (Figs. 2.36 and 2.37).

2.5.2.3. Genetic Enhancement of Wheat by Pyramiding of Rust Resistance Genes through Molecular Approaches in Northern Hills in India

Yellow rust is a devastating disease of wheat in the hilly areas of NW Himalayan states. A high yielding winter variety VL Gehum 738 from VPKAS, Almora, is highly resistant for about 12 pathotypes of yellow rust, but has started showing susceptibility to new prevalent pathotypes 46S119 and 78S84. Two yellow resistant genes Yr5 (Triticum aestivum album) and Yr10(Moro) were found to be effective to most of the known pathotypes. Hence under this project, we aimed to utilize broad spectrum resistance genes Yr5 and Yr10 for transferring yellow rust resistance to VL Gehum 738 using MAS. The SSR marker Xpssp3000 reportedly linked (1.2cM) with Yr10 in Moro derived population was found polymorphic between VL Gehum 738 and Moro and Moro derived lines (FLW10, China 84). Similarly,
Xwmec175 marker was found polymorphic between the recipient VL Gehun 738 and donors, *Triticum spelta* *album* and TSA derived line FLWL16 (UP 2338 + TSA).

Two crosses one for each gene i.e., VL Gehun 738 X FLWL16 for *Yr*5 and VL Gehun 738 X Moro for *Yr*10 were generated for development of yellow rust resistance version of VL Gehun 738. About 425 seeds of each BC1,F2 population were sown at Dalang Maidan (DWR, RS). After foreground selection, 54 plants for *Yr*5 and 60 plants for *Yr*10 were found positive. Back crosses were made using at least two ears in each plant. The genome recovery was found from 80% to 97% in *Yr*5 population whereas 75% to 97% in *Yr*10 population. The plants having genome recovery of more than 90% in case of *Yr*5 and 88% in case of *Yr*10 were selected to generate BC1,F2 population. Seventeen plants from *Yr*5 and 21 plants from *Yr*10 population were selected for the advancement of the generation. About 350 seeds of each population were planted in *rabi* 2011-12. Out of 286 plants, 127 for *Yr*5 gene and out of 271 plants 123 for *Yr*10 gene were found to carry the allele for the resistant gene(s) after foreground selection. The background selection was done with 46 markers for *Yr*5 population and 70 markers for *Yr*10 population. The genome recovery was observed 92.9% to 98.9% for *Yr*5, and 83.3% to 97.6% in *Yr*10 population. On the basis of genome recovery and phenotypic observations, 36 plants on *Yr*5 population and 45 plants in *Yr*10 population were selected. A total of 176 intercrosses were made between *Yr*5 and *Yr*10 population to pyramid both the genes. About 802 crossed seeds were planted at Dalang Maidan, Lahaul Spiti (HP), for generation advancement during off-season nursery in May, 2012. Out of 802 seeds 778 plants germinated. After the foreground selection for both the genes using markers Xpp3000 and S26M47 (*Yr*10) and Xwmec175 and STS7/10 (*Yr*5), 230 plants were found positive. These plants were selfed and harvested. The seeds of each plant was phenotyped for seed morphology and 157 plants were selected. The selected plants were sown in plant to row (1.5 m) during *rabi* 2012-13. These rows were phenotyped for morphological traits of VL Gehun 738 and 25 lines were selected. The foreground selection of these lines was done for both the genes. The background selection is done with 35 markers which are polymorphic among all the three parents. The genome recovery is more than 95% and almost all the loci were fixed.

### 2.5.2.4. Development of Micronutrient Enriched Maize through Molecular Breeding: Phase II

A set of 67 maize entries was analyzed for kernel Fe and Zn concentration over three years. Analysis of variance indicated significant variation for both kernel Fe and Zn concentration in all the three years, suggesting the availability of wider genetic variation. The study also revealed no significant correlation between kernel Fe and Zn concentration among the genotypes. Taking into consideration mean performance, regression coefficient and deviation from linearity, V336, CM129, CM139, V340, VQL1 and VQL5 were found to be stable and promising genotypes for kernel Fe concentration. In case of kernel Zn, BAJIM-06-10, CM129, V340 and VQL1 were identified as the stable genotypes. Considering both Fe and Zn concentration, CM129, V340 and VQL1 were identified as the most stable and promising genotypes.

**Molecular localization of Fe and Zn:** The selected lines with phenotypic contrast in respect of kernel Fe and Zn concentrations, were used for developing mapping populations. The F2 mapping population, V336 x CM140 was developed and used for mapping kernel Fe and Zn content. The phenotyping of F2 seeds was done using AAS. The QTLs observed were found to be minor in nature (Fig 2.38). In addition, analysis of F1 plant harvests (120 F1 seeds) of four populations (V336 x VQL1; V336 x VQL2; VQL1 x V336; VQL2 x V336) for kernel Fe content showed several individuals with transgressive segregation. Two crosses, CM145 x Ipa1 and V334 x Ipa2 were generated for transferring low phytate trait through MAS. The level of homozygosity among the best 10 plants for the cross CM 145 x Ipa was found to be more than 95% while the
same level was exhibited by 14 plants in case of V334 × lpa 2. The plant progenies are in BC2F3 generation.

2.5.3. Network Project on Transgenics

2.5.3.1. Development of Transgenic Maize with Resistance to Stem Borer

The project aimed to standardize the tissue culture conditions for the callus induction and whole plant regeneration, standardize the gene transformation methodology in sub-tropical maize, generate transgenic maize resistant to stem borer and to evaluate them for their efficacy. Among many maize genotypes evaluated, regeneration system could be standardized for VQL 2, one of the parents of Vivek QPM 9. Transformation of these embryogenic calli were done using Agrobacterium system by manipulating different factors. During the period of investigation, the transformation procedure using Agrobacterium was refined, factors like sonication and other factors were studied and putative transgenic plants were generated. The molecular analysis of the transgenic plants was done using PCR. The calli were induced from seed-derived nodal segment of VQL 2 for transformation and regeneration. A total of more than 100,000 seeds (approx.) of VQL 2 were placed for callus induction. The node-derived calli were cultured under 80 µmol light resulted in whole plant regeneration with excellent embryogenesis. Those calli were used for transformation. Twenty five putative transgenic plants along with 100 control plants were successfully transferred to soil and established in the transgenic greenhouse.

Validation of Cry 1 Ab in tobacco

Agrobacterium tumefaciens was used to transfect tobacco plants with genes encoding for antibiotic (kanamycin and rifampicin) resistance, herbicide resistance (bar gene), β-glucuronidase (GUS) expression (uid A gene) and Cry1Ab.

Steps of Experiment

A. Bacteria inoculation

Agrobacterium tumefaciens strain EHA-105 containing pCAMBIA 3301 plasmid was grown on the YEM agar medium (0.20 g MgSO4·7H2O, 0.10 g NaCl, 0.50 g K2HPO4, 10.0 g mannitol, 1.0 g yeast extract, agar (1.5% (w/v)) per L and pH 7.0) overnight at 28°C to get a fresh colony. EHA-105 strain containing pCAMBIA 3301 was selected on the YEM agar medium containing 10 mg/L rifampicin and 50 mg/L kanamycin. A single colony was picked and grown in 50 mL of YEM liquid medium (pH 7.0) overnight at 28°C, 250 rpm. The next day, cells were harvested by centrifugation for 10 min at room temperature at 6000 rpm and resuspended for 12 hrs at 25°C, 150 rpm in MS induction liquid medium (4.4 g/L MS salts, 30 g/L sucrose, pH 5.5) containing 200 µM acetosyringone (AS) until it reached to 0.3 A600 units. AS was prepared by dissolving AS powder in DMSO, and the appropriate amount was added to the cool medium after autoclaving. Ten ml of Agrobacterium inoculum was used for 45 leaf disks.

B. Infection and co-cultivation

Leaf disks were obtained from four week-old tobacco plantlets grown in vitro. Sterile tobacco leaves were cut from plantlets and soaked in MS liquid media in a sterile Petri dish to avoid dehydration. One hundred leaf disks were cut-out using a sterile scalpel with a 1-cm inner diameter, and placed in the liquid MS media (4.4 g/L MS salts, 30 g sucrose/L, pH 5.6) in a Petri dish at a time. Forty-five leaf disks were placed into one Petri dish for bacterial inoculation. Leaf disks were soaked in 10 mL of Agrobacterium tumefaciens (0.3 A600 units) containing 200 µM AS in the Petri dish. Two Petri dishes containing leaf disks and Agrobacterium tumefaciens were placed in a vacuum desiccator. Vacuum infiltration was performed using a vacuum pump for specified duration (30
seconds). After vacuum infiltration, these Petri dishes were kept for 10-15 minutes. Inoculated leaf disks were transferred to a Whatman filter paper (autoclaved) and then blotted thoroughly. Fifteen leaf disks were placed per Petri dish on the cocultivation medium. Petri dishes were covered and sealed well with a strip of parafilm and incubated in dark at 22°C for 48 hrs.

C. Selection

After co-cultivation, leaf disks were collected and washed with MS liquid medium containing 500 mg/L carbenicillin four to five times. Leaf disks were blotted thoroughly on the filter paper. Ten leaf disks were placed per Petri dish on the shoot selection medium (Fig. 2.39). The composition of the tobacco shoot selection medium is the same as the co-cultivation medium, except 1 mg/L naphthalene acetic acid was substituted for indole acetic acid. The shoot selection medium also contained 7.0 ppm basta and 500 mg/L carbenicillin. Leaf disks on selection medium were incubated at 25 ± 0.5°C under constant light for two weeks prior to the β-glucuronidase assay. The shoots were transferred to MS medium with 7.0 ppm basta and 500 mg/L carbenicillin and no plant growth regulators for rooting (Fig. 2.40).

Approximately 8-10 cm long plants with well-developed roots were washed with autoclaved distilled water and then transferred to potted manure mix (Fig. 2.41).

D. GUS Histochemical Assay

Treated tobacco leaf disks were soak in the phosphate buffer (50 mM NaPO₃, pH 6.8 with 0.1% (v/v) Triton X-100) at 37°C for one hour. Meanwhile, 3.0 mg of X-gluc (5-Bromo-4-chloro-3-indoyl β-D-glucuronide sodium) was dissolved in 150 µL of dimethyl formamide. Eight hundred fifty µL of solution B (5.0 mM potassium ferricyanide, 5.0 mM potassium ferrocyanide, 0.1 M sodium phosphate, and 0.1% (v/v) Triton X-100) was added to 150 µL X-gluc solution. Sodium phosphate buffer was discarded after incubation for one hr and then Solution B with XGluc was added until leaf disks were submerged. They were incubated overnight at room temperature and destained with destaining solution [50% (v/v) ethanol, 10% (v/v) formaldehyde, and 5% (v/v) glacial acetic acid] overnight again (Fig. 2.42).

E. Transgenic plants expressing GUS

Six plants were observed to be expressing gene thereby confirming that the gene construct has a functional selectable marker. The constructs are being utilized for the development of transgenic maize plants.
2.5.4. NAIP Projects

2.5.4.1. Enhancement of Livelihood Security through Sustainable Farming Systems and Related Farm Enterprises in N-W Himalaya

N-W Himalayan region comprising of Jammu & Kashmir, Himachal Pradesh and Uttarakhand spread over an area of over 33 million ha., is inhabited by 24.5 million people. This region has only 6% land (2 million ha.) under agriculture; consequently, per capita availability of agricultural land in the region is much lower (750 to 900 m²) as compared to the per capita national average of 1370 m². Agriculture is the mainstay of the people living in hills, yet, food self-sufficiency eludes the hills and this has led to the growing disparity in the standard of living. Hence, a well conceived sustainable rural livelihood security project on Enhancement of Livelihood Security through Sustainable Farming Systems and Related Farm Enterprises in North-West Himalaya was launched under Component-3 of the NAIP. The project is being implemented in a ‘Consortium Mode’ by VPKAS, Almora as Lead Centre and Cooperating Centres namely, SKUAST-K, Srinagar; SKUAST-J, Jammu; CSKHPCV, Palampur; GBPIHED, Kosi Katarmal; and BAIF, Haridwar to undertake need based multi-location project activities. Considering the extreme variability in agro-ecosystems in hill region, a total of fifteen clusters of villages in five districts, representing predominant growing conditions were identified.

The salient achievements of the project in 2012-13 were:

1. Cereals: Cultivation of improved varieties of cereals in 699 ha area with horizontal expansion of 1000 ha by unadopted villages. Increase in crop yield in the range of 39 to 66% resulted in additional income of Rs. 19,775 for an area of 0.4 ha/household/annum.

2. Vegetables & Cash crops: Vegetable cultivation was taken up in 74.2 ha. Seeds of improved high yielding varieties were supplied which resulted in income of Rs. 40,000 for an area of 0.1 ha per household per annum.

Vegetables production increased upto 130%. In Kupwara production of vegetable seedling in polyhouse resulted in fast growth and supply of vegetable seedlings in time.

3. Saffron was planted in 8.2 ha area and 16 farm families got additional income of Rs. 58,751 from an area of 0.1ha.

4. Cultivation of medicinal & aromatic plants and floriculture by 125 households in 7.7 ha area resulted in an annual income of Rs. 7,985-10,335 per household.

5. Seed production: Produced Truthfully Labelled seed of paddy (800 q), maize (130 q), oil-seed (105 q), oats (300 q), potato (200 q) by the farmers.

6. Horticulture: Quality of apple has improved by 22% (33% to 60%) & quantity has increased by 33% through introduction of pollinators, use of micronutrients and high yielding varieties which resulted in 6,715 new plants.

