Annual Report
2011 - 2012

Vivekananda Parvatiya Krishi Anusandhan Sansthan
(Vivekananda Institute of Hill Agriculture)
Indian Council of Agricultural Research
ALMORA - 263 601, Uttarakhand
Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, an institute of ICAR since 1974, has been engaged in agricultural research to cater the needs of farmers of north-western Himalayas. The Institute works with the mission of enhancing productivity and ecological sustainability of hill agriculture through niche-based diversification. To fulfill the objectives, the institute has 22 institutional and many other projects under HMNEH MM-I, DBT, AMAAS, AICRP, DUS, NAIP and CWC. The salient research achievements of different projects have been presented in this annual report of 2011-12.

During the period, three varieties (Vivek Maize Hybrid 39, Vivek Maize Hybrid 43 and VL Lahnun 2), developed by the institute, were notified. Besides, more than 20 entries in hill crops are in different stages of release. To realize the full yield potential, the matching production technologies of these varieties/advanced lines have also been developed.

This year, the institute produced about 22 q nucleus, 278 q breeder, and 63 q truthfully labeled seed of different varieties of hill crops, of which 265 q breeder seed was supplied to different seed producing agencies for further multiplication and 55 q TL seed was supplied to institute’s outreach programmes. 32 q seed was also procured from the farmers’ fields produced under farmers’ participatory seed production programme.

The institute commercialized its two technologies, viz., Vivek QPM 9 and VL White Grub Beetle Trap-1. A number of farmers’ fairs, training programmes and field days were organized for the benefit of the farmers of the region. This way, the institute has successfully generated the farmer-oriented technologies and attempted their dissemination to the ultimate stakeholders. The technologies and their extension are expected to play a significant role in enhancing the yield levels of various hill crops and sustenance in N-W Himalayan region.

The Institute also received Krishi Samshtha Samman under Mahindra Samvadhi India Agri Award 2012 for its outstanding contribution in the development of agricultural technologies and their popularization among farmers. Apart from this, scientists of the institute were vested with many other honours. Sincere efforts and hard work of its scientists and staff, with the untainted 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.

I place on record my sincere thanks to the Secretary (DARE) & DG, DDG (Crop Science) and ADG (Food & Fodder Crops), ICAR, for their wholehearted support to VPKAS. I also express my sincere appreciation to Editorial Board, all my colleagues and staff members of this Institute for their dedicated efforts and cooperation in carrying out the activities of the Institute and congratulate the Coordinator and the staff of PME Cell for bringing out this publication in time.

Almora
July 7, 2012

(J.C. Bhatt)
Director
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EXECUTIVE SUMMARY

Enhancement in the Productivity of Major Hill Crops

During the year, two varieties of maize, viz., Vivek Maize Hybrid 39 and Vivek Maize Hybrid 43 and one of garlic, VL Lahnun 2, were notified. Both the maize hybrids are extra-early (85-90 days) and out yielded the respective checks in the recommended zones for production. VL Lahnun 2 possesses higher yield, bulb weight, storage life, TSS and resistance to purple blotch and stemphylium blight than checks.

Besides, more than 20 entries in 13 crops are at different stages of release (identified/released by the CVRC/SVRC/under notification). These include rice (VL 30424, VL 30425, VL 30240, VL 31329, VL 7620), barley (VLB 94), maize (Vivek Maize Hybrid 45, Vivek QPM 21, FQH 55), finger millet (VL Mandua 347), lentil (VL Masoor 133, VL Masoor 514, VL Masoor 515, VL Masoor 516), field pea (VL Matar 47), groundnut (VLGN 9), soybean (VLS 73), toria (VLT 8), tomato (VL Tamatar Hybrid 1, VL Tamatar 5, VL Cherry Tamatar 1), capsicum (VL Shimla Mirch Hybrid 1, VL Shimla Mirch 3), french bean (VLFB 415) and garden pea (VP 434).

Physiological basis of drought tolerance was studied in different crops. Significant differences were recorded in days to 50% flowering, days to physiological maturity and grain yield in rice genotypes. VL 8214 and VL 8559 were among the genotypes which exhibited significantly higher grain yield compared to other rice genotypes. Relative water content and photosynthetic efficiency (Fv/Fm) showed significant positive correlation with grain yield and physiological traits. In soybean, significant increase in proline content was recorded under drought condition. Among genotypes, VL Soya 47 showed significantly better physiological traits for drought tolerance besides grain yield.

A total of 278.12 quintals of breeder seed of 39 released varieties/inbreds of different crops were produced. A total of 264.81 q breeder seed was supplied during this period to different seed producing agencies for further multiplication. Around 22 q nucleus seed of 38 released varieties were also produced. Hybrid seeds of many maize hybrids were produced and supplied. Notably, more than 10 q of Vivek QPM 9 seed was produced and supplied to different government and non-government agencies. In addition, around 60 q truthfully labeled (TL) seed was also produced, of which 55.1 q has been supplied to meet the demand of institute extension activities. Under farmers' participatory seed production programme, 32 q seed of wheat was produced at farmers' fields at different places. Seeds were also produced under different breeding programme and projects.

Natural Resource Management for Sustainable Productivity

In garden pea-french bean-okra cropping system, the effect of organic manures was studied in which the highest pod yield was obtained with the application of FYM @ 69.9 kg equivalent P/ha in garden pea and FYM @ 52.4 kg equivalent P/ha in french bean. In colocasia-based vegetable relay intercropping systems, colocasia-coriander-tomato and colocasia-onion-french bean were found to be the most suitable for its higher energy use efficiency and energy productivity.
In long-term fertility experiment, NPK+FYM treatment continued to show the highest soybean and wheat yield after 38 years. The highest grain yield and plant stand of wheat was observed in seed priming + deep sowing + FYM packing under moisture stress condition. In finger millet, significant differences in grain yield were recorded during second year due to Sesbania mulching (1,283 kg/ha) compared to no mulching (1,161 kg/ha).

Application of 125 and 150% of recommended dose of P through rock phosphate along with PSB and VAM gave yield levels comparable to that under recommended dose of SSP in soybean (3,500 kg/ha). Application of magnesite waste along with recommended dose of NPK increased yields of wheat, toria and lentil with increasing levels of magnesium up to 100 kg Mg/ha. However, in kharif, application of magnesite waste along with recommended dose of NPK responded up to 75 kg Mg/ha for rice and soybean and 100 kg Mg/ha for finger millet.

Inoculation with Azospirillum sp. isolate A6 enhanced the total chlorophyll (22.7%), available Fe content (34.0%), root length (19.8%) and shoot length (19.1%) at 40 days after transplanting (DAT) and enhanced N uptake in the plant and root by 23.0 and 38.1%, respectively, at 60 DAT in rice. Significant increase in yield was recorded with increasing level of irrigation in direct sown rice-wheat rotation. In wheat-soybean rotation, application of recommended NPK+10 t FYM recorded the highest wheat yield (5,770 kg/ha).

Spring discharge was higher after roof water harvesting in infiltrating trenches throughout the year. The annual discharge of spring increased from 18.9% in 2006 to 160.3% in 2011 in comparison to 2000 (before the inception of treatments).

Traditional ploughs are made of wood causing negative impact on environment due to deforestation, beside low capacity, inefficiency and frequent break down. After testing and modification a complete metallic VL Syahie Hal of 12-14 kg weight was developed. This can be used for ploughing as well as planking.

Among various forage crops, entry Hima-14 of Fescue grass (22,310 kg/ha) in winter, and S-20 of Setaria (85,344 kg/ha) in summer produced the highest green forage. In forage based cropping sequence the highest green and dry forage yields, net return (7,42,101/ha) and resource use efficiency (41.9%) was recorded in bio fertilizer + 75% NPK. In silvi-horti system the highest rhizome yield of turmeric was obtained under Quercus leucotrichophora (15,240 kg/ha). Improved pit planting had significantly higher green forage (5.72 kg/tree) and plant height (143 cm) than traditional pit planting in the sixth year.

Integrated Pest Management

Promising genotypes against major diseases were identified in different crops. Monitoring of virulence pattern of Pyricularia grisea at Hawalibagh revealed that BL 122, Remind Str. 3, Tadukan and Tetep were highly resistant. In rice trial at farmers' fields, adoption of IPM treatments showed increase in yield up to 950 kg/ha among different varieties with low incidence and severity of diseases and pests.

Trichoderma harzianum and fluorescent Pseudomonas isolates reduced damping-off disease in cauliflower. Fungicide Azoxystrabin @ 0.1% was found most effective in controlling French bean rust and angular leaf spot diseases. IPM modules with pesticides have given the best results in French bean however, significant yield increase was also observed in treatments with foliar sprays of panchgavya, cow dung extract and batain seed kernel extract (BSKE) along with reasonable control of diseases and
sucking bug. Antagonistic *Pseudomonas* isolates P3, P11, P17 and organic substrate such as mustard straw residue, mustard cake and neem cake were found effective against bacterial wilt of tomato and capsicum.

Overall *Helicoverpa armigera* moth catches in pheromone traps were higher than light traps. A total of 28,320 white grub beetles comprised of 25 species were trapped in light traps in the experimental farm, Hawaiabagh, with peak catches during June-July. Anisole is found to attract male beetles of *Holotrichia seticollis* in the fields with peak emergence during third and fourth weeks of May. Enhanced attraction index of 0.42 was obtained in case of *Sophronegus* beetles to pecan nut leaf extract.

Twelve new *Bacillus thuringiensis* isolates were isolated from 66 samples. Nine Bt isolates purified from root nodules of soybean, rice bean, horse gram and lentil showed the presence of a combination of cry 1 (cry1Ab, 1Ac, 1C and 1D) and cry 2 whereas six isolates showed the presence of only cry 8 gene through PCR studies. In 106 Bt native isolates, presence of vip 3 gene was found only in isolate VLBI 2.