7. Poultry and Livestock: Out of 5,839 artificial inseminations done, 1680 cross-bred calves were born, in which 811 were females. These are likely to come to milking age in next three years. Backyard poultry (56,845 chicks) have been distributed for meat & egg production. Poultry & ghati are supplementary income generation activities for rural poor households. For up-gradation of livestock, Jersey bulls (20) and crossbred rams (88) have been introduced.

8. Mushroom units: More than 2500 mushroom units benefitted 250 households. The net income of mushroom cultivation varied from Rs. 230 to 430 per bag.

9. Water harvesting structure: 154 water harvesting structures were utilized for fish and vegetables cultivation.

10. Polyhouse: 75 polyhouses were made for off-season vegetable cultivation and supply of quality vegetable nursery.

11. Introduced for the first time polyhouse technology for early production of vegetable nursery in Kupwara.

12. Organized 105 farmers training in the areas of crop production, seed production, protected
cultivation, fruit production and protection, vegetable production, sericulture, poultry, animal sector, apiculture and fisheries benefiting 6500 farmers. The training programmes made farmers choose the technology wisely as per their need.

**Recommended livelihood models**

<table>
<thead>
<tr>
<th>Model</th>
<th>Suitability target</th>
<th>Total number of Household covered</th>
<th>Total area covered (ha)</th>
<th>Net return per HH per year (in Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model I (for an area of 1.0 ha)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Crops + Vegetable Crops + Horticulture + Water Harvesting + fishery</td>
<td>1.0 ha</td>
<td>20</td>
<td>20.0</td>
<td>1,04,550</td>
</tr>
<tr>
<td>Model II (for an area 0.5 ha)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Crops + Vegetable Crops + Water Harvesting + fishery</td>
<td>0.5 ha</td>
<td>25</td>
<td>12.5</td>
<td>64,775</td>
</tr>
<tr>
<td>Model III (for an area 0.2 ha to 0.5 ha, income for 0.25 ha)</td>
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</tr>
<tr>
<td>Polyhouse + Vegetable Crops + Water Harvesting + Cash Crops (Flowers/ MAPs, Saffron) + Mushroom + fishery</td>
<td>0.33</td>
<td>15</td>
<td>3.75</td>
<td>77,000</td>
</tr>
<tr>
<td>Model IV (for an area of 0.2 ha, income for 0.1 ha)</td>
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<tr>
<td>Mushroom + Poultry/ Animals + cash crops + Value Addition/ Agro-processing</td>
<td>0.1 ha</td>
<td>250</td>
<td>25.0 ha</td>
<td>87,000</td>
</tr>
</tbody>
</table>

2.5.4.2. Enabling Small Holders to Improve their Livelihoods and Benefit from Carbon Finance

Two major interventions viz. horticulture and energy based, were undertaken to strengthen the positive carbon balance in the grid area. Horticulture is one of the most important components of agriculture in the hilly region due to steep slopes of cultivated area. Farmers prefer plantation of fruit crops, which sequeser large volume of carbon. So, there was huge demand for fruit saplings, as they want to rejuvenate their old orchards, which were not bearing marketable amount of fruits due to either semi-cultivated stage of the fruit plants or global warming (as some of the fruit crops require minimum of 1000-1500 chilling hours, which is not fulfilled). They want to rejuvenate through new species or less chilling hours, thereby requiring improved varieties. Recently, farmers have been planting tropical fruit plants, which have flourished due to global climate change. Therefore, 11,410 improved fruit saplings of mango, guava, pomegranate, lemon, Power cut is the most common and regular phenomenon in villages of Uttarakhand hill (grid area of the project). Sometimes it continues for hours and days together. People use kerosene lamp for lighting during night, which pollutes the air by emitting greenhouse gases. Use of solar lanterns will help in lighting during power cut, which will also avoid pollution. It is estimated that, there is reduction of about 372 kg CO2 emission per annum by adopting solar lantern instead of conventional practice followed during power cut. Therefore, solar lanterns have been introduced as energy related intervention in grid area. The Edison bulb consumes more energy and fluorescent CFL bulbs are more efficient in using energy. Again, about 65% of electricity in India is generated from thermal power, which is also a source of GHGs and pollution. Use of 15 watt CFL bulbs will reduce about 89 kg CO2 emission by substituting 100 watt Edison bulb with same or more lighting intensity. Villagers can use the available electricity more efficiently and
participate in carbon emission reduction activities through CFL bulbs. Therefore, CFL bulb was introduced as important intervention in project grid area. 38 solar lanterns and 112 CFL bulbs were distributed as carbon emission reduction interventions. The carbon emission reduction from these interventions would be 24 + CO₂ equivalent/year. On an average Rs. 840 per annum reduction in electricity bill per family was observed by using CFL bulb instead of Edison bulb in the grid area. Kerosene consumption reduced by 18 litre per annum per family with the use of Solar lantern.

A 3 day training programme on “Climate smart agriculture practices and carbon finance” for executive members was organized to provide knowledge to adapt to climate change and to achieve positive carbon balance in grid area. Another four day training programme on “Society management” was organized for executive members of the project with help of OUTREACH, Bangalore, and different organizations (NABARD, Assistant Registrar, DHO and Uttarakhand Dairy Development Board) in Almora to look over the carbon trading issue later.

2.5.4.3. Bio-prospecting of Genes and Allele Mining for Drought Tolerance

Screening of rice (Oryza sativa) genotypes for cold tolerance

A field experiment was conducted to screen 73 rice genotypes for drought stress at VIPKAS farm during kharif 2012. Three sets (irrigated, rainfed and late sown /cold) of sowing were done involving 73 genotypes with two replications for each set.

Cold stress was recorded during grain filling stage and the physiological observations like chlorophyll content, carotenoid content, photosystem II (PS II) and Fv/Fm were recorded in both normal and late sown cold stressed field. Under cold stress condition there was a significant decrease in all the aforesaid physiological parameters. Chlorophyll ‘a’ content, chlorophyll ‘b’ content, total chlorophyll content and total carotenoid content photosystem II (PS II) and Fv/ Fm were found to be reduced by 35.3, 38.6, 36.0, 12.9, 39.0 and 14.4, respectively, under cold stress condition compared to that of normal sown condition. Significant decline in percent sterility of grain was also recorded under cold compared to ambient condition (Fig. 2.43). IRCTN-91-94, IR 5941-23, Sinoatsu, RCPI 1-2C was recorded with better fertility compared to other genotypes and this could be due its reproductive tolerance to cold stress.

![Fruit plantation in grid area](image1)

![Variability parameters for grain sterility in 73 rice genotypes under irrigated and cold stress condition](image2)
Agro-morphological characters of rice genotype:
Data was recorded on seedling vigour, leaf blast, days to 50% flowering, panicle exertion, plant height, effective tillers, panicle length, panicle weight, spikelet fertility and sterility percentage, hundred grain weight, grain yield per plant and harvest index. The mean values of various traits were used for estimation of variability parameters. Considerable variability was observed for most of the characters except seedling vigour, leaf blast and panicle exertion. Under cold stress condition there was a significant decrease in all the physiological parameters. Chlorophyll 'a' content, chlorophyll 'b' content, total chlorophyll content and total carotenoid content, were found to be reduced by 48.92, 47.01, 48.62 and 32.66%, respectively under cold stress condition compared to that of normal sown environment condition. Chlorophyll stability index was recorded as 35.8%. A set of 25 genotypes viz., VLD 61, VLD 62, VLD 65, VLD 82, VLD 86, VLD 86, VLD 85, VLD 154, VLD 82, VLD 206, VLD 208, VLD Bio97, RB2, RB3, RB4, RB5, RB6, RB7, RB8, RB9, Basmati 370, Pusa Sugandha, Pusa Sugandha 5, Pusa Sugandh 3, TP 369 and Pusa Basmati 1 were evaluated for their potential for callus induction, regeneration and plant transformation. Four different regeneration media were evaluated to find proper regeneration media. MS based media with different combinations Kinetin, NAA and IAA were evaluated for the regeneration potential of the genotypes. Five genotypes viz., VL Dhan 206, VL Dhan 82, VL Dhan 86, VL Dhan 65 and VL Dhan Bio97 were found promising for their regeneration potential. More than 200 plants for different genotypes have been regenerated and transferred to soil. Twenty five plants came to flowering and maturity. The plants were observed for their agronomic traits and the seeds were harvested from these plants.

Screening of diverse maize (Zea mays) genotypes for drought tolerance: A field experiment is being conducted to screen 87 diverse maize genotypes for drought stress at VPKAS farm during khurif 2012. Two sets of sowing were done in RBD and irrigation was provided to one set (87 genotypes) and rain fed condition was maintained for another set (87 genotypes). Drought stress was recorded during reproductive stage and the photosystem II efficiency was recorded in both irrigated and drought field. Twenty five percent reduction in photosystem II efficiency was recorded in drought stress compared to irrigated plants. MGVD-38, MGVD-10 and V-393 were found with better photosystem II efficiency (Fig. 2.44).

2.5.5. AICR Projects

2.5.5.1 Post Harvest Technology for Value Addition and Marketing of Agricultural Produce
Design & development of prototype of medium capacity millet dehuller

A aspirator type single phase 2 hp electric motor driven millet dehuller was designed & prototype developed for threshing & de-husking of barnyard, proso, kodo, little & foxtail millets. The machine was tested for de-husking of barnyard millet at different moisture content of
Test results of machine

<table>
<thead>
<tr>
<th>M.C. of grain, %</th>
<th>Clearance, mm</th>
<th>RPM of cylinder, No.</th>
<th>Dehusking capacity, kg/h</th>
<th>Dehusking efficiency, %</th>
<th>No. of Pass</th>
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<tbody>
<tr>
<td>12</td>
<td>3</td>
<td>1000</td>
<td>20</td>
<td>99</td>
<td>Two</td>
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<tr>
<td>13</td>
<td>3</td>
<td>900</td>
<td>16</td>
<td>98</td>
<td>Two</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>1000</td>
<td>20</td>
<td>99</td>
<td>Two</td>
</tr>
</tbody>
</table>

grain, cylinder rpm and clearance. The highest dehusking capacity 20 kg/h and efficiency of 99% was observed at 1100 rpm and at 10% moisture content in two passes.

2.5.5.2 Use of Plastics in Agriculture Particularly under Protected Condition, Water Harvesting and Packaging

Development of improved aquaculture system in mid hills

Silver carp (Hypophthalmichthys molitrix), Grass carp (Ctenopharyngodon idella) and Common carp (Cyprinus carpio) have been stocked in the tanks at 2.5 fingerlings per m² of water in the ratio of 30:40:30 for Silver carp, Grass carp and Common carp. The survival rate is about 60 percent. Smooth diurnal fluctuation of temperature in poly tanks has been observed which favours the growth of the fish. The total plant volume varied from 1.6-3.2 ml/50 litre in different experimental ponds with maximum in polityanks and minimum in cemented tanks due to the higher temperature. Therefore, growth of fish is found better in the poly tanks in comparison to cement and earthen tanks due to the advantage of comparatively higher water temperature. There is 12.6, 10.6 and 9.4 times growth in length and 232.8, 779.2 and 311.5 times growth in weight as compared to initial size for Silver carp, Grass carp and common carp, respectively. Physico-chemical parameters in the different poly tanks, water temperature (°C), diurnal fluctuation in water temperature (°C), growth performance of different fish species in the poly tanks were observed (Fig. 2.45). The pH varied in the range of 7.2-8.3, dissolved oxygen varied in the range of 6.8-8.9 mg/l and CO₂ varied in the range of 1.1-1.4 mg/l. Minimum water temperature was observed in January and maximum in July-August in different types of tanks (Fig. 2.46).

Fig. 2.45: Poly tanks used for fish stock and data monitoring

Fig. 2.46: Temperature variation in different types of tanks

Functional and economic evaluation of polityanks and polyhouses used for supplemental irrigation

Primary data from 50 farmers were collected and analyzed for the poly tanks, poly houses and MIS systems installed in Dubkhad, Doonagiri and Bhagratola areas for functional and economic evaluation. 20 farmers having poly tanks with poly houses without MIS, 10 farmers having poly houses and poly tanks with MIS and 20 farmers cultivating under control conditions were selected. The average size of the poly tanks was 37.6 m² and poly house was 68.9 m². Only 17% area was irrigated in case of farmers having poly tanks and poly houses, 26 percent area was irrigated by the farmers having MIS system showing about 52% increase in area under irrigation. The B:C ratio for farmers having poly houses and poly tanks...
2.5.6. Application of Microorganisms in Agriculture and Allied Sectors (AMAAAS)

2.5.6.1. Development of a Bacterial Consortium to Alleviate Cold Stress

Effect of cold tolerant plant growth promoting bacterial consortia to enhance chilling tolerance, growth and productivity of wheat

Cold tolerant Pseudomonad strains were evaluated for intracellular free amino acid concentration at ambient (28°C) and low temperature (4°C) conditions. HPLC chromagrams for 17 tested amino acids in the intracellular extract of Pseudomonad cells revealed marked variation at growth temperature of 4 and 28°C. At low temperature (4°C) all strains showed increase in aspartic (1.3 to 3.0 fold) and prolinc (1.1 to 2.8 fold) amino acids content. In order to set the optimal and threshold stress (cold condition) temperature for the growth of Pseudomonads strain, an Arrhenius plot was made by expressing log of the specific growth rate constant μ (per hour) against the reciprocal of absolute temperature (K). The plot was linear from 30 to 7°C (the normal growth temperature range), and at temperatures below 7°C the slope decreased sharply. Single inoculation of cold tolerant bacteria Pseudomonas putida PBRs5 and Pseudomonas sp strain NARs9 enhanced lentil (VI. Masour 514) yield by 18.9 and 16.9%, respectively, over uninoculated control (12.3 q/ha) in field conditions. Inoculation with cold tolerant Pseudomonads significantly enhanced lentil Fe (0.77 to 2.37 fold) and Zn content (1.08 to 1.23 fold). Bacterization with P putida PGR44 recorded maximum Fe and Zn content (2.37 and 1.23 fold, respectively) followed by Pseudomonas sp strain PPERs23 (1.87 and 1.18 fold, respectively) as compared to uninoculated control (497.1 and 102.5 ppm, respectively). Bacterization with cold tolerant bacterial consortia significantly (P < 0.05) enhanced percent N (1.16 to 1.69 fold), P (0.78 to 1.04 fold), K (1.94 to 2.51 fold) content, and decreased Na+/K+ ratio in wheat (YL Cehun 804) at final harvesting as compared to nonbacterized control under field condition. Under field conditions three bacterial consortium C4, C7 and C5 significantly enhanced wheat (YL Cehun 804) yield by 7.6, 6.5 and 4.3% respectively, over uninoculated control (3670 kg/ha).