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

The study on status of adoption of VPKAS technologies in Kumaun Hills revealed that most of the farmers in adopted village belonged to high or medium category of adopters (97%), whereas all the respondents in non-adopted villages belonged to low and medium categories of adopters. The adoption index for the above categories of villages was found to be 64 and 38%, respectively. The two most adopted technologies were improved varieties of vegetables (72%) and cereals (65%). The farmers identified two most limiting factors responsible for poor adoption as weather vagaries (83%) and lack of irrigation facility (73%). The net return per hectare was highest (₹ 35,493) from cultivation of wheat (irrigated improved) and lowest (₹ 4,438) from finger millet. The most remunerative irrigated cropping sequences were rice-toria-potato and rice-wheat with a net income of ₹ 71,800 and ₹ 59,400/ha, respectively. In rainfed situation, soybean-lentil and finger millet-lentil gave a net income of ₹ 17,500 and ₹ 16,000/ha, respectively.

In a study to assess the nutritional status of hill farm women, it was found that daily calorie intake of farm women in non-adopted village was 1,932 kcal, with a deficit of 293 kcal [on the basis of Recommended Dietary Allowances (RDA), ICMR]. Iron, riboflavin and β-carotene consumption was also found to be deficient among the farm women of both the villages. In adopted and non-adopted village 37 and 63% farm women had lower Body Mass Index, respectively. Pulse consumption in farm women of adopted and non-adopted villages were 47g and 31g, respectively, against the RDA of 70g. Consumption of green leafy and other vegetables and sugar was also found to be less than RDA.

Agricultural database for major crops for north-western and north-east Himalayan states was updated to 2009-10. Genetic stock module database was developed for rice and finger millet crops.

**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) 1,114.25 kg seeds of different vegetables were produced for different groups of users; (ii) 71 training/field days/field schools were conducted benefiting more than 1700 participants; (iii) 485 demonstrations were laid on off-season vegetable and mushroom production; (iv) the total number of LDPE tanks and polyhouses
in farmers' fields has reached 189 and 151, respectively; (v) 86.86% reduction in white grub population was recorded using light traps along with entomopathogen, *Bacillus cereus* strain WGPSB-2 in 5 villages; (vi) 132 kg of talc based formulation of WGPSB-2 was prepared and (vii) significant increase in yield of fruits and seeds of vegetable crops was obtained by planned honey bee pollination of these crops.

**DBT Project**

Two QPM hybrids, FQH 38 (QPM version of Vivek Maize Hybrid 21) and FQH 55 (QPM version of Vivek Maize Hybrid 23) were identified and are under release. The other programme on QPM maize aims to increase the tryptophan level in maize hybrids, for which more than 200 plants from each population were selected from respective backcross population (VQL 1, VQL 2 and VQL 17) for background selection. The background selection was done with more than 30 SSR markers covering all the chromosomal regions. The genome recovery ranged between 62 to 90% in each population.

To make rice cultivars VL Dhan 207 and VL Dhan 85 with durable resistance against blast the pyramiding of two or more resistance gene was done using MAS. Progenies from six crosses (BC,F, generation) were used for foreground and background selection. Parental polymorphism between the recipient and donor parents were completed for *Ft 9*, *Ft 1* and *Ft K* (a). The marker for *Ft 9* is available right within the gene whereas *Ft 1* and *Ft K* (a) are highly close to the gene of interest. A set of 500 DNA markers were used to find polymorphic markers between respective recipient and donor parents.

The wheat variety, VL Gehun 738 has off late become susceptible to two prevalent pathotypes of yellow rust- 46S119 and 78S84. Two yellow rust resistance genes, *viz.*, *Yr5* and *Yr10*, were found to be effective to most of the known pathotypes including the above two.

The harvests of selected plants were grown in the off-season nursery at Dhalang Maidan, Lahaul Spiti, H.P. The foreground and background selections were done using SSR markers. In case of *Yr5*, 54 plants were found to possess allele for resistance whereas in case of *Yr10*, 60 plants were found positive. The genome recovery ranged from 80 to 97% in *Yr5* population while it was 75 to 97% in *Yr10* population. The plants having more than 90% recipient genome recovery in case of *Yr3* and 88% in case of *Yr10* genome recovery were selected to generate the BC,F, population.

A set of 67 maize entries was analyzed for kernel Fe and Zn concentration over three years. 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, BAJM: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. The level of homozigosity among the best 10 plants for the cross CM 145 × *ipa* 1 was found to be more than 95% while the same level was exhibited by 14 plants in case of V 334 × *ipa* 2.

**Network Project on Transgenics**

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, 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. More than 1,00,000 seeds 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. Agrobacterium mediated transformation of maize calli was also done at the NRCPB, New Delhi.

**NAIP Projects**

In the project on sustainable rural livelihood security, which is executed in the three NW Himalayan states covering 5 districts and 3,737 farm families, a total of 32 major interventions were taken up for enhancement in the agricultural productivity through proven technological interventions. Ten interventions were undertaken for the upgradation and management of natural resource base. Replacement of local varieties by HYVs and suitable production technology has resulted in significant benefits. With the use of HYVs the yield increased in the range of 25 to 48% as compared to traditional varieties. Farmers across the clusters/villages earned an income of ₹ 13,870/- to ₹ 18,650/- by selling this surplus produce. An additional income of ₹ 2,962/- to ₹ 45,000/- per house hold per season was obtained by the farmers by growing oyster and button mushroom in the various clusters. Farmers earned a net income of ₹ 4.71 lakhs by rendering service to the other farmers of the area on custom hiring of power tiller (3360.8 hrs) since May 2008. This system has created self-employment to the youth in the rural areas. Seeing the advantages of the technology, 20 power tillers have been purchased by farmers themselves. Backyard poultry has been replicated throughout the region for meat and egg production which gave a net profit of ₹ 250/-/bird.

In enabling small holders to improve their livelihoods from carbon finance project, five hundred soil samples have been collected from different places of the grid area for baseline carbon stock estimation. The highest total C content of the grid area was 2.16% (fertile agricultural land) and the lowest value was 0.20% (wasteland). The C:N ratio of the grid area varied from as low as 4.40 in wasteland to as high as 41.83 in grassland. As carbon sequestration intervention, 5,925 forest trees have been planted in community land of grid area.

In the project, bio-prospecting of genes and allele mining for abiotic tolerance, drought condition significantly reduced the chlorophyll and carotenoid content, photosynthetic and photosystem efficiency in different rice genotypes. Putative transgenic plants of rice varieties Vivek Dhan 65 and VL Dhan 206 were generated from calli bombarded with test construct with *gus* and *hpt*. The genomic DNA of 84 varieties of maize was extracted. Three drought specific primers ASR-1 (ABA-water stress-ripening induced protein), ZmPIP (Zea mays plasma membrane integral protein) and Vgr1 (Vegetative to generative transition 1) were used to amplify different drought related genes.

**AICRP Project**

Threshing and pearing capacity of finger millet and dehusking capacity of barnyard millet of modified millet dehuller were 40, 80 and 4 kg/hr, respectively. The weight of modified paddy thresher was reduced from 42 to 25 kg. Its threshing capacity was 80-100 kg/hr with 98% efficiency.

**AMAAS Project**

In wheat variety VL 804, (i) among bacterization treatment with eight cold
tolerant bacterial consortia to enhance chilling tolerance, consortium C1 recorded increased wheat yield (17%) over uninoculated control, and (ii) among bacterization treatment with another set of eight cold tolerant P solubilizing bacterial consortia, consortium C7 significantly enhanced P uptake and wheat yield by 55.1 and 21.7%, respectively, over uninoculated control.

**DUS Project**

Twenty one maize inbreds were studied by using essential characters, out of which 19 were found to be distinct while CM 212 and VQL 1 were found to be morphologically similar. Similarly, among 12 hybrids studied, 10 hybrids were found to be distinct while Vivek QPM 9 was found morphologically similar to Vivek Maize Hybrid 9.

**CWC Project**

Fifty one multilayered cross laminated film lined tanks (total capacity 3,000 m³ and normative command area 2.8 hectares) were constructed with farmer’s participation. Two training programmes and exposure visits at VPKAS, Almora were also organised for the adopted farmers.

**Technology Assessed and Transferred**

Under Transfer of Technology, more than 200 training programmes were conducted by institute and its KVKs benefiting around 6,000 farmers and state officials. Besides, FLDs on different crops were conducted on more than 89 ha area by benefitting more than 2,500 farmers.

Front Line Demonstration was conducted for rice varieties VL Dhan 85 and VL Dhan 65 among 135 farmers covering 9.82 ha area spread over 20 villages of Almora district and, were found significantly superior to the local cultivars adopted in that region. Similarly, the FLDs for horse gram covered 17 villages involving 88 farmers covering 2.66 ha. Similarly, the FLDs for pigeon pea covered 88 farmers of 20 villages of Bageshwar district. For soybean the FLD covered 29 farmers in 5 villages covering an area of 2.00 ha. In all the cases, the HYVs were found significantly superior to the local cultivars.
INTRODUCTION
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 Bosh 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 and 1,600 m amsl) 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/Kanikhet Road at an altitude of 1,250 m amsl (29°56'N and 79°40'E). The meteorological parameters of Hawalbagh are given in the table 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>Kharif (May to Oct.)</td>
<td>816.5</td>
</tr>
<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 88 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 Plaz 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-pearler 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.