2.5.6.2. Development of a Cold Tolerant Phosphate Solubilizing Bacterial Inoculant

Effect of cold tolerant ‘P’ solubilizing bacterial consortia to enhance P uptake, growth and productivity of wheat

Fourteen ‘P’ solubilizing bacterial strains were screened for phosphate activity but none of the strains was positive for phosphatase activity whereas, five strains showed positive reaction in phytase plate assay. Pseudomonas frag CS11RH1 recorded maximum zone of solubilization (1mm radius) on sodium phytate plate followed by P. putida PB26P1(2) (0.8mm radius) after 48 hrs of incubation at 28°C. Pseudomonas sp. CS11RPI produced four times more acid phytase (0.106 μ ml⁻¹ sec⁻¹) as compared to alkaline phytase (0.024 μ ml⁻¹ sec⁻¹) after 72 hrs of incubation. The glucose dehydrogenase enzyme production was detected in live cold tolerant ‘P’ solubilizing Pseudomonas strain, under in-vitro plate assay, the purple halo around the colony confirms the diffusion of both enzyme in the medium. P. frag CS11RH1 and Pseudomonas sp. CS11RPI revealed specific glucose dehydrogenase (GDIH) activities 29.4 and 24.7 Umg⁻¹ of protein, respectively (Fig. 2.4). In field conditions, inoculation with bacterial consortia enhanced percent ‘P’ content of wheat plants which ranged from 1.1 to 1.8 fold, except C3. Consortium C1 recorded maximum P5 (1.8 fold) followed by C2 (1.5 fold) over the uninoculated control (0.28%). Bacterization with bacterial consortium significantly enhanced wheat grain iron content (1.13 to 1.85 fold). Inoculation with C7 recorded maximum iron content (1.85 fold) followed by C1 (1.80 fold) as compared to uninoculated control (42.0ppm). Bacterization with cold tolerant ‘P’ solubilizing bacterial consortia significantly (P < 0.05) enhanced the percent Fe (1.16 to 1.69 fold), P (0.78 to 1.04 fold), K (1.94 to 2.51 fold) content, and decreased Na+/K+ ratio in wheat (YL Cehun 804) at final harvesting as compared to nonbacterized control under field condition. Under field conditions three bacterial consortium C4, C7 and C5 significantly enhanced wheat (YL Cehun 804) yield by 7.6, 6.5 and 4.3% respectively, over uninoculated control (3670 kg/ha).
consortium C3 (PR2RP1 (2), NS12RH2 (1), CS11RH4) enhanced wheat yield by 22.5% followed by C1 (CS11RH1, PR2RP1 (2), NS12RH2 (1)) (17.9%) over uninoculated control (31.2q/ha) under field conditions (Fig. 2.48).

Fig. 2.48: Glucose dehydrogenase (gldh) enzyme production (purple zone) by elite cold tolerant PR solubilizing Pseudomonads after 22 hrs incubation at 28°C

[PR2RP1, CS11RH1, PR2RP1, NS12RH2, CS11RH4, PR2RP1, PR2RP1, NS12RH2]

2.5.7 DUS Project

2.5.7.1. DUS Project on Maize, Soybean and French-bean

Twenty-one maize inbreds, 14 hybrids and 6 composites were characterized for 26 DUS traits. Four varieties of French-bean (two farmers’ varieties - Safed Sawant and Safed Jhulo Sawant) and two VPKAS varieties (VL65, VR 125) were characterized for 21 DUS traits as per national test guidelines. Ninety one released and notified varieties of soybean from different state Agricultural Universities/ Institutes were maintained by growing in the field. For maintaining the purity of these varieties, single true to type plants selected from last year harvest were sown in a single row and harvested separately. The seeds of these varieties are being maintained at VPKAS, Almora.

A sensitization workshop on “Protection of Plant Varieties and Farmers’ Rights Act (PPV&FRA), 2001” was organized by VPKAS, Almora, for the hill farmers at DCFR regional station, Champaner on February 16, 2013. The main purpose of organizing this workshop was to create awareness among hill farmers on various issues related to PPV&FRA, 2001.

2.5.8 Farmers Participatory Action Research Programme of Central Water Commission

2.5.8.1. Demonstration of Storage and Application System for Efficient Water Utilization in Major Crops of Uttarakhand Hills through Participatory Approach – 2nd Phase

During the reporting period, 38 multilayered cross laminated film lined tanks (total capacity 1006 m³) were dug with farmers participation in different villages of Almora and Pithoragarh districts. Farmers gained a profit of Rs. 5000 per nari (200 sq m) per year by using MDS for off season vegetables along with 80% reduction in labor. Besides, they could save 75% water as compared to conventional methods. Among various demonstrations, an increase of 72.4% was recorded in yield of QBF 9 maize variety. Among wheat demonstrations in irrigated conditions, VL Gehun 907, VL Gehun 802 and VL Gehun 829 gave 27.78, 8.6 and 6.3%, respectively higher yield as compared to farmer practice. However, under
rainfed condition, the demonstration yield was 27.36% superior to local variety. VI. 62 variety of rice recorded 31.87% higher yield than the local cultivar of rice.

Farmer's participation for the development of water structure was the main feature of the programme. Popular Non Government Organisations (NGOs) were also included in the programme for site selection, farmer's selection during the implementation programme and for horizontal spread and follow up action after the programme, for its sustainability. Horizontal expansion has been started in Gangothri block of Pithoragarh district by HGVs (NGO). Many farmers have expressed their gratitude through phone calls and letters to the institute.
MISCELLANEOUS ACTIVITIES
TECHNOLOGY ASSESSED
AND TRANSFERRED

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

3.1. KVK Chinyalisaur

3.1.1. Trainings

Krishi Vigyan Kendra (VPKAS), Chinyalisaur, Uttarkashi has offered 114 training courses for the practicing farmers, farm women, rural youth, extension functionaries and sponsored training on various topics in the disciplines of crop improvement, horticulture, plant protection, animal science, agriculture extension and Home Science during 2012-13 with an objective to improve skills and expertise of under privileged farmers through improvement in agriculture production and allied enterprises. Total 2657 participants (1576 male & 1081 female) attended the training programmes (Table 3.1.1).

Table 3.1.1: Training programme conducted by KVK, Chinyalisaur (including sponsored)

<table>
<thead>
<tr>
<th>Discipline</th>
<th>No. of courses</th>
<th>No. of participants</th>
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<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Horticulture</td>
<td>30</td>
<td>499</td>
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<tr>
<td>Animal Science</td>
<td>26</td>
<td>301</td>
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<td>Plant Protection</td>
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<td>Home Science</td>
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<tr>
<td>Agriculture Extension</td>
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<td>90</td>
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<tr>
<td>Sponsored training</td>
<td>15</td>
<td>191</td>
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<tr>
<td>Total</td>
<td>114</td>
<td>1576</td>
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3.1.2. Front Line Demonstration

Front line demonstration on oilseeds, pulses, other crops and livestock were conducted at the farmer's field in an area of 41.00 ha. FLD on poultry evaluation of breed and application of
mineral mixture to buffaloes were also conducted at farmer's field. A total of 853 farmers and 580 animals were covered under the programme. These farmers were supported with high quality seed material of newly released varieties and other technologies. They were also provided with the technological input through effective field oriented training programmes. There was wide variation in the yield of crops, as compared with the yield obtained at farmers field with their local practices. Details of demonstrations are presented in Table 3.1.2.

Table 3.1.2. Performance of Frontline demonstrations

<table>
<thead>
<tr>
<th>Crop</th>
<th>Technology</th>
<th>No. of Farmers</th>
<th>Area (ha)</th>
<th>Yield (kg/ha)</th>
<th>% Increase</th>
<th>Economics of demonstration</th>
<th>Economics of crops</th>
<th>BCR (Y)</th>
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<th>% Increase</th>
<th>Economics of demonstration</th>
<th>Economics of crops</th>
<th>BCR (Y)</th>
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<th>BCR (Y)</th>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Crop</th>
<th>Technology</th>
<th>No. of Farmers</th>
<th>Area (ha)</th>
<th>Yield (kg/ha)</th>
<th>% Increase</th>
<th>Economics of demonstration</th>
<th>Economics of crops</th>
<th>BCR (Y)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crop</th>
<th>Technology</th>
<th>No. of Farmers</th>
<th>Area (ha)</th>
<th>Yield (kg/ha)</th>
<th>% Increase</th>
<th>Economics of demonstration</th>
<th>Economics of crops</th>
<th>BCR (Y)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>
3.1.3. Technology Assessment (On-farm Trials)

On farm trials on latest technologies viz: management of scab disease in apple orchard, management of wilt disease of pigeon pea (*Pisum sativum* L), effect of calcium ammonium nitrate (CAN) on growth and yield of apple (*Malus domestica* Borkh,), weed management in young apple orchards, evaluation of growth and yield of late sown varieties of wheat under Mid Hill condition, introduction of guinea fowl and assessment of strategic supplementation for pregnant doe were conducted at farmers field with an objective to develop location specific sustainable technology during the year 2012-13.

<table>
<thead>
<tr>
<th>Thematic areas</th>
<th>Crop</th>
<th>Name of the technology assessed</th>
<th>No. of trials</th>
<th>No. of farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated Disease Management</td>
<td>Apple</td>
<td>Management of scab disease in apple orchard</td>
<td>05</td>
<td>05</td>
</tr>
<tr>
<td></td>
<td>Pigeon Pea</td>
<td>Management of wilt disease of pigeon pea (<em>Pisum sativum</em> L)</td>
<td>05</td>
<td>05</td>
</tr>
<tr>
<td>Integrated Nutrient Management</td>
<td>Apple</td>
<td>Effect of Calcium Ammonium Nitrate (CAN) on growth and yield of apple (<em>Malus domestica</em> Borkh)</td>
<td>05</td>
<td>05</td>
</tr>
<tr>
<td>Weed Management</td>
<td>Apple</td>
<td>Weed Management in young apple orchards</td>
<td>05</td>
<td>05</td>
</tr>
<tr>
<td>Crop management</td>
<td>Wheat</td>
<td>Evaluation on growth and yield of late sown varieties of wheat under Mid Hill condition</td>
<td>05</td>
<td>05</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

Table 3.1.4. Summary of technologies assessed under livestock by KVKs

<table>
<thead>
<tr>
<th>Thematic areas</th>
<th>Name of the livestock enterprise</th>
<th>Name of the technology assessed</th>
<th>No. of trials</th>
<th>No. of farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction of Insect</td>
<td>Poultry</td>
<td>Introduction of Guinea Fowl</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Semi intensive goat based, sheep and goat rearing</td>
<td>Sheep and goats</td>
<td>Assessment of strategic supplementation for pregnant doe</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>35</td>
<td>35</td>
</tr>
</tbody>
</table>
### 3.1.4 Seed/ Seedling Production

#### Table 3.1.5. Seed Production at KVK farm

<table>
<thead>
<tr>
<th>Name of the crop</th>
<th>Name of the variety</th>
<th>Quantity of seed (q)</th>
<th>Value (Rs.)</th>
<th>Number of farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>VL Gehum 802, 829</td>
<td>32.50</td>
<td>81,250.00</td>
<td>234</td>
</tr>
<tr>
<td>Amaranth</td>
<td>VL Chux 44</td>
<td>0.21</td>
<td>1470.00</td>
<td>15</td>
</tr>
<tr>
<td>Muster</td>
<td>Vivek Sankal 35</td>
<td>3.70</td>
<td>9250.00</td>
<td>78</td>
</tr>
<tr>
<td>Soybean</td>
<td>YLS 47, 63</td>
<td>3.27</td>
<td>14715.00</td>
<td>134</td>
</tr>
<tr>
<td>Lahi/Rye</td>
<td>Harbalan</td>
<td>0.02</td>
<td>1000.00</td>
<td>20</td>
</tr>
<tr>
<td>Pigeon pea</td>
<td>VL Arhar 1</td>
<td>1.39</td>
<td>10115.00</td>
<td>124</td>
</tr>
<tr>
<td>Horse gram</td>
<td>VLG 8</td>
<td>1.04</td>
<td>9360.00</td>
<td>56</td>
</tr>
<tr>
<td>Lentil</td>
<td>VL Maasor 100, 125</td>
<td>1.26</td>
<td>3780.00</td>
<td>85</td>
</tr>
<tr>
<td>Field pea</td>
<td>VL Mante 42</td>
<td>0.37</td>
<td>3430.00</td>
<td>34</td>
</tr>
<tr>
<td>Okra</td>
<td>VL Bhendi 3</td>
<td>0.90</td>
<td>16200.00</td>
<td>92</td>
</tr>
<tr>
<td>Tobacco</td>
<td>VLT 4</td>
<td>0.083</td>
<td>420.00</td>
<td>20</td>
</tr>
<tr>
<td>French bean</td>
<td>BL Buni Ben 2</td>
<td>0.04</td>
<td>600.00</td>
<td>10</td>
</tr>
<tr>
<td>Garden pea</td>
<td>Vivek Matar 10, 11</td>
<td>1.17</td>
<td>12230.00</td>
<td>65</td>
</tr>
<tr>
<td>Onion</td>
<td>VL pyaz 3</td>
<td>0.894</td>
<td>3208.00</td>
<td>23</td>
</tr>
<tr>
<td>Onion bulb</td>
<td>VL pyaz 3</td>
<td>2.91</td>
<td><strong>Sown in</strong></td>
<td></td>
</tr>
<tr>
<td>Radish</td>
<td>Pusha chorki</td>
<td>0.2</td>
<td>150.00</td>
<td>14</td>
</tr>
<tr>
<td>Pudik</td>
<td>All green</td>
<td>0.22</td>
<td>3188.00</td>
<td>15</td>
</tr>
<tr>
<td>Cucumber</td>
<td>Pusa Radhir</td>
<td>0.10</td>
<td>4000.00</td>
<td>12</td>
</tr>
<tr>
<td>Mushroom</td>
<td>Spawn: Dhingri</td>
<td>1.0</td>
<td>7000.00</td>
<td>63</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>30.50</strong></td>
<td><strong>181428.00</strong></td>
<td><strong>1029</strong></td>
</tr>
</tbody>
</table>