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 125 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, Vivek Dhan 62 and Vivek Dhan 82 of rice; VL Sankul Makka 11, Vivek Maize Hybrid 9, Vivek Maize Hybrid 15, Vivek Maize Hybrid 17, VL Baby Corn 1 of maize; VL Mandua 146, VL Mandua 149 and VL Madira 172 of small millets; VL Soya 2, VL Soya 47 of soybean; VL Masoor 4, VL Masoor 103 of lentil; VL Ageti Matar 7, Vivek Matar 6, Vivek Matar 8 of garden pea; VL Rajma 63 of rajmah and VL Ura 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 2007, 34 improved varieties of wheat (VL Gehun 892, VL Gehun 907), maize (Vivek Maize Hybrid 25, Vivek Maize Hybrid 27, Vivek QPM 9, Vivek Maize Hybrid 33, Vivek Maize Hybrid 39, Vivek Maize Hybrid 43, Vivek Sankul Makka 31, Vivek Sankul Makka 35, Vivek Sankul Makka 37), millets (VL Madira 207), Pulses (VL Gahat 15, VL Gahat 19, VL Matar 47, VL Masoor 129, VL Masoor 133, VL Masoor 514, VL Rajma 125, VL Bhat 65), oilseeds (VL Soya 59, VL Soya 63, VL Moongphali 1) and vegetables (Vivek Matar 9, Vivek Matar 10, Vivek Matar 11, VL Tamatar 4, VL Cherry Tamatar 1, VL Tamatar 5, VL Hybrid Tamatar 1, VL Hybrid Shimla Mirch 1, VL Shimla Mirch 3, VL Bean 2, VL Labsun 2) were released. During these five years, around 980 quintals of breeder, 77 quintals of nucleus and 222 quintals of truthfully labeled seeds were produced for various agencies and farmers. More than 10,000 native and exotic accessions of wheat, rice, maize, small millets, pulses, oil seeds and vegetables are being maintained at the institute. Besides, 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–toria 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, rajmah-french bean–toria, 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 toria in wheat were found more profitable than pure crops.

Long term fertility management, being studied since 1973, revealed that use of FYM (10 t/ha) along with the recommended dose of inorganic fertilizers was capable of rectifying nutritional problems of crops and the deterioration of soil physical conditions. Institute was awarded “KRIBHCO BARANI KIETI 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 risers, 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-season high value vegetables.
Survey of Kumaon and Garhwal regions show prevalence of yellow and brown rusts, loose smut, powdery mildew and hill bunt in wheat; stripe 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. Fuscous blight of french bean/rajmash and zonate leaf spot of maize have been reported for the first time from this region. Viral diagnosis, based on symptomatology, 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 cereus are the potential alternatives to manage the white grubs.

Demonstration of improved agricultural production technology was 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 its credit a technological options publication entitled, “क्षेत्र परिवर्तनीय कर्मकाल से जन्म उद्योग का गुणधर्म के लिए समझौता व्यवस्थाएँ” which is very popular among farmers and extension workers. The publication was awarded prestigious Dr. Rajendra Prasad Purushkar of Indian Council of Agricultural Research in the year 2004. Vivek Thresher-I for pearl 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. This year, the Institute received Mahendra Krishi Samridhi India Agri Award 2012 for its outstanding contribution in the development of agricultural technologies and their popularization among farmers.
Infrastructural Developments

During the period under report, different construction/renovation works at Institute and KVKs were carried out. This includes construction of retaining wall on the back side of guest house at Almora, the site near to library/auditorium building which were damaged due to severe rainfall in 2010. Kota stone flooring in front of administrative building and guest house, road from main gate to residential colony at KVK Chinyalisaur were completed. At KVK Bageshwar, road/path, railing along the road and paver laying in office front was done.

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 60 Indian periodicals. Library has a collection of 3,900 (approx.) bound volumes. A sum of ₹ 13,94,058.00 was spent for the procurement of the books/periodicals etc. during the period. Books worth ₹ one lakh were also purchased under NAIP. Besides, many annual reports, and other miscellaneous publications were also received on grants 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 set up 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 provide hardware, software, anti-malware and agricultural database support to the institute. AKMU also maintain institute’s website, which can be accessed at the http://vpkas.nic.in.

Staff

The staff position of the Institute as on 31.3.2012 is given below:

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<tr>
<th>Sanctioned</th>
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<th>Vacant</th>
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<td>151</td>
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</table>

*Against 22 sanctioned posts of T-I, 24 incumbents are in position.

Finance

The budget outlay for 2011-12 (₹ in lakhs) is given hereunder:

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<td>986.35</td>
</tr>
<tr>
<td>Plan</td>
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<tr>
<td>Total</td>
<td>1,136.39</td>
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</table>

Weather and Crop Season at Research Farm (2011-12)

The mean maximum daily temperature during kharif season (May to October) ranged from 27.9°C (August and October) to 31.0°C (May) and mean minimum daily temperature varied from 10.9°C (October) to 20.8°C (July and August). During kharif about 950 mm of rainfall was received. The maximum rainfall was received during August (374.5 mm) followed by June (258.5 mm). The mean maximum daily temperature during rabi season (November to April) ranged from 15.9°C (January) to 27°C (April) and the mean minimum daily temperature from -1°C (December) to 8.7°C (April), respectively. During rabi, about 106 mm of rainfall was received with no rainfall in the month of November. The total rainfall for entire year was 1,056 mm.
2

Research Achievements

VL Lahsun-2
Azospirillum sp.
VL Mandua 347

Rice VL 31329
Seed-cum-ferti drill
Vivek Maize Hybrid 43
Enhancement in the Productivity of Major Hill Crops

- Genetic Enhancement for Productivity and Nutritional Quality in Millets and Underutilized Crops (Drs. A. Gupta, S. Sood, B.M. Pandey, Chandrashekara C. & R. Arun Kumar)
- Genetic Enhancement for Productivity and Quality in Vegetable Crops (Drs. N.K. Hedau, P.K. Agrawal, M.D. Tuti, Chandrashekara C., Mr. A.R.N.S. Subkanna, Mr. R.S. Pal, Drs. R. Arun Kumar & M.L. Roy)
- Enhancing Quality and Resistance to Biotic Stresses through Molecular Breeding (Drs. P.K. Agrawal, J.C. Bhatt, L. Kant & N.K. Hedau)
- Seed Production (Drs. L. Kant, U.B. Khetinini – Field crops; N.K. Hedau – Vegetable crops)
2.1. Enhancement in the Productivity of Major Hill Crops

2.1.1. Maize

Maize, an important cereal, ranks third after rice and wheat. It is cultivated in an area of 8.55 million hectares with production and productivity of 21.7 million tonnes and 2.54 t/ha. In North-Western Himalayas, maize is grown in 632.9 thousand hectares with production and productivity of 1241.1 thousand ton and 1,960.1 kg/ha, respectively. 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 turcicum leaf blight in particular.

2.1.1.1 Varietal Improvement

Varieties Notified

Hybrid Development: Two extra-early single cross hybrids, namely Vivek Maize Hybrid 39 (FH 3356) and Vivek Maize Hybrid 43 (FH 3358) were notified in 2012 for commercial cultivation in Zone-I, and Zone-III and Zone-V, respectively. One single cross hybrid FH 3483 was identified for release in Zone I, II, III and IV.

Vivek Maize Hybrid 39: An extra-early maturing (85-90 days) single cross hybrid with yellow, semident grain was released by CVRC for commercial cultivation in Zone-I (Uttarakhand, Himachal Pradesh, Jammu and Kashmir and NEH region). The hybrid recorded average yield of 6.959 kg/ha, which is 21.93% higher over the best check Vivek Maize Hybrid 17.

Vivek Maize Hybrid 43: An extra-early (85-90 days) yellow, semi-flint grain single cross hybrid was released by CVRC for Zone-III (Eastern UP and Eastern states of the country) and Zone-V (Central Western India). Vivek Maize Hybrid 43 recorded average yield of 4,491 kg/ha and 5,868 kg/ha and established yield superiority of 24.04 to 32.92% in Zone-III and 31.85 to 52.28% in Zone-V, respectively over Vivek Maize Hybrid 17.

Evaluation of Normal and Specialty Corn in Coordinated and Station Trials

Two hundred twenty-one genotypes including 94 hybrids, five composites and 17 inbreds of normal maize developed at VPKAS were evaluated in thirteen trials. Besides, fifty-eight genotypes of specialty corn including 30 hybrids
of VPKAS were evaluated in five trials to identify superior genotypes in medium, early and extra-early maturity groups.

Eight extra-early maturity (85-90 days) trials namely, AET-II (8), AET-I (9), IET (12), Zonal 103 (21), SVT (10), 51 new hybrids in two Station Trials, 20 sweet corn hybrids in a Station Trial and 17 parental lines of experimental hybrids in another station trial were evaluated. In AET-II (Extra-early), FH 3483 (7.776 kg/ha) was found to be superior to Vivek Maize Hybrid 9 (7.286 kg/ha) whereas single cross hybrid FH 3506 (9.039 kg/ha) followed by Bio-605 (8.865 kg/ha) were found to be superior over the best check Prakash (6.681 kg/ha) in AET-II (Early). In Extra-early trial of AET-I, FH 3525 (12.339 kg/ha) recorded highest yield followed by KH 9888 (12.280 kg/ha) and FH3510 (10.256 kg/ha). All these hybrids were recorded higher yield than the best check Vivek Maize Hybrid 9 (9.317 kg/ha). In AET-I (Early), XBS561 recorded highest yield (8.743 kg/ha) followed by KDMH 755 (8.598 kg/ha). VPKAS hybrid FH 3513 recorded 6.714 kg/ha grain yield and found superior to the best check JH 3459 (6.271 kg/ha).

In IET (extra-early), single cross FH 3556 (8.279 kg/ha), FH 3554 (8.034 kg/ha) and FH 3558 (8.012 kg/ha) outyielded the best check Vivek Maize Hybrid 9 (7.137 kg/ha). In early maturing trial (IET early), DAS-MH 501 (10.000 kg/ha), EH 2101 (9.985 kg/ha), BISCO 2238 (9.952 kg/ha), EH 2184 (9.765 kg/ha) and FH 3548 (9.740 kg/ha) were the five high yielding hybrids and also exhibited significant superiority over the best check JH 3459 (6.934 kg/ha). In Zonal Trial, VL Hybrids FH 3583 (8.704 kg/ha), FH 3605 (8.170 kg/ha), FH 3609 (7.949 kg/ha) and FH 3594 (7.887 kg/ha) were superior to the best check Vivek Maize Hybrid 9 (7.337 kg/ha). These hybrids performed well across the locations in Zone-I and registered yield superiority ranging between 11.8 and 18.1% over Vivek Maize Hybrid 9. Normal and QPM hybrids were evaluated in two station trials. In Station Trial-I, FH 3596 (7.230 kg/ha), FH 3581 (6.769 kg/ha) and FH 3577 (6.881 kg/ha) were found promising and registered superiority over the best check Vivek Hybrid 39 (5.875 kg/ha). Single cross hybrids FH 3626 (8.304 kg/ha) and FH 3630 (7.872 kg/ha) were found to be promising and recorded higher yield potential than the best check Vivek Maize Hybrid 39 (7.342 kg/ha). In sweet corn, Station Trial consisted of 20 hybrids of VPKAS, FSCH 17 and FSCH 18 were observed to be superior in terms of yield, quality and resistance. Among 21 entries evaluated for green cob, Vivek Maize Hybrid 25 (11.480 kg/ha), Vivek Maize Hybrid 33 (11.107 kg/ha), Vivek Maize Hybrid 23 (10.959 kg/ha), Vivek QPM 9 (10.678 kg/ha) were found to be promising.

Development of Early and Extra-early Duration Yellow Composites

- Sweet corn synthetic VL 15 was subjected to mild selection for uniformity, better yield and tolerance to biotic stress.
- Experimental composite VL Popcorn 1, synthesized involving seven elite materials, was further improved by selection for better yield, uniformity, shorter plant height and tolerance to prevailing diseases.

Development of Early and Extra-early Yellow Hybrids

- In order to develop short duration productive inbred lines, inbreeding was initiated in 28 promising materials. Of these, 37 lines possessing early maturity, shorter plant height and resistance to prevailing diseases were retained for further inbreeding and selection.
- One hundred seventy eight lines of different homozygosity levels (28 S, 26 S, 29 S, 51 S, 14 S, 9 S and 21 advance generation) were evaluated. Of these, 142 lines (27 S, 16 S, 21 S, 33 S, 15 S and 30 advance stage) possessing carliness, shorter plant and ear height, good vigour, shorter ASL and tolerance to biotic stresses mainly E. turicatum were retained for further selection and inbreeding. Eight elite lines possessing desirable traits were established.
Selection and inbreeding was continued in 17 different homozygous inbred lines of sweet corn (1 S₀, 1 S₁, 13 S₂, and 2 advance stage) and 13 desirable lines (11 S₀, and 2 advance stage) with shorter plant height, earliness and tolerance to *E. turricum* and other prevailing diseases were retained for further inbreeding and selection.

**Development of Experimental Single Cross Hybrids**

Forty one new hybrid combinations were generated involving 22 new promising lines and 6 parental lines of released hybrids, namely, CM 212, V 335, V 341, V 345, V 346 and V 373. Twenty five new sweet corn hybrids were generated involving 11 exotic and indigenous lines.

**Germplasm Resource – Evaluation and Maintenance**

- Twenty one PFSR resistant lines received from DMR were evaluated. Of these, 11 early-medium lines possessing desirable agronomic traits were maintained for their potential use in hybridization programme.
- Twenty five indigenous/exotic inbred lines received from DMR were evaluated. Of these, 17 early-medium lines possessing desirable agronomic traits and resistance to turricula leaf blight were maintained for their potential use in hybridization programme.
- Fifty seven early-medium duration germplasm received from DMR and CIMMYT, India during 2010 were evaluated. Of these, 26 early materials possessing desirable agronomic traits and resistance to TLB were maintained.
- Five local maize accessions collected from Almora, Nainital, Champawat and Jaunsar-Bhabhar of Uttarakhand were maintained through bulk sib mating.
- Sixty seven maize germplasm kept in mid-term gene bank were revived.

**Maintenance and Seed Increase of Parental Lines**

- Purification, maintenance and seed increase of 41 parental lines (0.5-1.0 kg) of 63 experimental hybrids was done.
- Nucleus seed (0.5-10.0 kg) of parental lines of VL Makka 42, Him 129, Vivek Hybrid 4, Vivek Hybrid 5, Vivek Hybrid 21, Vivek Hybrid 23, Vivek Hybrid 25, Vivek Hybrid 27, Vivek Hybrid 39, Vivek Hybrid 43 and Vivek QPM 9 was produced. Single cross seed production of double cross hybrid VL 42 and double top cross Him 129 were performed.
- F₁, seed (2.5-40.0 kg) of 63 test hybrids for All India Coordinated and standard varietal trials and on farm demonstrations was produced by controlled pollination.
- F₁, seed (2.0-340.0 kg) of 11 released hybrids was produced.
- Nucleus seed of released composites Vivek Sankul Makka 31 (26.0 kg) and VL Amber Popcorn (12.0 kg) was produced.

**Sharing of Maize Germplasm and Inbred Lines with Coordinated Centers**

A total of 34 inbred lines of normal corn and QPM lines were supplied to seven centers of AICMIP including five centres in zone I so as to strengthen their extra-early maize breeding programme (Fig. 2.1.)

![Fig. 2.1. Inbred Lines supplied](image-url)
2.1.1.2. Crop Protection Investigations

A total of 702 AICRP entries were screened against turcicum leaf blight (TLB) under high disease pressure conditions. Most of the entries showed moderate resistance, few were found to be resistant and highly susceptible to TLB.

- In AET trials, FH 3513 (Early) and FH 3478, FH 3483, FH 3487 (Extra early) were found to be resistant to TLB.
- In IET trials, FH 3534, FH 3559, FH 3548 (Early) and FH 3555, FH 3556 (Extra early) were found to be resistant to TLB.
- In Station Trial, 35 maize inbred lines were screened against TLB and banded leaf and sheath blight (BLSB) separately. The inbred lines, like V 373, V 398, V 407, V 418, VQL-2, CM 145 showed high degree of resistance to TLB and V 334, V 336, V 410, V 441 were found tolerant to BLSB.
- A total of 268 elite maize inbred lines were screened for identification of sources of resistance against TLB, of which 69 lines were found resistant.

In gene pyramiding network project, 55 lines including inbreds and crosses were evaluated against TLB, of which 23 lines found to be resistant.

2.1.1.3. Agronomic Investigations

Evaluation of Interactive Effects of Plant Density, Geometry on Productivity of Early Maturity Maize Genotypes for Rainfed Condition

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 (intra-row spacing of 25, 20 and 15 cm) and mulching (clean field and residue retention). The intra-row spacing of 15 cm (7,600 kg/ha) and 20 cm (7,470 kg/ha) provided significantly higher grain yield than 25 cm spacing (6,850 kg/ha). There was no significant difference between equal row (7,280 kg/ha) and paired row (7,330 kg/ha) and, between clean field (7,290 kg/ha) and residue retention (7,390 kg/ha) in grain yield. There was interaction between plant density and mulching. Residue retention (7,190 kg/ha) provided significantly higher grain yield than clean field (6,510 kg/ha) at higher (25 cm) intra-row spacing.

Performance of Maize Hybrids to Adopt Rainfall Changes and Climatic Aberrations

Vivek QPM 9 and Vivek Maize Hybrid 25 were evaluated under different dates of sowing (5th June to 5th July at 10 days interval). The 5th June was found to be the most suitable date of sowing, which provided 7,590 kg/ha grain yield. Vivek Hybrid 25 (6,660 kg/ha) performed better than Vivek QPM 9 (6,250 kg/ha). The production of both the genotypes got reduced as sowing advanced beyond June 5.

Performance of New Genotypes (Early Maturity) under Different Fertility Levels

Five new genotypes namely, FH 3506, BIO 605, KHI 9560, DMR 1019, REH 2001 and REH 2003 were evaluated against two checks: Prakash, and BIO 9637 for different fertilizer levels (100:50:50, 150:65:65 and 200:80:80 kg NPK/ha). Among new genotypes, only BIO 605 produced significantly higher grain yield (8,060 kg/ha) over the best check BIO 9637 (7,680 kg/ha). The fertilizer level 200:80:80 kg NPK/ha recorded significantly higher grain yield (7,520 kg/ha) than other levels.

Performance of New Genotypes (Extra Early Maturity) under Different Fertility Levels

Two new genotypes namely, FH 3478 and FH 3483 were evaluated against two checks Prakash, and BIO 9637 for different fertilizer levels (100:50:50, 150:65:65 and 200:80:80 kg NPK/ha). All the new genotypes were found significantly inferior to best check BIO 9637 (9,740 kg/ha). The fertilizer level 200:80:80 kg NPK/ha recorded significantly higher grain yield (9,250 kg/ha) than 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 1,921 kg/ha in 2009-10 whereas the average national productivity was 2,125 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 related production technologies for their suitability under rainfed upland (spring and summer sowing) and irrigated transplanted conditions.

2.1.2.1. Varietal Improvement

Varieties Identified/Recommended for Release

**VL 31329**: VL 31329 was identified by the SVRC for the irrigated medium condition of Uttarakhand hills. It is derived from the cross IR 64 × *O. rufipogon* and developed by selection from International Rice Fine grain Aromatic Observational Nursery (IRFAON). On the average of three years of testing, VL 31329 has shown grain yield of 4,199 kg/ha which out-yielded the check varieties Vivek Dhan 62 by 12.12% and Pant Dhan 12 by 11.41%. It matures in about 127 days and has plant height of 92 cm. It has more number of panicles/m² (245) in comparison to Vivek Dhan 62 (232).