#### Table 3.1.6 Production of planting materials

<table>
<thead>
<tr>
<th>Crop</th>
<th>Name of the crop</th>
<th>Name of the variety</th>
<th>Name of the hybrid</th>
<th>Number</th>
<th>Value (Rs.)</th>
<th>Number of farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vegetable seedlings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomato</td>
<td>VLT-4</td>
<td>Maliahu, Himawa</td>
<td>21120</td>
<td>8645</td>
<td>106</td>
<td></td>
</tr>
<tr>
<td>Capsicum</td>
<td>PRC-1, California</td>
<td>Wonder</td>
<td>18550</td>
<td>7420</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>Rye</td>
<td>Harbalan</td>
<td></td>
<td>2250</td>
<td>430</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Rangoli</td>
<td>V L Pico-3</td>
<td>Choochhoo, Sarolena</td>
<td>2150</td>
<td>880</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Onion</td>
<td>NS 22</td>
<td>Pudla</td>
<td>30000</td>
<td>6000</td>
<td>176</td>
<td></td>
</tr>
<tr>
<td>Cabbage</td>
<td>NS 22</td>
<td>Paedla</td>
<td>7900</td>
<td>1580</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Cauliflower</td>
<td></td>
<td></td>
<td>7500</td>
<td>1580</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>89420</strong></td>
<td><strong>262355</strong></td>
<td><strong>492</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Forage crop seedlings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid Napier</td>
<td>CO 3</td>
<td></td>
<td>68000</td>
<td>17000</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td></td>
<td></td>
<td><strong>157470</strong></td>
<td><strong>432355</strong></td>
<td><strong>559</strong></td>
<td></td>
</tr>
</tbody>
</table>

*Annual Report 2012 - 2013*
Table No. 3.1.7. Production of Bio-Products

<table>
<thead>
<tr>
<th>Bio Products</th>
<th>Name of the bio-product</th>
<th>Quantity Kg</th>
<th>Value (Rs.)</th>
<th>No. of Farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bio Fertilizers</td>
<td>FYM</td>
<td>6243</td>
<td>4370.10</td>
<td>Farm use</td>
</tr>
<tr>
<td></td>
<td>Vermi compost</td>
<td>500</td>
<td>2500.00</td>
<td>Farm use</td>
</tr>
<tr>
<td></td>
<td>NADEF compost</td>
<td>260</td>
<td>1200.00</td>
<td>Farm use</td>
</tr>
<tr>
<td>Mushroom spawn</td>
<td>Mushroom spawn (T/H-google)</td>
<td>180</td>
<td>3900.00</td>
<td>02</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>9043</td>
<td>14870.10</td>
<td>02</td>
</tr>
</tbody>
</table>

Table No. 3.1.8. Production of livestock materials

<table>
<thead>
<tr>
<th>Particulars of Live stock</th>
<th>Name of the breed</th>
<th>Number</th>
<th>Value (Rs.)</th>
<th>No. of Farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy animals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cow</td>
<td>HF x Friesian</td>
<td>02</td>
<td>30000.00</td>
<td>02</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>02</td>
<td>30000.00</td>
<td>02</td>
</tr>
</tbody>
</table>

3.1.4. Other Extension Activities

The Kendra has organized 47 kisan gathries, three kisan melas, four exhibitions, live field days, 314 advisory services at the different villages of development blocks of the district, and 57 activities were covered by newspapers. Approximately 11044 farmers and 511 extension personnel were benefited by these activities.
Table 3.1.9. Other Extension Activities

<table>
<thead>
<tr>
<th>Activities</th>
<th>No. of Programmes</th>
<th>No. of Farmers</th>
<th>No. of Extension Personnel</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advisory Services</td>
<td>314</td>
<td>334</td>
<td>17</td>
<td>351</td>
</tr>
<tr>
<td>Diagnose visits</td>
<td>17</td>
<td>105</td>
<td>19</td>
<td>121</td>
</tr>
<tr>
<td>Field Day</td>
<td>05</td>
<td>373</td>
<td>-</td>
<td>373</td>
</tr>
<tr>
<td>Group discussions</td>
<td>17</td>
<td>261</td>
<td>38</td>
<td>299</td>
</tr>
<tr>
<td>Kisan Clinic</td>
<td>47</td>
<td>4256</td>
<td>256</td>
<td>5012</td>
</tr>
<tr>
<td>Film Show</td>
<td>44</td>
<td>585</td>
<td>46</td>
<td>931</td>
</tr>
<tr>
<td>Self-help groups</td>
<td>6</td>
<td>75</td>
<td>1</td>
<td>76</td>
</tr>
<tr>
<td>Kisan Mela</td>
<td>3</td>
<td>2168</td>
<td>47</td>
<td>2207</td>
</tr>
<tr>
<td>Exhibition</td>
<td>4</td>
<td>1193</td>
<td>45</td>
<td>1238</td>
</tr>
<tr>
<td>Scientists' visit to farmers field</td>
<td>156</td>
<td>432</td>
<td>23</td>
<td>455</td>
</tr>
<tr>
<td>Plant/animal health camps</td>
<td>2</td>
<td>95</td>
<td>4</td>
<td>99</td>
</tr>
<tr>
<td>Farm Science Club</td>
<td>3</td>
<td>40</td>
<td>-</td>
<td>40</td>
</tr>
<tr>
<td>Method Demonstrations</td>
<td>35</td>
<td>241</td>
<td>6</td>
<td>247</td>
</tr>
<tr>
<td>Celebration of important days</td>
<td>2</td>
<td>54</td>
<td>7</td>
<td>61</td>
</tr>
<tr>
<td>Exposure visits</td>
<td>2</td>
<td>90</td>
<td>2</td>
<td>92</td>
</tr>
<tr>
<td>Total</td>
<td>657</td>
<td>11044</td>
<td>511</td>
<td>11555</td>
</tr>
</tbody>
</table>

3.1.5. Kisan Mela and Agri exhibition

Kisan Mela and Agri exhibition was organized at Krishi Vigyan Kendra on October 30, 2012. Shri Pritam Singh Panwar, Hon'ble Minister for Urban Development, Animal Husbandry, Fisheries, and Fruit Industry, of Uttarakhand Government was the chief guest and inaugurated the event. He along with other dignitaries visited the farm and appreciated the activities. More than 26 Exhibition-cum-sale stalls were put up by various institutions/line departments and NGOs. About 900 farmers from different blocks of Uttarakashi district participated in this event. A farmer-scientist interaction meet was also organized.

3.2. KVK Bageshwar

3.2.1. Trainings

The KVK organized 70 training programmes, with 1,644 beneficiaries, for the practicing farm women, rural youth and extension functionaries on various topics including 18 sponsored training programmes (Table 3.1.10).
Table 3.1.10. Training programmes conducted

<table>
<thead>
<tr>
<th>S.No</th>
<th>Discipline</th>
<th>No. of courses</th>
<th>No. of trainers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Male</td>
</tr>
<tr>
<td>1</td>
<td>Horticulture</td>
<td>16</td>
<td>270</td>
</tr>
<tr>
<td>2</td>
<td>Livestock production and management</td>
<td>16</td>
<td>267</td>
</tr>
<tr>
<td>3</td>
<td>Home science</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Plant protection</td>
<td>5</td>
<td>56</td>
</tr>
<tr>
<td>5</td>
<td>Agricultural Extension</td>
<td>15</td>
<td>241</td>
</tr>
<tr>
<td>6</td>
<td>Sponsored training programmes</td>
<td>18</td>
<td>331</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>70</td>
<td>1188</td>
</tr>
</tbody>
</table>

3.2.2. Front Line Demonstrations

Front line demonstrations on various kharif, rabi and spring crops were conducted on 107.53 ha area which benefited 3,051 farmers. These FLDs resulted in increasing the yield from 20 to 150% in various hill crops (Table 3.1.11).

Table 3.1.11. Details of FLD conducted

<table>
<thead>
<tr>
<th>Enterprise</th>
<th>Crop</th>
<th>No of Technology Demonstrated</th>
<th>Farming situation</th>
<th>No of Farmers</th>
<th>Area (ha)</th>
<th>Yield (q/ha)</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kharif</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oilseed</td>
<td>Soybean</td>
<td>VL-Seja-47</td>
<td>Mid hills (1200-1500 MSL), Rainfed</td>
<td>23</td>
<td>1.00</td>
<td>10</td>
<td>69.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VL-Seja-03</td>
<td></td>
<td>194</td>
<td>6.2</td>
<td>19</td>
<td>60.26</td>
</tr>
<tr>
<td>Total/Avg.</td>
<td></td>
<td></td>
<td></td>
<td>217</td>
<td>7.29</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>Pulses</td>
<td>Pigeon pea</td>
<td>VL Achar 1</td>
<td>Mid hills (1200-1500 MSL), Rainfed</td>
<td>905</td>
<td>47.48</td>
<td>10</td>
<td>105 (New Introduction)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VL Galat 13</td>
<td></td>
<td>49</td>
<td>0.88</td>
<td>9</td>
<td>6.9</td>
</tr>
<tr>
<td>Total/Avg.</td>
<td></td>
<td></td>
<td></td>
<td>954</td>
<td>49.06</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Cereals</td>
<td>Paddy</td>
<td>VL Dhan-65</td>
<td>Mid hills (1200-1500 MSL), Irrigated</td>
<td>30</td>
<td>2.53</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VL Dhan 154</td>
<td></td>
<td>30</td>
<td>1.58</td>
<td>23</td>
<td>49.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VL Mutha 315</td>
<td>Mid hills (1200-1500 MSL), Rainfed</td>
<td>53</td>
<td>1.61</td>
<td>13</td>
<td>38.46</td>
</tr>
<tr>
<td>Total/Avg.</td>
<td></td>
<td></td>
<td></td>
<td>120</td>
<td>5.37</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Fodder</td>
<td>Hybrid Napier</td>
<td>Green fodder producer</td>
<td>Mid hills (1200-1500 MSL), Rainfed</td>
<td>10</td>
<td>0.42</td>
<td>20</td>
<td>150</td>
</tr>
<tr>
<td>Total/Avg.</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td>0.42</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1343</td>
<td>62.19</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Rabi Crops</td>
<td>Oilseed</td>
<td>VL Tadka 1</td>
<td>Mid hills (1200-1500 MSL), Rainfed</td>
<td>45</td>
<td>1.96</td>
<td>3.5</td>
<td>67.19</td>
</tr>
<tr>
<td>Total/Avg.</td>
<td></td>
<td></td>
<td></td>
<td>45</td>
<td>1.96</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>Pulses</td>
<td></td>
<td>VL Math 63</td>
<td>Mid hills (1200-1500 MSL), Rainfed</td>
<td>08</td>
<td>1.1</td>
<td>11</td>
<td>77.14</td>
</tr>
<tr>
<td>Lentil</td>
<td></td>
<td>VL Misai 120</td>
<td>Mid hills (1200-1500 MSL), Rainfed</td>
<td>125</td>
<td>3.6</td>
<td>12</td>
<td>50</td>
</tr>
<tr>
<td>Total/Avg.</td>
<td></td>
<td></td>
<td></td>
<td>131</td>
<td>5.6</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Cereals</td>
<td>Wheat</td>
<td>VL Gobha 616</td>
<td>Mid hills (1200-1500 MSL), Irrigated</td>
<td>19</td>
<td>0.65</td>
<td>40.00</td>
<td>43.86</td>
</tr>
<tr>
<td>Total/Avg.</td>
<td></td>
<td></td>
<td></td>
<td>19</td>
<td>0.65</td>
<td>40.00</td>
<td></td>
</tr>
</tbody>
</table>
### Table 3.1.2. FLDs on other aspects

<table>
<thead>
<tr>
<th>Category</th>
<th>Thematic area</th>
<th>Name of the technology demonstrated</th>
<th>No. of Farmer</th>
<th>Need of Units (Animal/ Poultry/ Birds, etc)</th>
<th>Major parameter</th>
<th>% change in major parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffalo</td>
<td>Animal health management</td>
<td>Disease control, animal welfare, nutrition, immunization</td>
<td>20</td>
<td>20 (1 animal/unit)</td>
<td>8.5 kg milk/unit/day</td>
<td>5.0%</td>
</tr>
<tr>
<td>Poultry</td>
<td>Income enhancement</td>
<td>Backyard poultry (Cocks)</td>
<td>20</td>
<td>28 (28 Cocks/unit)</td>
<td>77.5 kg/unit</td>
<td>66.67%</td>
</tr>
</tbody>
</table>

### 3.2.3. On-Farm trials

The following trials were conducted at farmers’ fields:

**Effect of polystyrene in mitigating weather vagaries in raising vegetable nurseries (Cabbage) (Plot size – 3m²)**

Plant population of cabbage nursery was 352 / m² under polystyrene while it was only 45 in open environment (Farmer’s practice). The B: C ratio of the technology assessed was 2.02, while farmer’s practice had B: C ratio of 0.49.

**Utilization of micro-organisms in onion (VL-Pyz-3) yield and quality enhancement (Plot size – 4.5m²)**

Onion crop grown with FYM @ 20t/ha + Azotobacter + PSB (Pseudomonas fragi) gave highest yield of 363 q/ ha that was 17.76 % higher over farmer’s practice (FYM only). The B: C ratio of technology assessed was 2.22 and for farmer’s practice, 1.90.

### 3.2.4. Seed Production/Enterprises

- Following seed material was produced at KV farm:
<table>
<thead>
<tr>
<th>Crop</th>
<th>Name of the crop</th>
<th>Name of the variety</th>
<th>Quantity of seed(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>Paddy</td>
<td>VL Dhan 154</td>
<td>2.17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VL Dhan 65</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td>Wheat</td>
<td>VL Gehun 862</td>
<td>6.83</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VL Gehun 616</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td>Maize</td>
<td>VQI 1</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>Finger Miller</td>
<td>VL Maudan 324</td>
<td>0.135</td>
</tr>
<tr>
<td>Oilseeds</td>
<td>Soybean</td>
<td>VL Soya 61</td>
<td>1.35</td>
</tr>
<tr>
<td></td>
<td>Toxix</td>
<td>VL Toxix 3</td>
<td>0.027</td>
</tr>
<tr>
<td>Pulses</td>
<td>Figece pea</td>
<td>VL Ashar 1</td>
<td>2.08</td>
</tr>
<tr>
<td></td>
<td>Horse gram</td>
<td>VL Gehun 15</td>
<td>0.525</td>
</tr>
<tr>
<td></td>
<td>Field pea</td>
<td>VL Messr 62</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td>Lintil</td>
<td>VL Maunder 126</td>
<td>1.73</td>
</tr>
<tr>
<td>Vegetables</td>
<td>Vegetable pea</td>
<td>VL Mazar 11</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td>Onion</td>
<td>VL Pizz 3</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td>Okra</td>
<td>VL Bindri 2</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>French bean</td>
<td>VL Bean 2</td>
<td>1.4</td>
</tr>
<tr>
<td>Spices</td>
<td>Guster</td>
<td>Kao de Janatin</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Total</strong></td>
<td><strong>25.467</strong></td>
</tr>
</tbody>
</table>

- Details of milk production: Total 6375.75 Liter milk was produced and sold.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Milk Production (April 2011- March 2012)</th>
<th>Rate</th>
<th>Amount (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6375.75 Liter</td>
<td>24/Liter</td>
<td>1.33,018</td>
</tr>
</tbody>
</table>

3.3. Institute Headquarters Endeavour on Transfer of Technology

3.3.1. Trainings

Thirty five training programmes were organized for the Agricultural Officers of the state and farmers on different aspects of hilly agriculture benefiting 1015 farmers.

3.3.2. Front Line Demonstrations

Maize: FLDs of seven hybrids and one composite were conducted on 25 acres at Liti and Shama village in Bageshwar district (Uttarakhand). Two field days were also organized at FLDs to provide all the information of hybrid maize cultivation to farmers.

Rice: Front Line Demonstration of released varieties viz., VL Dhan 85 and VL Dhan 65 was conducted among 97 farmers in 8.0 ha area of 10 villages of Almora and Bageshwar District. In these areas, the overall yield advantage of VL Dhan 85 and VL Dhan 65 was 34.75 and 38.06 per cent, respectively over local checks.

Wheat: During 2011-12, wheat FLDs have been conducted in 2.04 ha area involving 15 farmers of Nainital and Almora districts. The high
yielding variety namely HS 507 was used. The improved variety HS 507 recorded an average yield of 4,083 kg/ha, which was 32.45% higher than the local check.

**Small millets**: Three improved varieties of finger millet covering 10 ha and one variety of barnyard millet covering 5 ha area were demonstrated in Almora, Champawat and Pithoragarh districts. Three field days were conducted at three different places of demonstration. The average grain yield improvement was 26.2% and 21.33% in finger millet and barnyard millet, respectively.

**Horsegram**: Front line demonstration on improved cultivars was conducted among 53 farmers in 11 villages in Bageshwar district covering an area of 2.72 ha. Both the improved cultivars, viz., VL. Gahtar 15 and VL. Gahtar 19 showed significant yield advantage (20.12 and 26.24%, respectively) over local check in all the villages.

**Pigeon pea**: Two hundred on farm trials were conducted in 16 villages of Bageshwar district. The yields recorded in these villages ranged from 803 to 1500 kg/ha with a mean of 1145.1 kg/ha.

**Soybeans**: Front line demonstration on improved cultivars was conducted among 38 farmers in 13 villages of Bageshwar, Almora and Pithoragarh districts covering an area of 1.43 ha. The improved cultivars, VL. Soybean 63, VL. Soybean 47 and VL. Bhat 65 showed significant yield advantage (33.02, 29.71 and 184.6%, respectively) over local check in all the villages.

3.3.3. **Krishi Samridhi**

The institute sponsored programme aims at providing the farmers with information on topical issues in an interactive format. The programme is broadcast every Sunday at 6 pm from All India Radio, Almora.

3.3.4. **Krishak helpline**

In order to provide answers to farmers queries, the institute offers a toll-free telephone (1800 180 2311) service to the clientele.

3.4. **Participation in Fair/ Melas**

- Dr. B.M. Pandey, Dr. M.L. Roy and Mr. Shiv Singh participated in *Pusa Krishi Vigyan Mela*, IARI, New Delhi, March 6-8.
- Mr. Athrequa G.A., Dr. K.K. Misra, Dr. Pratibha Joshi and Mr. M.C. Pant participated in *Kisan Mela* at GBPIUA&T, Pantnagar, March 8-11.
4 EDUCATION AND TRAININGS

4.1 Training of Institute's Staff at Other Institutes

The following institute personnel were deputed for different HRD programmes during 2012-13.

<table>
<thead>
<tr>
<th>Duration</th>
<th>Participant</th>
<th>Topic</th>
<th>Venue</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 25-30</td>
<td>Dr. J. Stanley and Mr. ARNS Subbanna</td>
<td>Taxonomy of Pollinators</td>
<td>GBPIHED, Kest-Katrnámú, Almora</td>
</tr>
<tr>
<td>September 26-21</td>
<td>Mr. Pankaj Nathual</td>
<td>Preparation of Agromet Advisory Services and use of weather data</td>
<td>CRIDA, Hyderabad</td>
</tr>
<tr>
<td>October 15</td>
<td>Dr. P.K. Misra</td>
<td>Use of modules in ICAR web portal</td>
<td>KAB-II, Pusa, New Delhi</td>
</tr>
<tr>
<td>November 5-9</td>
<td>Dr. P.K. Misra</td>
<td>Exposure visit to scientific laboratories/ institutions in South Africa under the scheme &quot;National Programme for Training of Scientist &amp; Technologists working in Govt. sector&quot; by DST, Government of India</td>
<td>Cape town, Johannesburg</td>
</tr>
<tr>
<td>November 19-23</td>
<td>Dr. R.P. Yadav</td>
<td>Climate Change and Carbon Mitigation (DST sponsored)</td>
<td>ICFRR, Dehradun</td>
</tr>
<tr>
<td>November 20-25</td>
<td>Dr. D.C. Sahoo</td>
<td>Scientific Report Writing and Presentation</td>
<td>NAARM, Hyderbad</td>
</tr>
<tr>
<td>December 3-7</td>
<td>Dr. J.K. Bisht</td>
<td>MUP Training</td>
<td>NAARM, Hyderbad</td>
</tr>
<tr>
<td>January 7-19</td>
<td>Dr. P.K. Mishra, E.M. Pandey, K.K. Mishra, N. Saini, Sher Singh and Satyvir Singh</td>
<td>Refresher Course on Agricultural Research management</td>
<td>NAARM, Hyderbad</td>
</tr>
<tr>
<td>January 22-February 11</td>
<td>Dr. Chandrasekaran C.</td>
<td>Managing Plant-Microbe Interactions for the Management of Soil Born Plant pathogens</td>
<td>GBPUAT, Patnaigur</td>
</tr>
<tr>
<td>March 11-12</td>
<td>Dr. R. K. Tezari</td>
<td>Transferable technologies for fodder production</td>
<td>IGFR, Jhansi</td>
</tr>
</tbody>
</table>
Institute Jhanka was awarded First Prize in Republic Day Parade, 2013 at Almora.

Institute exhibition stall was awarded “Best Stall Award” in I USA Krish Vigyan Mela 2013, IAHI, New Delhi (March 6-8).

Mr. Pankaj Nautiyal, SMS (Horticulture) received the Young Scientist Award for presentation entitled “Study on women participation in high hill farming system with reference to drudgery reduction through mechanization” in 7th USSTC, 21-23 November 2012 at Dehradun.

Dr. S.P. Singh, SMS (Plant Protection) received the Young Scientist Award for presentation entitled “Practicability analysis and economics of using different substrates for oyster mushroom Pleurotus djamor and Pleurotus sajor-caju by women self help group in district Uttarkashi,” in 7th USSTC, 21-23 November 2012 at Dehradun.

Dr. P.K. Mishra and co-authors received the Best Publication Award 2012 for research paper “Alleviation of cold-stress in inoculated wheat (Tricicum aestivum) seedlings with psychrotolerant pseudomonads from N-W Himalayas (Archives of Microbiology 193: 497-513) given by the Society for Advancement of Human and Nature (SAHNA).

Dr. N.K. Hedau received Fellow Award of Indian Society of Horticultural Research & Development, Uttarakhand.

Dr. Anubhuti Sharma, Senior Scientist and Ms. Manisha, SMS (Home Science), bagged runners up trophy (second position) in badminton in the zonal sports meet at IISR (ICAR), Lucknow. Besides, Mr. Gopal and Ms. Manisha also got bronze medal in 200 meter and 100 meter race, respectively. Dr. D.C. Sahoo, Senior Scientist secured the second position in Chess.
6

LINKAGES AND COLLABORATIONS

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

6.1 Local Institution in the Area
- C.B. Pant Institute of Himalayan Environment and Development (GPIHEID), Kosi-atamral, Almora.
- Defence Institute of Bio-Energy Resources (DIBER), Haldwani.

6.2. National Institutes and Agricultural Universities
- Indian Agricultural Research Institute (IARI), New Delhi.
- Indian Institute of Pulses Research (IIPR), Kanpur.
- Central Rice Research Institute (CRRI), Cuttack.
- Directorate of Wheat Research (DWR), Karnal.
- Directorate of Rice Research (DRR), Hyderabad.
- Directorate of Maize Research (DMR), New Delhi.
- G.B. Pant University of Agriculture & Technology (GBPUAT), Pantnagar.
- C.S.K. Himachal Pradesh Krishi Vidyalaya (CSKHPKV), Palampur.
- Y.S. Parmar University of Horticulture and Forestry (YSPUHF), Solan.
- Sher-e-Kashmir University of Agriculture Science & Technology (SKUAST-K), Srinagar.
- Sher-e-Kashmir University of Agriculture Science & Technology (SKUAST-J), Jammu.

6.3. International Organizations
- IRRI, Manila, Philippines.
- CIMMYT, Mexico.
- ICRIAT, Hyderabad, India.
- ICARDA, Syria.

6.4. Extension & Development Agencies
- State Department of Agriculture, Uttarakhand.
- Indian Farmers Fertilizer Cooperative (IFFCO).
- National Agricultural Bank for Rural Development (NABARD).
- Mahindra & Mahindra Subh Labh Services.
- Private agencies.
- NGOs.
7.1. Samaj samiti of the institute

7.2. Quinquennial Review Team (2007-12)
Chairman - Dr. S.K. Sharma, Vice Chancellor, CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur

Members - Dr. C.L. Acharya, Ex-Director, IISS, Bhopal; Dr. S.S. Singh, Ex-Project Director, DWR, Karnal; Dr. S.K. Pande, Ex-Director, CPRI, Shimla; Dr. D.C. Upadhyay, Ex-Principal Scientist, Crop Physiology, IARI, New Delhi; Dr. K.V. Bhat, In-charge, DNA Fingerprinting, NBPGA, New Delhi.

Member Secretary - Dr. J.K. Bish, Principal Scientist & Head, Crop Production

7.3. Research Advisory Committee (RAC)
Chairman - Dr. B. Mishra, Former Vice Chancellor, Sher-e-Kashmir University of Agriculture Sciences and Technology, Jammu

Members - Dr. R.P. Dua, Assistant Director General (FFC), ICAR; Dr. H.S. Sen, Former Director, CHAUAF; Dr. Sain Das, Former Director, DMR; Dr. R.A. Singh, Former Prof. & Head, Plant Pathology, GBPUA&T, Pantnagar; Dr. M.C. Nautiyal, Former Dean, College of Forestry, GBPUA&T, Ranichauri Campus; Prof. T.C. Thakur, National Professor, Deptt. of Farm Machinery and Power Engineering, GBPUA&T, Pantnagar; Dr. I.D. Tyagi, Former Professor, CSAU A&T, Kanpur; Shri Vikram Singh Negi (farmer's representative); Shri Jayendra Singh Rana (farmer's representative).