**VL 7620**: VL 7620 has shown yield performance of 2,426 kg/ha. VL 7620 out-yielded the check varieties VL Dhan 221 by 47.21%, and Vivek Dhan 154 by 30.15%. It matures in about 110-120 days and has plant height of 95-105 cm.

**Multilocational Evaluation Trial**

A total of 11 trials were conducted as a part of the multi-locational trials. These include 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), IVT-M (H), AVT-U (H), IVT-U (H)], one trial under the Hybrid rice (SVT). Two entries, viz., VL 31407 and VL 31441 of irrigated (early) and one entry VL 31348 of irrigated (medium) have been promoted for the third year of testing, whereas four entries, viz., VL 8158, VL 8051, VL 8116 and
VL 8094 of rainfed upland have been promoted for the third year of testing under AICRP trials.

**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 multi-locational testing. Promising lines selected from advance station trials include VL 11223 (3,193 kg/ha) and VL 11227 (3,041 kg/ha) in rainfed upland spring sown; VL 8040 (2,474 kg/ha) and VL 8608 (2,422 kg/ha) in rainfed upland June sown; VL 31654 (5,271 kg/ha) and VL 31656 (5,000 kg/ha) in irrigated early and, VL 31644 (5,754 kg/ha) and VL 31639 (5,230 kg/ha) in irrigated medium conditions. All these lines were 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, tolerance to drought, disease and insect-pest resistance, desired maturity and plant height, a total of 2,524 progenies derived from 278 crosses were selected in F1 to F4 generations under different ecosystems, viz., rainfed upland (Spring and June sown) and irrigated transplanted conditions (Early and Medium maturity). Under rainfed upland spring sown conditions, 26 plants were selected from 3 crosses of F1 generation. 191 plant progenies from 20 crosses in F1 generation, 474 plant progenies from 34 crosses in F2 generation and 110 plant progenies from 24 crosses in F3 generation were selected for drought tolerance, blast and brown spot resistance and better yielding ability.

Under June-sown rainfed upland conditions, 16 plants were selected from two crosses in the F1 generation. A total of 149 plant progenies derived from 15 crosses in F1 generation, 188 plant progenies from 24 crosses in F2 generation and 79 plant progenies from 12 crosses in F3 generation were selected for drought tolerance, short duration, blast resistance and better yielding ability.

For the irrigated ecosystem, 211 plants were selected from 12 crosses in F1 generation, 347 plant progenies from 37 crosses in F2 generation, 427 plant progenies from 41 crosses in F3 generation and 114 plant progenies from 32 crosses in F4 generation were selected. In this ecosystem more emphasis was given to select short duration plants with resistance against blast. Emphasis is also laid to develop quality rice for the hill farmers. In the breeding programme for the quality (aromatic/slimmer), 139 plant progenies from 17 crosses in F1 generation and 53 plant progenies from 5 crosses in F3 generation were selected in the fine grain aromatic rice. All of them possess fair 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 nursery’, some of the advanced lines found resistant to blast with a score of 3.0 in a scale of 0 to 9. These were VL 11168, VL 11152, VL 11225, VL 11271, VL 31696, VL 8394, VL 8553, VL 8598, VL 8654, VL 8657, VL 31674, VL 31716, VL 31679, VL 31694 and VL 31699.

**Off-season Nursery**

During **n attribute** 2011-12, F1, F2 and F3 generations of the breeding populations covering an area of 1600 m² were grown at the off-season facility at Central Rice Research Institute, Cuttack for the advancement of generation. In addition, seed multiplication of thirteen genotypes was undertaken to increase the seed availability.

**2.1.2.2 Crop Protection Investigations**

**Evaluation for Disease Resistance**

Sixty nine rice entries were evaluated under Donor Screening Nursery (DSN) against blast and brown spot. Entries CB 08-534, CB 09-507, CB 05-754, RP Patho-2 and RP Patho-3 showed high resistance (3 score on 0-9 scale) against leaf and neck blast whereas entries CB 05-022, TNRH 192 and RP Biopatho-3 were promising against brown spot.
In NSN-Hills rice nursery, 77 entries were screened for leaf blast, neck blast and brown spot diseases. Entries like VL 8158, VL 7954, VL 8185, VL 31611, Sukadarhan 1 and IR 64 were found resistant against leaf and neck blast with the score of 2-4, whereas, no entry was found resistant against brown spot.

In advance breeding materials for spring sown, June sown and transplanted conditions, 66 entries were evaluated for leaf and neck blast under artificial epiphytotic conditions. Resistant entries identified include VL 8394, VL 8553, VL 8598, VL 8654 and VL 8657 for June sown; VL 11168 and VL 31152 for spring sown and VL 65, VL 31674 and VL 31716 for transplanted conditions. In addition, 68 VL rice lines were screened for leaf and neck blast. Out of these lines, VL 31289, VL 31290, VL 31430, VL 31611 and VL 31919 showed resistant reaction.

Entomological Investigations

In National Screening Nursery (NSN-H), seventy eight lines were tested and none was found resistant to pink stem borer and leaf folder. Out of thirty entries tested in Multiple Resistant Screening Trial (MRST), five lines, viz., CR 3005-226-7, CR 3006-8-2, TNRH 192, TNRH 244 and TNRH 258 were found to be moderately resistant to pink borer and leaf folder of rice. Brown plant hopper infestation was recorded in the very late stage of rice crop.

2.1.2.3 Agronomic Investigations

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

Five AVT-II entries each of short duration group (IET 21384, IET 21386, IET 21390, IET 21392 and IET 21393) and medium duration group (IET 21374, IET 21375, IET 21377, IET 21378 and IET 21383) were tested at three levels of nitrogen (50, 100 and 150% N/ha of recommended dose). No significant differences were found among various nitrogen levels. The highest grain yield was recorded by RP 2421 (5,956 kg/ha) and IET 21375 (6,793 kg/ha) under short and medium duration groups, respectively.

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

Four AVT-II entries, viz, IET 21318, IET 21319, IET 21320 and IET 21326 with 2 checks (Vivek Dhan 154 and Sukadarhan 1) were evaluated for their growth and yield parameters at three levels of nitrogen. Application of 60 kg N/ha (100% dose) produced the highest grain yield (2,629 kg/ha), however, an increase of 30 kg N/ha affected the yield adversely. IET 21326 (3,026 kg/ha) recorded the highest grain yield followed by Sukadarhan 1 (2,912 kg/ha).

2.1.2.4 Seed Technology Investigations

Study of Storage Potential of Released VL Rice Varieties at Various Temperature Regimes

An experiment was conducted with freshly harvested seed lots of released VL rice varieties (kharif 2010) to evaluate the storage potential at different temperature regimes. Seed lots were targeted to 10-11% moisture content by using glycerol (for humidification) and silica gel (for drying), which were sealed in moisture proof containers and were kept at three temperature regimes (ambient, 5°C and 30°C). Initial germination studies revealed that VL Dhan 221 and VL Dhan 82 were superior with respect to germination percentage, root length, shoot length, seedling length and vigour indices (Table 2.1.1). Whereas in varieties VL Dhan 62 and VL Dhan 65, considerable number of hard seeds were found, i.e., 15 and 21%, respectively. Overnight soaking in water or boiling water treatment for 2 hours were found to be effective in counteracting hard seeds in VL Dhan 62 and VL Dhan 65. Amylograph studies (final viscosity value, a sound quality of seed) also reaffirmed our results and shown that the quality was better in seed lots of VL Dhan 221 and VL Dhan 82.
Table 2.1.1: Seed quality parameters of released VL rice varieties

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<th>Germination (%)</th>
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<th>Shoot length (cm)</th>
<th>Seedling dry weight (g)</th>
<th>Final viscosity</th>
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</tr>
<tr>
<td>VL Dhan 207</td>
<td>96.00 (78.49)</td>
<td>9.00</td>
<td>3.68</td>
<td>0.04</td>
<td>92.08</td>
<td>1217</td>
<td>4.03</td>
</tr>
<tr>
<td>VL Dhan 221</td>
<td>98.66 (83.43)</td>
<td>12.39</td>
<td>5.10</td>
<td>0.04</td>
<td>226.14</td>
<td>1735</td>
<td>5.42</td>
</tr>
<tr>
<td>VL Dhan 82</td>
<td>96.33 (79.10)</td>
<td>12.09</td>
<td>5.39</td>
<td>0.06</td>
<td>213.56</td>
<td>1684</td>
<td>6.13</td>
</tr>
<tr>
<td>VL Dhan 209</td>
<td>97.66 (81.22)</td>
<td>10.39</td>
<td>3.63</td>
<td>0.05</td>
<td>90.73</td>
<td>1370</td>
<td>5.14</td>
</tr>
<tr>
<td>VL Dhan 62</td>
<td>74.33 (59.54)</td>
<td>9.25</td>
<td>2.90</td>
<td>0.04</td>
<td>201.13</td>
<td>909</td>
<td>3.22</td>
</tr>
<tr>
<td>VL Dhan 65</td>
<td>68.33 (55.73)</td>
<td>8.44</td>
<td>3.35</td>
<td>0.05</td>
<td>212.46</td>
<td>805</td>
<td>3.51</td>
</tr>
<tr>
<td>VL Dhan 154</td>
<td>95.33 (77.50)</td>
<td>10.63</td>
<td>4.62</td>
<td>0.05</td>
<td>198.86</td>
<td>1454</td>
<td>4.99</td>
</tr>
<tr>
<td>VL Dhan 208</td>
<td>97.66 (81.22)</td>
<td>9.57</td>
<td>3.81</td>
<td>0.03</td>
<td>89.30</td>
<td>1307</td>
<td>3.71</td>
</tr>
<tr>
<td>CD (0.05)</td>
<td>2.92</td>
<td>0.43</td>
<td>0.35</td>
<td>0.004</td>
<td>2.68</td>
<td>54.16</td>
<td>0.42</td>
</tr>
</tbody>
</table>

(Values in parentheses are arcsine transformed values)

2.1.2.5 Physiological Investigations

An experiment was conducted in twenty rice genotypes, viz., VL 154, VL 221, VL 8394, VL 8412, VL 8549, VL 8551, VL 8553, VL 8559, VL 8587, VL 8590, VL 8598, VL 8608, VL 8654, VL 8657, VL 8707, VL 8083, VL 8040, VL 8214, VL 31587 and VL 31597 to study the genotypic variations in physiological traits. Under the study, 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).