Member Secretary - Dr. J.K. Bish, Principal Scientist & Head, Crop Production

7.4. Institute Management Committee (IMC)
Chairman - Director

Members - Assistant Director General (PPC), Director, Agriculture HP; Director Research, GBPUA&T, Pantnagar; Joint Director, Agriculture, UK; Chief Finance and Accounts Officer, TVRI, Bareilly; Dr. J.K. Bish, Principal Scientist; Dr. (Mrs.) P.K. Sahu, Principal Scientist, DCFR, Bhatial; Dr. B.L. Atri, Principal Scientist and Head, CGTH Regional Station, Mukteshwar; Dr. K. S. Negi, Principal Scientist, NBPGF Regional Station, Bhowali; Shri Vikram Singh Negi; Shri Jayendra Singh Rana.

Member Secretary - Administrative Officer

7.5. Institute Research Council
Chairman - Director

Members - All the Scientists of VPKAS, Almora
Member Secretary - Coordinator (PME Cell)

7.6. Institute Joint Council
Chairman - Director

Members (Official side) - Mrs. Gyanainder Singh, Senior Scientist; N. Saini, Senior Scientist; Mr. A.R.N.S. Subraman, Scientist; Dr. K. Jeevendran,
Scientist; Administrative Officer and Finance & Accounts Officer

Members (Staff side) – Mr. Bahadur Ram, Assistant Administrative Officer; Mr. Santosh Dafaut, Assistant; Mr. Davendra Lal, T-3; Mr. Jiwani Singh Bisht, T-3 (up to Nov 1); Mr. Vishnu Dutt Pandey, Skilled Supporting Staff (Member CIFSC), Mr. N.K. Pathak, T-3 and Mr. Surendra Singh Gwal, Skilled Supporting Staff.

7.7. Institute Technology Management Committee

Chairman – Director

Members – Heads, Crop Improvement and Crop Production Division; Dr. K.S. Negi, Principal Scientist (NBPGR Regional Station, Ilmowa); Dr. J.K. Bisht, Principal Scientist and Coordinator (PME Cell).

Member Secretary – Dr. P.K. Agrawal, Principal Scientist & Chairman (ITMU)

7.8. Institute Technology Management Unit

Chairman – Dr. P.K. Agrawal, Principal Scientist & Head, Crop Improvement

Members – Dr. Lakshmi Kant, Principal Scientist, Dr. B.L. Mina, Scientist, Coordinator (PME Cell), Finance & Accounts Officer

7.9. Results Framework Document (RFD) Committee

Chairman – Director

Nodal Officer – Dr. J.K. Bisht, Coordinator, PME Cell

Scientific Members – Drs. S.K. Jain, Principal Scientist, Lakshmi Kant, Principal Scientist, Mukesh Kumar, Sr. Scientist (Co-Nodal Officer)

Other Members – Ms. Renu Sanwal, Technical Officer, Mr. R.K. Kanjolia, Assistant, Administrative Officer, Finance and Accounts Officer

7.10. Study Leave Committee

Chairman – Dr. Lakshmi Kant, Principal Scientist

Member – Dr. P.K. Mishra, Senior Scientist

7.11. PERMISNET/PIMSCAR/IITYPM

Nodal Officer – Dr. Mukesh Kumar, Sr. Scientist

7.12. Committee for Monitoring of Field Experiments

Chairman – Director

Members – Heads, Principal Scientists and Coordinator (PME Cell)

7.13. Vigilance Cell

Dr. J.K. Bisht, Principal Scientist

7.14. Grievance Cell

Chairman – Dr. Lakshmi Kant, Principal Scientist

Members – Dr. Anubhuti Sharma, Senior Scientist, Farm Coordinator, Administrative Officer, Finance & Accounts Officer

7.15. Women Cell

Chairman – Dr. Renu Jethi, Scientist

Members – ARNS Subba, Scientist, Ms. Shanti Sah. Senior Announcer, AIR, Almora, Smt. Shalaku Goswami, Fin. & Accounts Officer, Smt. Radhika Arya, Assistant

7.16. Purchase Advisory Committee

Chairman – Dr. S.K. Jain, Principal Scientist

Members – Dr. N. Saini, Senior Scientist; Mr. A.K.N.S. Subba, Scientist; FAO; AO

7.17. Standing Purchase Committee

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

Members – Dr. Mukesh Kumar, Sr. Scientist; FAO; AO

7.18. Institute Bio-Safety Committee (ISBC)

Chairman – Director

Members – Dr. Attil Kumar, Head, Molecular Biology and Genetic Engineering GBPIUA&T, Pantnagar, Dr. A.S. Gisain, Medical Officer, Almora

Member Secretary – Dr. P.K. Agrawal, Principal Scientist & Head
7.17. House Allotment Committee

Chairman – Dr. J.K. Bisht, Principal Scientist and Head

Members – Mr. K.K.S. Bisht, Scientist; Dr. Gyanendra Singh, Senior Scientist; Mr. Mahesh Lal, Administrative Officer (30.6.12); Mr. H.L. Meena, Administrative Officer (01.7.12)

Member Secretary – Mr. T.B. Pal, Technical Officer

7.18. Public Information Cell

Public Information Officer – Dr. J.K. Bisht, Head; Dr. Gyanendra Singh, Senior Scientist; Administrative Officer.

Public Information Officer (KVK, Chinyalisaur and Bageshwar)

Programme Coordinator, KVK Bageshwar.

Programme Coordinator, KVK Uttarkashi.
8.1 Book Chapters


Kant, L., Bisht, J.K., Khetirmeni, U.B., Gupta, H.S., Bhatt, J.C. and Agrawal, P.K. (2012). Enhancing quality seed availability in North-Western Hills through ICAR Seed Project on “Seed Production in Agricultural Crops”. In: ICAR Seed Project on “Seed Production in Agricultural Crops and Fisheries- A way to sustained quality seed supply in India”, 351-356 pp.


8.2 Scientific Paper Published in Journals/Proceedings

8.2.1. Research Papers

8.2.1.1. International Journals


8.2.2. Papers in Proceedings


8.3. Popular Article


8.4. Training and Extension Book


of Millets in Uttarakhand (in Hindi), Training manual, pp 90.

8.5. Institute Publications
- *Krishi Calendar 2012* 13
- VPKAS Newsletter Vol. 16 (No. 1 & 2)
- Parvatya Krishi Darpana Vol. 10

8.6. Extension Folders
- *Dhan ki Madai heta VL Paddy Thresher*, VPKAS Extension leaflet. Sahoo, D.C., Singh, S., Bista, J.K. and Bhatt, J.C.
- *Parvatya Kshetron Main Bawari heta VL Seed-cum- Ferti Drill*, VPKAS Extension leaflet. Sahoo, D.C., Singh, S., Bista, J.K. and Bhatt, J.C.

8.7. Other Publications
LIST OF ONGOING PROJECTS

9.1 Institute's Core Research Projects

Flagship Projects
- Development of Iron Rich Quality Protein Maize (QPM) Composites and Hybrids of N-W Hills
- Utilization of Plant Growth Promoting Bacteria (PGPB) for Enhancing Crop Productivity in Hill Agriculture
- Mechanization of Hill Agriculture through Development of Suitable Farm Equipment and Machineries

Enhancement in the Productivity of Major Hill Crops
- Genetic Improvement of Rice for Higher Productivity, Quality, Biotic and Abiotic Stresses
- Genetic Improvement of Wheat and Barley for Higher Productivity, Quality, Biotic and Abiotic Stresses
- Genetic Improvement of Maize for Higher Productivity, Quality, Biotic and Abiotic Stresses
- Genetic Improvement of Small Millets and Under-utilized Crops for Higher Productivity, Quality, Biotic and Abiotic Stresses
- Genetic Improvement of Vegetables for Higher Productivity, Biotic Stress and Quality Traits
- Genetic Improvement of Pulses and Oilsseeds for Higher Productivity, Quality, Biotic and Abiotic Stresses
- Basic and Strategic Research for Genetic Enhancement of Major Hill Crops for Biotic Stresses and Quality Traits

Natural Resource Management for Enhancing the Productivity
- Soil Health Management for Enhancing Productivity of Hill Crops
- Yield Enhancement of Major Hill Crops through Diversification and Efficient Resource Utilization
- Enhancing Crop Productivity with Special Emphasis on Conservation Agriculture
- Fodder Production Management with Special Reference to Utilization of Marginal and Wasteland
- Integrated Water and Soil Management for Enhancing Production and Input Use Efficiencies

Integrated Management of diseases and pests of hill crops:
- Development of Cost Effective Management Strategies for Major Diseases and Insect-pests under Protected Cultivation
- Management of Major Soil Borne Diseases under Different Vegetable Cropping Sequences
- Integrated Pest Management (IPM) for Controlling Pests in Major Hill Crops

Socio-economic Studies, Transfer of Technology and Information Technology
- Information Communication Technology and Knowledge Management in Agriculture
- Assessment of Drought Prone Activities and Nutritional Status of Hill Farm Women
- Study on Socio-economic Aspects of Hill Farming and Extension Methods
9.2. Externally Funded Projects

**Horticulture Mission for North East & Himalayan States Projects**
- Production of Quality Seed and Planting Material (Vegetables)
- Quality Seed Production of Capsicum and Squash under Protected Condition
- Multiplication of Quality Planting Material of Important Cut Flowers of Uttarakhand
- Purification and Seed Multiplication of Underutilized Important Hill Vegetable
- Standardization of Improved Vegetable Production Technologies under Protected Cultivation
- Standardization of Organic Nutrient Management for Major Vegetable Crops
- On Farm Sustainable Production and Dissemination of Fruits and Vegetables Based Farming System
- Efficient Water Management through Micro-Irrigation System in Terraced Land for Growing Vegetables
- Dissemination of Growing Off-Season Vegetable Technology under Protected Environment
- Refinement and Dissemination of Mushroom Production Technologies
- Evaluation and Mass Multiplication of Plant Growth Promoting Bioinoculants to Enhance Vegetable Production
- Deployment of Entomopathogens and Light Traps for the Management of Scarabaeids in Uttarakhand Hills
- Planned Honey Bee Pollination for Improvement in Horticultural Crop Production
- Status of Horticulture and Market Opportunities in the State of Uttarakhand
- Training in Mechanization of Horticulture
- Assessment and Refinement of Available Methods/Devices to Check Wildlife Damage in Hill Crops
- Purification of A, B and R lines in Onion for Parastal and Hybrid Seed Production using Molecular Tools

**DBT funded Projects**
- Rapid Conversion of Normal Maize Inbreds to Quality Protein Maize and Further Enhancement of Limiting Amino Acids in Elite Inbreds through Marker Assisted Selection
- Pyramiding Multiple Resistance Genes using MAS for Durable Resistance against Blast in the North West Himalayas
- Genetic enhancement of Wheat by Pyramiding of Rust Resistance genes through molecular approaches in Northern hills in India
- Development of Micronutrient Enriched Maize through Molecular Breeding-Phase II
- Network Project on Transgenics

**AMAAS Projects**
- Development of a Bacterial Consortium to Alleviate Cold Stress
- Development of a Cold Tolerant Phosphate Solubilizing Bacterial Inoculant

**NAIP Projects**
- Enhancement of Livelihood Security through Sustainable Farming Systems and Related Farm Enterprises in NW Himalaya
- Enabling small holders to improve their livelihoods and benefit from carbon finance
- Bio-prospecting of Genes and Allele Mining for Abiotic Stress Tolerance (Rice and Maize)

**All India Coordinated Research Projects**
- Use of Plastics in Agriculture Particularly in Protected Cultivation, Water Harvesting and Packaging
- AICRP on Post Harvest Technology

**DUS Project**
- DUS Project on Maize, Soybean and French bean

**CWC Project**
Demonstration of Storage and Application System for Efficient Water Utilization in Major Crops of Uttarakhand Hills through Participatory Approach
CONSULTANCY, PATENTS, COMMERCIALIZATION OF TECHNOLOGY

- Commercialization of Varieties: Vivek QPM 9, the QPM version of Vivek Maize Hybrid 9, developed through ‘Marker Assisted Selection’ was licensed to the government undertaking company “M/s Hindustan Insecticide Company, New Delhi for commercial production and marketing of Vivek QPM 9. They are producing more than 1000 quintals of hybrid seed of Vivek QPM 9 in West Bengal for the NE Himalayan states and other parts of India.
- VL Shyahi Hal and improved small tools (line marker, garden rake, hand rake, hand hoe, hand fork, cutla, kharpi, big and small darat) were commercialized and the license was given to M/s Himalayan Hi-tech Nurseries, 85, Subhashnagar, Haldwani on June 2, 2012.
- MOU signed with CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur, Himachal Pradesh for better coordination on research and extension activities on May 3.
- MOU for taking scientific intervention and research findings of VPKAS to the farmers was signed with Society for Advancement of Networking & Communication & Allied Resources (SANCHAR), a non-governmental organization having its head office at New Delhi and its branch office Waste Bio-Mass Utilization Center at village Kalet, Post – Maraon, Tehsil – Soneshwar, District – Almora, Uttarakhand on July 26.
11.1. Quinquennial Review Team (QRT) Meeting

The QRT of the institute for the year 2007-12 was constituted vide Council’s letter No. 16-9/11-IA.IV dated the 26th September 2012. After its constitution, the first meeting of Dr. S.K. Sharma, Hon’ble VC of CSKHPKV and Chairman of QRT of VPKAS, Almora with DDG (CS) was held on January 14. Dr. S.K. Pandey, ex-Director CPRI and member QRT was also present during the discussions. Then the QRT team visited the Institute from March 11 to 13, 2013. On 11th, the team has seen laboratories and facilities at Almora and Experimental farm at Hawalbagh (1.3 km away from Almora). The Team appreciated the experiments and their maintenance.