Significant differences were also recorded in days to 50% flowering, days to physiological maturity and grain yield. VL 8214, VL 8587, VL 8707, VL 8549 and VL 8559 exhibited significantly higher grain yield compared to other rice genotypes and 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 and physiological traits. This can be used in rice breeding programmes in future. Among all parameters the biomass showed significantly higher correlation with grain yield.
2.1.3. Wheat

Wheat is the most important cereal crop of rabi season in the North-Western Himalaya with the average productivity of 1,333 kg/ha, which is much below the national productivity of 2,839 kg/ha in 2009-10. It is grown over an area of 0.95 million ha in N-W Himalayas with the average productivity of 928, 1,003 and 2,068 kg/ha in the states of Himachal Pradesh, Jammu and Kashmir and Uttarakhnad, respectively. The present status of production and productivity can be raised by the adoption of high yielding varieties having resistance/tolerance to biotic (yellow rust, 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 0764 - A Genetic Stock for Grains/Spike:**
A genetic stock VW 0764 (HD 3060/YL 830) has been identified for number of grains/spike through All India testing from 2008-09 to 2010-11. On the basis of three years of testing at 52 locations, the grains/spike in VW 0764 were 62.3 as compared to 51 in the best check WH 147.

**VW 0770 - A Genetic Stock for 1000-grain Weight:**
A genetic stock VW 0770 (Lucero/Amigo/VW 2033) has been identified for 1000 grain weight through All India testing from 2008-09 to 2010-11. On the basis of three years of testing at 52 locations, the 1000 grain weight in VW 0770 was 50.3 g as compared to 46.0 g in WH 147, the best check.

Resistant Stocks Developed through Competitive Grant Programme (NATP)

Five promising yellow as well as brown rust resistant genetics stocks, viz., VW 1134, VW 1135, VW 1136, VW 1115, P.No.1537, P.No. 1539 and P.No. 1613 were developed through CGP (NATP) project and were tested at DWR, RS, Flowerdale, Shimla for the two most prevalent pathotypes of yellow rust, viz., 46S119 and 78S84 and brown rust, viz., 121R63-1 (77-5) and 21R55 (104-2). In addition to rust resistance, these stocks have better combining yield components also.

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 rained early sown, rainfed as well as irrigated timely sown and restricted irrigation late sown conditions of Northern Hill Zone (NHZ). Under the rainfed situations, the early sown trials included twenty nine entries, i.e., AVT (13) and Station trial (17). None of the test entry under AVT could surpass the best check VL Gehun 829 (2,650 kg/ha). In station trial also VL Gehun 829 (2,872 kg/ha) the best check was the top yielder followed by VW 20103 (2,452 kg/ha). Eighty-seven entries in four timely sown trials, viz., AVT (10), IVT (25), SVT organic (10) and Station trial (42), were evaluated. TL 2969 (2,510 kg/ha), HS 514 (2,290 kg/ha) in AVT, VL 950 (4,280 kg/ha), HS 537 (3,790 kg/ha), HPW 365 (3,730 kg/ha) and HPW 268 (3,710 kg/ha) in IVT, VL 939 (3,1810 kg/ha) and VL 953 (3,4371 kg/ha) in SVT were found superior in yield. Under the late sown restricted irrigation (pre-sown irrigation only) trials 30 entries (AVT 13, Station trial 17) were evaluated. The entries, viz., HS 545 (3,160 kg/ha), HPW 347 (3,120 kg/ha), VL 946 (3,100 kg/ha) and VL 959 (3,100 kg/ha) yielded at par with the best check VL Gehun 892 (3,330 kg/ha). Under the irrigated conditions, 87 entries were evaluated under four timely sown trials, viz., AVT (10), IVT (25), SVT organic (10) and Station trial (42). TL 2969 (6,300 kg/ha) and HS 514 (3,330 kg/ha) yielded
significantly superior with the best check VL 804 (5,490 kg/ha) in AVT trial, VL 953 (6,570 kg/ha) and VL 954 (6,520 kg/ha) with the best check VL 804 (6,260 kg/ha) in IVT trial and UP 2744 (3,311 kg/ha) with the best check VL Gehun 907 (2,960 kg/ha) in SVT. Out of 69 new bulks generated under the institute breeding programme and evaluated in different station trials under the rainfed as well as irrigated conditions, eleven promising strains were entered in different All India Coordinated Trials of northern hill 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 NHZ. Diverse donors of Winter and Spring wheats were used and 165 fresh crosses [55 Spring × Spring (S×S) and 110 Winter × Spring (W×S) wheat] including two and three way crosses were successfully made. Three hundred and thirty six F$_1$ hybrids were evaluated and 104 better performing F$_1$ hybrids, consisting of 26 S×S and 78 W×S, were identified for growing their F$_2$ generation. The breeding materials were handled following selected bulk pedigree method. F$_1$ and F$_2$ generations were exposed to low fertility and rainfed conditions. A total of 106 F$_2$ 's (i.e., 14 S×S and 92 W×S), and 266 bulk progenies of 266 crosses (169 W×S and 97 S×S) in F$_2$, to F$_2$ generations and 630 single plant progenies (210 S×S and 420 W×S) of 43 crosses in F$_3$, and subsequent generations were subjected to rigorous selection. Rust inoculum received from DWR Regional Station, Flowerdale, Shimla, (H.P.) was multiplied under glass house conditions. The infector 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, 302 bulk and 731 individual plant progenies from F$_3$ generations onward and 70 bulks in F$_4$, 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 such as high protein content, high micro-nutrients, good charpatti and biscuit making quality etc. through hybridization with proven donors. The donors like KYZ 97122, QLD 10, QLD 11, UP 2672, VW 9095, VW 9026, QLD 09, QLD 05 (for protein >14%), QLD 27, QLD 31, QLD 38, QLD 48 (for protein yield), HUW 609, VL 858 (for charpatti quality), QLD 18, HS 490 (for biscuit quality), HPW 298, PQW 114, VW 9032, QLD 27, QLD 31 (for sedimentation value) have been crossed with adapted genotypes. During 2010-11, twenty fresh crosses were attempted. In addition, 21 F$_3$ 's were also evaluated and retained for growing F$_4$ generation. Besides, 24 bulk progenies of 24 crosses and 12 single plant progenies of 3 crosses were selected in F$_4$, 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 68 lines, 7 lines were having >12.0% protein content and >36 ml sedimentation value and have been included in All India Trials (Table 2.1.2).

**Table 2.1.2: The promising strains for wheat quality**

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Protein (%)</th>
<th>Moisture (%)</th>
<th>Starch</th>
<th>Wet gluten</th>
<th>Sedimentation value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VW 20139</td>
<td>12.8</td>
<td>12.3</td>
<td>66.5</td>
<td>31.2</td>
<td>41.9</td>
</tr>
<tr>
<td>VW 20158</td>
<td>13.0</td>
<td>12.4</td>
<td>65.5</td>
<td>31.0</td>
<td>47.8</td>
</tr>
<tr>
<td>VW 20151</td>
<td>12.5</td>
<td>12.3</td>
<td>66.9</td>
<td>30.3</td>
<td>46.1</td>
</tr>
<tr>
<td>VW 20137</td>
<td>12.3</td>
<td>12.7</td>
<td>64.0</td>
<td>28.0</td>
<td>37.6</td>
</tr>
<tr>
<td>VW 20154</td>
<td>12.3</td>
<td>12.6</td>
<td>67.9</td>
<td>30.6</td>
<td>43.0</td>
</tr>
<tr>
<td>VW 20103</td>
<td>12.2</td>
<td>11.7</td>
<td>65.9</td>
<td>29.2</td>
<td>37.0</td>
</tr>
<tr>
<td>VW 20111</td>
<td>12.8</td>
<td>11.8</td>
<td>65.4</td>
<td>30.2</td>
<td>48.8</td>
</tr>
</tbody>
</table>
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 bulks, synthetic lines and other proven component lines. A total of 424 single plant progenies arising out of 85 crosses in F<sub>1</sub>-F<sub>7</sub> generations were evaluated under artificial epiphytotic condition out of which 583 single plant progenies from 68 crosses were selected for their further evaluation. Some promising stocks like VW 0764 (grains/spike=62.3) and VL 0770 (1000 grain weight = 50.3 g) have been identified through multilocation test by the Directorate of Wheat Research, Karnal from this programme. In addition, VW 1138, VW 1141 and VW 1156 genetic stocks were developed and found resistant to both brown and yellow rust pathotypes (Table 2.1.3).

New Avenues for Yield Advancement: Winter x Spring Wheat Hybridization

During 2010-11, twenty five winter and facultative wheat, selected for their high grain yield, tillering, ear length, grain number per ear and disease resistance were planted in the crossing block at the experimental farm, Haryana and crossed to spring wheats like PBW 582, PBW 599, PBW 611, VL 404, VL 829, VL 892, VL 907, VL 914, VL 946, HS 507, MACS 6240, UP 2711, HD 2963, HUW 609, DBW 28 and DBW 37 known for their high yield potential, disease resistance (rust resistance in particular) and adaptation to the major wheat growing regions of the country. Based on the rust resistance analysis parents were further selected for attempting crosses. In addition, three way crosses were also attempted with the F<sub>1</sub> of the previous year by crossing them with selected spring wheat.