11.2. Research Advisory Committee (RAC) Meeting

The XVII Research Advisory Committee (RAC) meeting of VPKAS, Almora was held on October 30-31, 2012 under the Chairmanship of Dr. B. Mishra, Former Vice-Chancellor, SKUAS&T- Jammu. The other RAC members, who attended the meeting were Dr. Himadri S. Sen, Former Director, CSIR, Dr. Sain Dano, Ex-Director, DMR; Dr. M.C. Naithyal, Ex-Dean, College of Forestry & Hill Agriculture, GBPUA&T Hill Campus, Dr. T.C. Thakur, ICAR National Prof. Deptt. of Farm Machinery & Power Engineering, GBPUA&T and Dr. I.D. Tyagi, Ex-Professor, CSAUAT, Kanpur. Besides, all the scientists of the institute attended the meeting.

11.3. Institute Research Council (IRC) Meeting

The Institute Research Council (IRC) meeting for khurif 2012 and rabi 2012-13 were held on May 18-19, 2012 and October 19-20, 2012 under the Chairmanship of Director, VPKAS.

11.4. Institute Management Committee (IMC) Meeting

The Institute Management Committee (IMC) meeting was held on October 16, 2012 under the Chairmanship of Director, VPKAS.

11.5. Evaluation of Experiments by Field Monitoring Team

The monitoring of field experiments conducted in rabi 2011-12 and khurif 2012 were done on April 2, 2012 and September 21-22, 2012, respectively. All the Scientists of the institute visited and monitored the experiments. The progress was reviewed by the Director.
# Participation of Scientists in International & National Conferences, Symposia & Meetings

## Participants

<table>
<thead>
<tr>
<th>Programme</th>
<th>Participants</th>
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<tbody>
<tr>
<td><strong>International</strong></td>
<td></td>
</tr>
<tr>
<td>Workshop/ Seminar/ Symposium/ Congress/ Conference/ Meeting</td>
<td>Dr. Dibakar Mohanty</td>
</tr>
<tr>
<td>Carbon Footprint assessment training workshop and climate change research planning workshop, ICRAF, United Nations Avenue, Oigara, Nairobi, Kenya, April 23-27.</td>
<td></td>
</tr>
<tr>
<td>Dr. Dibakar Mohanty</td>
<td>Regional Workshop on Scaling-up of Climate Smart Agriculture Practices, NASC, Pusa, New Delhi, August 21-23.</td>
</tr>
<tr>
<td>Regional Workshop on Scaling-up of Climate Smart Agriculture Practices, NASC, Pusa, New Delhi, August 21-23.</td>
<td>Des. P.K. Misra and K. Jeevanandam</td>
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<tr>
<td><strong>National</strong></td>
<td></td>
</tr>
<tr>
<td>47th Annual Rice Group Meeting, IISR, Hyderabad during April 6-9.</td>
<td>Des. B.M. Pandey and J.P. Aditya</td>
</tr>
<tr>
<td>Annual Workshop on Small Millets, IARRS, Annapakali, AP, April 13-15.</td>
<td>Dr. M.D. Tari</td>
</tr>
<tr>
<td>XX Biennial Workshop of AICRP on Weed Control, IARI, Tisslar, Kerala, April 17-18.</td>
<td>Dr. M.D. Tari</td>
</tr>
<tr>
<td>Meeting of the staff of VPKAS, Almora and CSKHPKV, Palampur to identify the B.M. Pandey common programmes between both the institutions for future collaboration, May 2.</td>
<td>Des. J.C. Bhut, P.K. Agrawal and B.M. Pandey</td>
</tr>
<tr>
<td>CIC Meeting of the SRLS Project, CSKHPKV, Palampur, May 3.</td>
<td>Dr. J.K. Bisht</td>
</tr>
<tr>
<td>Annual Conference on Rice National Group Meet, IARRS, Pusa, May 4-6.</td>
<td>Dr. D.C. Sahoo</td>
</tr>
<tr>
<td>Coordination Committee meeting under AICRP on APA, CIPIET, Ludhiana, May 4-5.</td>
<td>Dr. Lakshmi Kant</td>
</tr>
<tr>
<td>Board of Directors meeting, Uttarakhund Seed and Triari Development corporation, May 2-24.</td>
<td>Drs. N.K. Hedoo and D.C. Sahoo</td>
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<tr>
<td>Workshop run exhibition organized by HIMNEH, Mission II, Ramnagar, May 12-13.</td>
<td>Dr. G. Singh</td>
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<tr>
<td>AICRP on Pigeon pea annual group meet at GKVK, Bangalore, May 13-15.</td>
<td>Dr. B.M. Pandey</td>
</tr>
<tr>
<td>SAC meetings of KVK, Chapamau and Lahaqat, respectively, May 28 and December 11.</td>
<td>Drs. N.K. Hedoo and D.C. Sahoo</td>
</tr>
<tr>
<td>14th Annual workshop of AICRP on Mushroom, Bhubaneswar, May 31 June 01.</td>
<td></td>
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<tr>
<td>Participants</td>
<td>Programme</td>
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<tr>
<td>Dr. J.K. Bhat</td>
<td>Advisory Council meeting of milk project of IILRI, Dehradun, June 7.</td>
</tr>
<tr>
<td>Dr. J.C. Bhat, P.K. Agrawal, B.M. Pandey and Satish Soon</td>
<td>CIC Meeting of the SRLS Project at DCFR Regional Centre, Chimpauw, June 12.</td>
</tr>
<tr>
<td>Dr. Sukhbir Singh</td>
<td>QRT meeting of AICRP on PHT, SKUAST, Srinagar, June 20-22.</td>
</tr>
<tr>
<td>Dr. B.M. Pandey</td>
<td>SAC Meeting of KVK, Uttarkashi, July 19.</td>
</tr>
<tr>
<td>Dr. Lakshmi Kari</td>
<td>Review meeting of ICAR Seed Project on Seed Production in Agricultural Crops, NASC, New Delhi, July 25-26.</td>
</tr>
<tr>
<td>Dr. J.K. Bhat</td>
<td>SAC meeting of KVK, Kasauli, Hoshiarpur, August 1.</td>
</tr>
<tr>
<td>Dr. J.K. Bhat</td>
<td>RAS meeting of Uttarakhand Forest Research and Training Dep., Dehradun, August 4.</td>
</tr>
<tr>
<td>Drs. Lakshmi Kari, S.K. Jain and Debiacar Mahanta</td>
<td>53rd All India Wheat and Barley Research Workers Meeting, ARS, Durgapura, Jaipur, August 24-27.</td>
</tr>
<tr>
<td>Dr. P.K. Mishra</td>
<td>QRT Meeting of AMAAS, NBPGR, Max, August 29.</td>
</tr>
<tr>
<td>Dr. Sukhbir Singh</td>
<td>Orientation meeting and training of AICRP on PHT, SKA, RCR, Durgapura, September 3-4.</td>
</tr>
<tr>
<td>Dr. J.K. Bhat</td>
<td>AICRP on forage National Group Meet, IGIFR, Jabalpur, September 14-16.</td>
</tr>
<tr>
<td>Dr. S.C. Pandey</td>
<td>QRT Meeting of AICRP on Water Management, CSKHPKV, Palampur, September 20-21.</td>
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<tr>
<td>Dr. H. Banerji</td>
<td>Meeting with UJRL/IF (NGO), Dehradun, September 22.</td>
</tr>
<tr>
<td>Dr. A.K. Misra</td>
<td>Stake level stakeholder workshop on Bridging Research Gap to Extension: Strategies and Policies, ICAR-BCR for NCP Region Shillong Centre, Ctg, October 11-12.</td>
</tr>
<tr>
<td>Dr. Lakshmi Kari</td>
<td>SVT meeting, Directorate of Agriculture, Dehradun, October 12.</td>
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<tr>
<td>Dr. J.K. Bhat</td>
<td>RPD Midterm Review Meeting, Krishi Bhawan, New Delhi, November 20.</td>
</tr>
<tr>
<td>Dr. Sher Singh</td>
<td>7th National Conference on KVK, PALI, Jodhpur, November 26-27.</td>
</tr>
<tr>
<td>Dr. Lakshmi Kari</td>
<td>AICRP (NSP) monitoring, Pantnagar, November 22.</td>
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<tr>
<td>Dr. Lakshmi Kari</td>
<td>Review meeting of ICAR-ICARDA Collaboration, NASC, New Delhi, November 29.</td>
</tr>
<tr>
<td>Dr. J.K. Bhat</td>
<td>Sensitization meeting of PME in-charges of ICAR institutes, NDRI, Karnal, December 5.</td>
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<tr>
<td>Dr. B.M. Pandey</td>
<td>SAC meeting of KVK, Pithoragarh, December 12.</td>
</tr>
<tr>
<td>Dr. J.K. Bhat</td>
<td>Advisory Council meeting of milk project of IILRI, Kasar Jangal Resort, Kasauli, Almora, December 18.</td>
</tr>
<tr>
<td>Dr. R.K. Kishore</td>
<td>Seed Production Meeting, Directorate of Agriculture, Dehradun, January 1.</td>
</tr>
<tr>
<td>Drs. Lakshmi Kari and G. Singh</td>
<td>State Food Security Mission sanctioning committee meeting, Dehradun, January 2.</td>
</tr>
<tr>
<td>Dr. J.K. Bhat</td>
<td>RPD meeting of Directors and social officers of CS Division institutes for preparation of RPD 2013-14, DMRI, New Delhi, January 14.</td>
</tr>
<tr>
<td>Drs. Lakshmi Kari and Dhipak Mahanta</td>
<td>Meeting on Organic farming and seed production for enhancement of Hill Agriculture production in Uttarakhand, Dehradun, February 5.</td>
</tr>
<tr>
<td>Dr. H. Banerji</td>
<td>XI Agricultural Science Congress, OUAT, Bhubaneshwar, February 7-9.</td>
</tr>
<tr>
<td>Participants</td>
<td>Programme</td>
</tr>
<tr>
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<tr>
<td>Dr. B.M. Pandey</td>
<td>Management Committee and General Body of ATMA, Almora, February 12.</td>
</tr>
<tr>
<td>Mr. A.R.N.S. Subbaiah</td>
<td>4th International Conference on Insect Science, University of Agricultural Science, Bengaluru, February 14-17.</td>
</tr>
<tr>
<td>Dr. P.K. Agiyal</td>
<td>NAIP C- III National Workshop on Natural Resources Management in backward districts of India at NRSS&amp;LUP, Nagpur, February 21-22.</td>
</tr>
<tr>
<td>Dr. J.K. Bhir</td>
<td>Meeting of Directors and Heads of Crop Science Division with DOG and DG, NASC, New Delhi, March 7.</td>
</tr>
<tr>
<td>Dr. R.K. Khudie</td>
<td>National Workshop on Productivity and Future Pathways for Agricultural Research through Youth in India, NASC, New Delhi, March 1-2.</td>
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<tr>
<td>Dr. R.K. Khudie</td>
<td>Annual Breeder Seed Review Meeting, NBPIR, New Delhi, March 17.</td>
</tr>
<tr>
<td>Dr. D.C. Sahoo</td>
<td>Review meeting with ADG (PE) and Project Coordinator, ICRISAT on Application of plastic in Agriculture, Bums Agricultural University, Ranchi.</td>
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</table>
WORKSHOPS, SEMINARS, FARMERS' DAYS ORGANIZED

VPKAS-Industry Meet organized

A VPKAS-Industry meet was held at Experimental Farm, Hawalbough on May 30, 2012 under the Chairmanship of the Director. Representatives of Industry and scientists of the Institute participated in the meeting. Presentations on the technologies commercialized by the Institute and those which are available for commercialization were made by Dr. P.K. Agrawal, Chairman, ITMU, supplemented by the scientists. The participants showed keen interest in high yielding varieties and implements for hill agriculture. They also visited the museum, laboratories, FHT workshop and other facilities.

Foundation Day Celebrated

Institute celebrated its 89th Foundation Day on July 04, 2012. Prof. Swapan Kumar Datta, DDG (CS), ICAR, New Delhi graced the occasion as the Chief Guest and Shri M.C. Joshi, Former Director, DARL, Pithoragarh presided over the function. Dr. J.C. Bhatt, Director, VPKAS highlighted the achievements of the Institute during 2011-12. Prof. Datta appreciated the research efforts of the Institute and suggested for improvements in the programmes to serve the people in a better way. He stressed upon the pivotal role of agriculture and farmers in Indian economy and society, and expressed his views, mentioning the examples from the life of visionaries, like Swami Vivekananda, Rabindranath Tagore, Prof. M.S. Swaminathan and Prof. Boshu Sen, who led the Indian society to the path of integral prosperity. He contemplated that improvement of global science needs to be connected to local needs of the region and farmers. Once the model village or
highlighted the invasive nature of the weed and the health hazards posed by the weed on human and even on animals and urged the scientists to sensitize the ill effects of the weed amongst farmer community and also to curb the menace on all fronts. The loss in crop yields due to this weed, harmful effects, management and utilization as a compost and bioherbicide were also highlighted. Posters and pamphlets in Hindi on management of Parthenium were also displayed for the benefit of the participants.

Parthenium Awareness Week Celebrated

Parthenium Awareness Week was celebrated at Hawalbagh Experimental Farm during August 16 to 22, 2012 to create awareness among people about this weed. A cleaning campaign was organized to uproot the Parthenium at Hawalbagh. The institute’s staff and farmers participated in this campaign. The Director appealed to the participants to completely uproot this weed and model system is developed, it can be replicated in other parts of the region and even to other parts of the country, with the specific modifications, which in turn will benefit the farmers at wider scale. Shri M.C. Joshi, who had a long association with Prof. Boshi Sen, expressed his views on Prof. Sen’s personality and deeds and briefed about the institute’s role in upliftment of the rural mass. The celebration ended with traditional mango feast.

A program was also broadcasted through All India Radio, Almora under Krishi Samvadhi Programme to create awareness among the people and local farmers of the area.