A total of 48 crosses were successfully attempted during rabi 2010-11. In addition, 60 F<sub>1</sub>’s made during last season were planted and 45 F<sub>1</sub>’s retained for growing their F<sub>2</sub> generation during the coming season. A total of 50 F<sub>2</sub>’s retained during last year, were raised during rabi 2010-11. The high incidence of yellow and brown rust facilitated the selection. Only negative selection was practiced in these materials and finally these 50 F<sub>2</sub>’s were bulked. These will be supplied for further distribution in the coming crop season to DWR Karnal. Forty-three F<sub>1</sub> bulbs were supplied during rabi 2010-11 to DWR, Karnal. These were further distributed to different coordinating and cooperating centers. Some promising lines generated at DWR, Karnal, under this project are from the crosses of UP 2572/ Wugeng 8025, UP 2556/MY 231-98, 90Zhong65/UP 2572, HUW 548/MV 231-98, UP 2425/ Zander 33 and VL 832/Druchamp/PHR 1012. The seed of 43 F<sub>1</sub> bulbs was shared with 6 cooperators through DWR, Karnal. The utilization report from cooperating centers was 70% at IARI, New Delhi, 100% at NDUAT, Falahabad, 51% at GRPUA&T, Panthagar, 84% at RAU, Sabour, 42% at SDAU, Vijapur and 70% at JNKVV, ZARC Powarkheda for yield components, morphological traits and disease resistance.

Preparedness for Breeding for Resistance against the Killer 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, HW 5103, HW 5104, PBW 583, PHS 822, Raj 4125 and VL 829. A total of 13 fresh crosses were attempted. In

---

Table 2.1.3: Yellow and brown rust resistant genetic stocks

<table>
<thead>
<tr>
<th>No.</th>
<th>Pedigree</th>
<th>Brown rust</th>
<th>Yellow rust</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>12-R53-1</td>
<td>21R55</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>46S19</td>
</tr>
<tr>
<td>YW 1138</td>
<td>PBW500/CMB3.1518</td>
<td>0; 1; 1; 1</td>
<td>1; 1; 1; 1</td>
</tr>
<tr>
<td>YW 1141</td>
<td>HD2844/ VL 864</td>
<td>1; 12; 12; 12</td>
<td>1; 1; 1; 1</td>
</tr>
<tr>
<td>YW 1156</td>
<td>VL 332/SPARTANKA-KAK-HORI-DOLL</td>
<td>1; 1; 1; 1</td>
<td>1; 1; 1; 1</td>
</tr>
</tbody>
</table>

Rust reaction: _0_ = Resistant

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addition, 70 bulk progenies of 70 crosses and 88 single plant progenies of 10 crosses were selected for further evaluation during ensuing season.

**Genetic Resources - Evaluation and Maintenance**

A total of 645 entries comprising of four national and two international nurseries and materials selected at CIMMYT, Mexico and PBI, University of Sydney, Australia 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 (2), yield component (2), high tillers and grains/spike (2), high grain number and grain weight (1), rust resistance and yield components (12). Sixteen genotypes were selected from the Short Duration Screening Nursery. Similarly, thirteen genotypes, having high protein, high protein yield, good chapati and biscuit quality were selected from Quality Component Screening Nursery (QCSN). Besides, 20 local wheat germplasm (collected through exploration in Uttarakhand) were evaluated and deposited for long term storage. Ninety-five lines were selected from the international nurseries, materials selected from CIMMYT and Australia.

**Off-season Nursery**

During kharif/2011, 30 F_j's were grown at the off-season facility at Dalang Maidan, Lahaul Spiti (HP) and selections were made. In addition, 649 advance lines were planted at Dalang Maidan as well as at IARI Regional Station Wellington (TN) for screening against yellow and brown rust, respectively. BC, F_j of VL Gehun 738/ FLW 13, VL Gehun 738/ Moro were also planted for attempting back crosses. Out of these, 243 lines having desirable rust reaction were selected and on over all basis 70 lines were selected. Grow out test of two seed lots of farmers' participatory wheat seed was found satisfactory.

**2.1.3.2 Crop Protection Investigations**

One thousand and eighty nine wheat lines/ entries were evaluated under artificial/natural conditions in various nursery namely, VL Rust Screening Nursery (VLRSN), Hill Bunt Screening Nursery (HBSN), Loose Smut Screening Nursery (LSSN), Powdery Mildew Screening Nursery (PMSN), Leaf Blight Screening Nursery (LBSN), Elite Plant Pathological Screening Nursery (EPFSN) and Multiple Disease Screening Nursery (MDSN), SAAAC Wheat Disease Trap Nursery and Wheat Disease Monitoring Nursery (coordinated by DWR Regional Station, Flowerdale, Shimla). Promising lines in station nurseries were identified (Table 2.1.4).

Wheat genotypes VW 0513, VW 0636, VW 0751, VW 0752, VW 0810, VW 0855, VW 0856, VW 0911, VW 0912 and 0954 showed immune reactions to both hill bunt and loose smut over the years of screening. In EPFSN, VL 914, VL 925, VL 930, VL 931, VL 943, VL 944,

<table>
<thead>
<tr>
<th>Nursery</th>
<th>No. of lines screened</th>
<th>Promising lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>VLRSN</td>
<td>175</td>
<td>VW20101, VW20102, VW20104, VW20109, VW20110, VW20112, VW20114, VW20126, VW20133, VW20144, VW20150, VW20152, VW20158, VW20163, VW20164, VW20165, VW20166, VW20167, VW20168</td>
</tr>
<tr>
<td>HBSN</td>
<td>99</td>
<td>VW20112, VW20114, VW20115, VW20124, VW20125, VW20143, VW20155, VW20166, VW20167, VW20168</td>
</tr>
<tr>
<td>LSSN</td>
<td>127</td>
<td>VW0806, VW0911, VW0912, VW0920, VW0924, VW0926, VW0933, VW0939, VW0948, VW0950, VW0951, VW0955, VW0963, VW0964, VW0965</td>
</tr>
<tr>
<td>PMSN</td>
<td>89</td>
<td>VW20116, VW20120, VW20128, VW20133, VW20144, VW20150, VW20152, VW20158, VW20163, VW20164, VW20165, VW20166, VW20168</td>
</tr>
<tr>
<td>LBSN</td>
<td>89</td>
<td>VW20114, VW20115, VW20116, VW20118, VW20120, VW20163, VW20164, VW20165, VW20166, VW20168</td>
</tr>
</tbody>
</table>
VL 946 maintained their resistance against yellow rust when screened at VPKAS Experimental farm, Hamalbagh. In HBSNL, VL 941, VL 955, VL 956, VL 959 and VL 804 were found immune to hill bunt. Wheat genotypes developed at VPKAS, Almora were evaluated at different locations in the country under AICRP through the Directorate of Wheat Research, Karnal. Multi-location testing of wheat genotypes showed that VL 907, VL 920, VL 926, VL 934 were resistant to all the three rusts (yellow, brown and black rusts) and flag smut whereas VL 907 and VL 920 were also found resistant to powdery mildew. Popular variety VL Gehun 829 was highly resistant to loose smut, leaf blight and resistant to Karnal bunt. Among wheat lines evaluated against black rust race Ug99 at Kenya through DWR, Karnal during 2010 crop season, entry VL 944 was found resistant. Sixteen samples of wheat yellow rust were analyzed at DWR Regional Station, Floridale, Shimla collected from Almora, Nainital and Haridwar districts. Four pathotypes namely, 46S119 (8 samples), 78S84 (6 samples), K (47S102) and U (102S100) in one sample each were identified.

2.1.3.3 Agronomic Investigations

Effect of Row Spacing on Performance of Wheat

Row spacing 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). All reduced spacing recorded significantly higher grain yield than recommended spacing. Spacing of 17.5 cm provided the highest grain yield which was at par with 15.0 and 20.0 cm. Among genotypes, VL Gehun 907 recorded significantly higher grain yield (7,510 kg/ha) than rest genotypes.

The response of row spacing to wheat grain yield was quadratic (Fig. 2.2), indicating increase in grain yield with increase in row spacing up to a certain spacing, and then decreased with further increase in spacing. From the quadratic response equation, it was estimated that maximum grain yield of 60.6 q/ha could be achieved with row spacing 17.4 cm. At this point the response curve tended to level off. It was estimated that 95.3 kg increase in grain yield per cm decrease in row spacing from recommended spacing (22.5 cm) up to 17.4 cm spacing. Further reduction in spacing would decrease the grain yield.

Fig. 2.2. Response of wheat grain yield to row spacing

Performance of New Wheat Genotypes at Different Dates of Sowing under Irrigated Condition

HS 514, TL 2969 and HS 507 were evaluated against three checks (viz., HS 240, VL 804 and TL 2942) at normal and late sown irrigated condition. None of the genotypes provided significantly more grain yield than the best check, VL 804 (6,330 kg/ha), although HS 514 performed best (6,410 kg/ha) among all genotypes. There was no significant difference between the normal sown (5,900 kg/ha) and the late sown condition (5,640 kg/ha). The interaction between genotype and date of sowing was significant. TL 2942 and HS 507 recorded significantly higher grain yield in normal sown condition than late sown condition.