Kisan Mela Organized

‘Kisan Mela’ was organized at Experimental Farm, Hawalbagh on September 28, 2012. Sh. Govind Singh Kunjwal, Hon’ble Speaker, Legislative Assembly Uttarakhand, was the chief guest of the function. All the dignitaries visited the farm and appreciated the technologies developed by the institute. More than twenty five exhibition-cum-sale stalls were put by various line departments, institutes and NGOs. About 600 farmers including tribal farmers from border districts of Uttarakhand participated in this event. Director briefed about the technologies developed by the institute, especially on the advances made in past one year. A farmer-scientist interaction mee was also organized.
- A field day on wheat was organized on April 20 at Chaurna village in Bageshwar.
- Biodiversity Day was organized at the institute on July 28. On the occasion around 300 plants of *Quercus* sp. and *Balsamia* sp. were planted.
- Vigilance awareness week during October 29 to November 4, 2012.

Kisan Mela at KVK, Chinyalisa

Kisan Mela and Agri-exhibition was organized at Krishi Vigyan Kendra of district Uttarkashi located at Chinyalisa on October 30, 2012. Shri Pritam Singh Pawar, Honorable Minister for Urban Development, Urban Employment, Animal Husbandry, Fisheries, Fruit Industry, Civil Defence & Homeguards and Prisons of Uttarakhand Government, the chief guest inaugurated the event. He along with other dignitaries visited the farm and appreciated the activities. He advised the farmers to adopt the improved agricultural practices for better production. More than 26 Exhibition-cum-sale stalls were put by various line departments/ institutions and NGOs. About 900 farmers from different blocks of Uttarkashi district participated in this event. A farmer-scientist interaction meet was also organized.

- A sensitization workshop on “Protection of Plant Varieties and Farmers’ Rights Act (PPV&FRA), 2001” was organized by VPKAS, Almora, for the hill farmers at DCFR regional station Champawat on February 16, 2013. The main purpose of organizing this workshop was to create awareness among hill farmers on various issues related to PPV&FRA, 2001.

- Under Tribal Sub Plan (TSP) more than 200 farmers of Munsiyari and Dharchula region of Pithoragarh district were trained and exposed to latest agricultural technologies developed at VPKAS, Almora. Two exhibitions cum farmers fair were organized at Pithoragarh and Munsiyari. The seeds of improved varieties of hill crops, agricultural tools and machines were distributed to them.

Farmers in TSP Training
DISTINGUISHED VISITORS

- Dr. (Mrs.) Indu Sharma, Project Director, Directorate of Wheat Research on April 2.
- Dr. S.K. Singh, Former VC, RAU, Puja, Bihar on April 9.
- Dr. P.H. Kunwar, Head, Agronomy, CTRI Rajahmundry on June 1.
- Dr. A.P. Srivastava, National Coordinator, NAIP, ICAR, New Delhi on June 26.
- Prof. D.S. Pokhariya and Prof. S.S. Bish, Hindi Department, S.S.J. Campus, Almora on June 27.
- Dr. Swapan Kumar Datta, D.D.G. (CS), ICAR, New Delhi on July 4.
- Dr. K.D. Pandey, Retired Principal Scientist, IVRI, Bareilly on July 4.
- Dr. Ashish K. Gupta, Chief Manager, Indian Express on July 4.
- Shri Pradeep Tantra, MP, Almora on August 4.
- Dr. Tej Pratap Singh, Vice-Chancellor, along with Director Research Dr. Vani, SKUAST-K on November 3.
- Dr. R.P. Dua, ADG (FPC), ICAR, New Delhi on October 1.
- Dr. B. Mishra, Former VC, SKUAST-I on October 31.
- Dr. B.S. Bisht, ADG (EQR), ICAR, New Delhi on January 18.
- Dr. J.P. Singh, Director Research, GBPUA&T, Pantnagar on January 18.
- Dr. R.C. Goyal, Principal Scientist, IASRI, New Delhi on January 18.
- Prof. G. Sarkar, Ex. Director Research, BCKV on January 18.
- Shri B.M. Joshi, Devidhura, Champawat on March 20.
- B.Sc. (Agri) Students of College of Agriculture, Rowe (J.N.K.V.V., Jabalpur) on March 9.
- P.G. Students of Anand Agriculture University, Anand, Gujarat on March 21.
LIST OF SCIENTIFIC, TECHNICAL AND ADMINISTRATIVE STAFF

Dr. J.C. Bhatt, Director

Crop Improvement Division
Dr. P.K. Agarwal, Head
Dr. Lakshmi Ram, Pr. Scientist (Pl. Breeding)
Dr. N.K. Singh, Pr. Scientist (Pl. Breeding) (up to Aug. 6)
Dr. Gyanendra Singh, Sr. Scientist (Plant Breeding)
Dr. N.K. Heda, Sr. Scientist (Horticulture-Vegetable Science)
Dr. Navinder Saini, Sr. Scientist (Biotechnology)
Dr. R.K. Khulbe, Sr. Scientist (Plant Breeding)
Dr. Amalbhu Sharma, Sr. Scientist (Biochemistry)
Dr. B. Kalyan Babu, Scientist (Biotechnology)
Dr. R. Arun Kumar, Scientist (Plant Physiology)
Dr. Jay Prakash Aditya, Scientist (Plant Breeding)
Dr. Amuradha Bharatiya, Scientist (Plant Breeding)
Dr. Shailendra Kumar Jha, Scientist (Plant Breeding)
Dr. Udai Bhaskar Khetinani, Scientist (Seed Science & Technology) (upto June 14)
Dr. Salej Sood, Scientist (Plant Breeding)
Mr. Ramesh Singh Pal, Scientist (Biochemistry)
Mr. Raghu B.R., Scientist (Genetics & Plant Breeding)
Ms. Shefali Amratali, Scientist (Economic Botany)

Crop Production Division
Dr. J.K. Bish, Head
Dr. S.C. Pandey, Pr. Scientist (Soil Science)
Dr. P.K. Mishra, Sr. Scientist (Microbiology)

Dr. B.M. Pandey, Sr. Scientist (Agronomy)
Dr. D.C. Sahoo, Sr. Scientist (Land & Water Management)
Dr. Sushil Singh, Sr. Scientist (Farm Machinery & Power)
Dr. Sher Singh, Sr. Scientist (Agronomy)
Dr. Hiran Biswas, Sr. Scientist (Soil Science)
Dr. B.L. Misra, Scientist (Soil Science)
Dr. Mangal Deep Tuti, Scientist (Agronomy)
Dr. Dibakar Mahanta, Scientist (Agronomy)
Dr. K. Jeevaandhan, Scientist (Agril. Microbiology)
Mr. Ram Prakash Yadav, Scientist (Forestry)
Mr. Shauo Kumar Das, Scientist (Agri. Chemistry) (up to Feb. 2)

Crop Protection Section
Dr. S.K. Jain, Principal Scientist (Plant Pathology)
& I/c Head
Dr. K.K. Mishra, Senior Scientist (Plant Pathology)
Dr. J. Stanley, Scientist (Agril. Entomology)
Mr. A.R.N.S. Sabhanna, Scientist (Agril. Entomology)
Dr. Chandrashekara C., Scientist (Plant Pathology)

Social Service Section
Dr. Nirmal Chandra, Pr. Scientist (Agril. Extension) I/C Head
Dr. Mukesh Kumar, Sr. Scientist (Computer Application)
Mr. K.K.S. Bish, Scientist (Agril. Statistics)
Dr. Manik Lal Roy, Scientist (Agri. Extension)
Dr. Renu Jethi, Scientist (Horse Science)
Mr. Hulinam Raj Laxmanta Kharbikar, Scientist (Agri. Economics)
Dr. Pratibha Joshi, Scientist (Home Science & Family Resource Management)
Mr. Arbeequlla, G.A., Scientist (Agri. Extension)

Coordinator

Library & ARIS Cell
Mr. K.K.S. Bisht

PME Cell
Dr. J.K. Bisht

Farm
Dr. Gyanendra Singh

Vehicle
Mr. T.B. Pal

Guest House
Mr. T.B. Pal

Maintenance
Mr. T.B. Pal

Technical Officers
Mr. Beer Singh
Mr. P.C. Pant
Mr. Dhirendra Nath
Mr. T.B. Pal
Mr. L.D. Melkani
Mr. Saroj Kumar Arya
Mr. B.D. Pandey
Mr. N.C. Belwal
Mr. D.S. Gosain
Mr. P.C. Verma
Mr. Shankar Lal Arya
Mr. M.S. Khatti
Mr. Shiv Singh
Mr. G.S. Bisht

Mr. G.S. Bankoti
Mrs. Reenu Sarswal
Mr. M.C. Pant
Mr. D.S. Panchpal
Mr. D.C. Mishra
Dr. G.S. Bisht
Mr. Poonam Singh Mehta

Administration and Finance

Administrative Officers
Mr. Mahesh Lal (up to June 30)
Mr. H.L. Meena (w.e.f. June 25)

Assistant Administrative Officers
Mr. Bahadur Ram
Mr. Shambhu Dutt Bisht

Finance & Accounts Officer
Mrs. Shashikala Goswami

Stores
Mr. Mahesh Lal (upto June 30)
Mr. H.L. Meena (w.e.f. July 1)

Managerial Staff at KVK, Chinyalisour
Dr. V.K. Sachan, Programme Coordinator
Mr. Hari Govind, SMS, Plant Breeding
Mr. Pankaj Narwal, SMS, Horticulture
Dr. R.K. Teswari, SMS, Animal Science
Dr. S.P. Singh, SMS, Plant Protection
Dr. Gaurav Pargal, SMS, Agri. Extension (w.e.f. Dec. 10).
Ms. Manisha, SMS, Home Science (w.e.f. Dec. 14)

Managerial Staff at KVK, Bageshwar
Dr. Vijay Avinash Tuljagam, N.A., Programme Coordinator
Dr. N.K. Singh, SMS, Veterinary Science
Mr. Karnal Kumar Pandey, SMS, Horticulture
Ms. Shobha, SMS, Home Science
Dr. Ram Prakash Sahu, SMS, Agril. Extension
Mr. H.C. Joshi, SMS, Plant Protection (w.e.f. Oct. 5)

New Colleagues
- Dr. Rajesh Kumar Khulbe, Sr. Scientist (Plant Breeding) on April 3.
- Dr. Hritick Baisas, Sr. Scientist (Soil Science) on April 9.
- Dr. S.P. Singh, SMS (Plant Protection) on April 19.
- Dr. Anubhuti Sharma, Sr. Scientist (Biochemistry) on May 21.
- Mr. H.L. Meena, Administrative Officer on June 25.
- Mr. Manej Bhatt, Technical Assistant, T-3 on July 13.
- Mr. Abhinav Singh, LDC on July 20.
- Mr. Sachin Pandey, LDC on July 20.
- Mr. Nareen Sehrawat, Assistant on July 27.
- Mr. J.P. Gupta, Technical Assistant T-3 on August 9.
- Dr. Gaurav Papwal, SMS, Agril. Extension on December 10.
- Ms. Manisha, SMS, Home Science on December 14.

Retirement
- Mr. A.A. Khan, Driver, T-4 on April 30.
- Mr. Mahesh Lal, Administrative Officer on June 30.
- Mr. Ruidas Lal, Skilled Supporting Staff on August 31.
- Mr. Rajendra Singh Rawat, Driver T-4 on September 30.
- Mr. Jeevan Singh Bhatt, T-3, Technical Assistant, VRS on November 1.

Promotion
- Mr. Devendra Lal, Field Technician T-3 to T-4 w.e.f. July 1, 2008.
- Mr. Giteesh Ram Taonta, Field Technician T-3 to T-4 w.e.f. January 1, 2009.
- Dr. S.C. Pandey, Sr. Scientist to Pr. Scientist w.e.f. November 10, 2009.
- Mr. Jeevan Singh Bhatt, Field Technician T-3 to T-4 w.e.f. January 1, 2010.
- Mr. Chandan Singh Kaorwal, Field Technician T-3 to T-4 w.e.f. January 1, 2010.
- Mr. Dhirendra Nath, Technical Officer T-6 to Technical Officer T-7-8 w.e.f. January 1, 2010.
- Mr. L. D. Melkani, Technical Officer T-5 to Technical Officer T-6 w.e.f. January 1, 2010.
- Mr. Pooran Singh Mehta, Field Technician T-4 to Technical Officer T-5 w.e.f. February 3, 2010.
- Mr. D. S. Gosain, Technical Officer T-5 to Technical Officer T-6 w.e.f. January 1, 2011.
- Mr. Jagdish Kumar Arya, Field Technician T-3 to T-4 w.e.f. January 17, 2011.
- Dr. Mukesh Kumar, Scientist to Sr. Scientist w.e.f. January 24, 2011.
- Mr. Sanjay Kumar Arya, Technical Officer T-5 to Technical Officer T-6 w.e.f. April 17, 2011.
- Mr. T. B. Pal, Technical Officer T-6 to Technical Officer T-7-8 w.e.f. June 29, 2011.

Transfer
- Dr. Udaya Bhaskar Kherinini, Scientist to DSR, Mau on June 14.
- Mr. Shaon Kumar Das to ICAR Research Complex for NEH, Barampuri on February 2.
- Mr. Hari Govind, SMS (Plant Breeding) to KVK, Buxar of ICAR Research Complex for Eastern Region, Patna on March 18.

Selection
- Mr. Vimal Joshi, Stenographer as Additional Personal Secretary in Secretariat, Dehradun on July 12.

Resignation
- Dr. N.K. Singh, Pr. Scientist (Plant Breeding) on August 6.
- Mr. Rajesh Khetwal, Farm Manager , KVK, Chinyalisar on May 5.
- Mr. Vikram Kumar, Programme Assistant (Computer) on October 9.