Performance of New Wheat Genotypes at Different Nitrogen Levels under Rainfed Condition

HS 514, TL 2969 and HS 507 were evaluated against three checks (viz., HS 240, VL 804 and TL 2942) with three nitrogen levels (40, 60 and 80 kg N/ha) in rainfed condition. HS 514 (4,010 kg/ha) and TL 2942 (3,900 kg/ha) recorded significantly higher grain yield than all checks. The grain yield significantly increased as the level of N increased from 40 kg (3,160 kg/ha) to 80 kg N/ha (4,040 kg/ha).
2.1.4. Small Millets and Under-utilized Crops

Small millets and other under-utilized crops are the traditional rainfed crops of North-Western Himalayas 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 229.6 thousand ha in North-Western Himalayas and their productivity is 1,284.8 kg/ha. These crops occupy relatively larger area (210 thousand ha) in Uttarakhand with relatively higher productivity (1,343 kg/ha) as compared to Himachal Pradesh and Jammu and Kashmir. Development of short duration, high yielding varieties of millets having tolerance to diseases is the main activity.

2.1.4.1. Varietal Improvement

Variety Released

**VL Mandua 347**: VL Mandua 347 has been developed from the cross VR 708 (Early duration) × VL 149 (Blast resistant, High yielding). It is short duration (95-100 days) and high yielding variety (2,250 kg/ha). In Bihar, Gujarat, Jharkhand, Karnataka, Madhya Pradesh and Uttarakhand, its yield level surpassed the check variety VR 708 by 10% and was found to be moderately resistant to blast. VL Mandua 347 will be suitable for those areas where monsoon gets delayed or drought is a common phenomenon, higher hills (where crop growth period is limited) and also for alternative planning. The iron and zinc contents of VL Mandua 347 (iron 7.9 mg/100 g; zinc 3.56 mg/100 g) are 39.75 and 339% higher than check VR 708 (iron 5.66 mg/100 g; zinc 0.81 mg/100 g), respectively. The protein content of VL Mandua 347 is at par with VR 708. Varietal identification committee on small millets recommended the release and notification of this variety for Bihar, Gujarat, Jharkhand, Karnataka, Madhya Pradesh and Uttarakhand states. The variety is under notification by the CVRC.

Varietal Trials

Ten varietal trials comprised of five in finger millet, three in barnyard millet and one each in amaranth and rice bean with 204 genotypes were conducted in order to identify improved genotypes for North Western hill zone.

Finger Millet

Adaptability Evaluation of Brown Grained Finger Millet Strains

One hundred and ten finger millet genotypes were evaluated for yield and yield contributing characters. The promising genotypes superior to checks were identified in Advance Varietal Trial (AVT), Initial Varietal Trial (IVT), State Varietal Trial (SVT) and Station Trial. VL 352 (3,980 kg/ha), VL 353 (3,757 kg/ha) and PRM 9002 (3,680 kg/ha) in AVT; VL 349 (3,230 kg/ha) and VL 348 (2,988 kg/ha) in IVT; RH 901 (1,847 kg/ha) and RH 907 (1,765 kg/ha) in SVT under organic cultivation; VR 508 (4,521 kg/ha) and VR 512 (4,290 kg/ha) among medium duration and, VR 500 (3,611 kg/ha) and VR 516 (3,383 kg/ha) among early duration in Station trial were found to be superior than checks.

Adaptability Evaluation of White Grained Finger millet Strains

Sixteen white grained lines were bulked at F₃ generation in 2010. These lines along with parents were evaluated for yield and yield contributing
factors in 2011. Lines namely, VR 441 (4,020 kg/ha, maturity 99 days), VR 443 (3,980 kg/ha, maturity 99 days), VL 356 (3,842 kg/ha, maturity 96.5 days) and VL 360 (4,089 kg/ha, maturity 96.5 days) were identified as genetic stock for higher yield and early maturity in white grained finger millet.

Development of New Strains

During kharif 2011, thirty new cross combinations were attempted involving released varieties or good agronomical lines RAU 8, GPU 45 or VL 330 (high yielding but late in maturity), local adapted material VL 146, VL 201 (early but blast susceptible), VL 356 and VL 360 (early white grained but less grain yield) and donors as early maturing genotype (VL 347), blast resistant genotypes (GPHCPB 52, PRM 701, VL 149), agronomical superior genotypes (IE 4502, VL 330) and high calcium genotypes (GPHCPB 45, GE 86). In F₁ generation, out of 36 crosses attempted during 2010, 26 crosses are suspected to be true hybrids. In F₂ generation, seven crosses advanced from F₁ crosses planted at Almora during kharif 2010 and four crosses advanced from F₁ crosses planted at Mandya during nahi 2010-11, both the advanced material planted during kharif 2011 at VPKAS experimental farm, Havelabagh and 303 superior plants were selected from 10 crosses. In F₃ generation, 175 progenies of ten crosses were grown and 290 single plants were selected involving 9 crosses. In F₄ generation, 127 progenies of 7 crosses were planted and 166 superior single plants were selected and 4 bulks were made. In F₅ generation, 20 progenies of 3 crosses were planted and 27 superior single plants were selected and 2 bulks were made. In F₆ generation, 17 single plant selections were made from 73 progenies of 10 crosses and 46 uniform progenies were bulked.

Barnyard Millet

Forty-three genotypes were evaluated for yield and yield contributing characters in Barnyard millet Advance Varietal Trial (BAVT), State Varietal Trial (SVT) and Station Trial. TNAU 141 (4,324 kg/ha), PB 903 (3,556 kg/ha) in BAVT, whereas JH 1008 (1,334 kg/ha) in SVT, VB 495 (2,418 kg/ha) VB 512 (2,416 kg/ha) and VB 506 (2,414 kg/ha) in Station trial were found superior to the checks.

Development of New Strains

During kharif 2011, twenty-one fresh crosses were attempted in barnyard millet involving local adapted material, viz., VL Madira 172, VL Madira 29, K 1, VL 198, VL 200, VL Madira 207 and VL Madira 181; and agronomical superior genotypes, viz., GECH 779, GECH 271, GECH 204 and HCBMG 1011 as donors. In barnyard millet, all 11 crosses attempted during 2010 are suspected to be true hybrids. In F₁ generation, 13 crosses were planted and 59 superior single plants were selected from 12 crosses. In F₂ generation, 244 superior single plants involving 16 crosses were planted and 376 superior plants were selected and one bulk was made. In F₃ generation, 109 progenies of 7 crosses selected and 124 single superior plants which showed resistance to grain smut, one uniform progeny was bulked. Two plants were selected and 12 bulks were made from 28 progenies of 7 crosses grown in F₃ generation. In F₄ generation, only one plant was selected and 3 bulks were made from four families of a cross VL 199 × IEC 76.

Germplasm Evaluation

Barnyard millet core collection obtained from ICRI SAT comprising of 89 lines along with 5 check varieties were evaluated in augmented design. The genotypes were evaluated for fourteen quantitative and eight qualitative characters. The wide range of variation was observed for days to flowering (29-66 days), maturity (56-105 days), plant height (71-220 cm), inflorescence length (10.1-29.7 cm), raceme number (9-66) and grain weight/ear (0.42-8.42 g). The range of variation in different agro-morphological characters in barnyard millet germplasm is depicted through box plots in Fig. 2.3 and Fig. 2.4. The box represents the mean ± one standard deviation (SD), with error bar of one SD beyond the box. The name of the donors identified for yield per plant is mentioned against star mark.
Underutilized Crops

One trial each of amaranth and rice bean was conducted in which 28 genotypes were evaluated. Genotypes PRR 2011-1 (2,147 kg/ha), RBHP 30 (1,948 kg/ha) in rice bean and IC 38156 (1,730 kg/ha), PRA 2011-2 (1,700 kg/ha) in grain amaranth were found superior to the respective checks.

Development of New Strains

Rice Bean: Ten crosses were attempted involving determinate parents (PRR-2007-1, PRR 2007-2), indeterminate parent (ICM 104011) and local adaptive material VRB 1 or promising material LRB 489, LRB 490, LRB 491 and LRB 496. Twenty eight single plants involving six crosses in F1 generation, 28 single plants involving 6 crosses in F2 generation, 19 single plants involving five crosses in F3 generation and 5 single plants involving two crosses in F4 generation were selected.

Amaranth: One new cross was attempted involving parent IC 42334 × PLP 1. Single plant was selected from a cross involving VL 44 and PLP1 in F1 generation, while, 6, 3 and 2 single plants were selected in crosses involving parents VL 44 × PLP 1, VL 44 × GA 2 and Annapurna × GA 2, respectively in the F2 generation. In F3 generation, 11 superior single plants were selected in a cross involving parents IC 35407 × PLP 1 and 2 bulks were made.

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 9 quantitative characters. Accessions IC 38378, IC 38373 and IC 38164 recorded grain yield per plant > 30 g, while accessions IC 38316, IC 38378 and IC 38169 exhibited inflorescence length > 70 cm. IC 38301 was found early flowering (55 days) and early maturing (<88 days).

Rice Bean: Fifty rice bean accessions along with four checks namely, RBL 1, RBL 6, PRR 1 and PRR 2 were evaluated in augmented block design for 8 quantitative and 8 qualitative traits. The

<table>
<thead>
<tr>
<th>Traits</th>
<th>Promising accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>50% flowering ≤ 77 days</td>
<td>LRB 448</td>
</tr>
<tr>
<td>Days to maturity ≤ 130 days</td>
<td>LRB 472</td>
</tr>
<tr>
<td>Pod length ≥ 10.6 cm</td>
<td>LRB 457, LRB 461</td>
</tr>
<tr>
<td>Seeds per pod ≥ 10</td>
<td>LRB 225, LRB 448, LRB 468, LRB 488</td>
</tr>
<tr>
<td>100 seed weight &gt; 7 g</td>
<td>LRB 477</td>
</tr>
<tr>
<td>Yield per plant ≥ 30 g</td>
<td>LRB 471, LRB 475, LRB 311, LRB 356</td>
</tr>
</tbody>
</table>
promising accessions identified for various quantitative traits have been given in table 2.1.5.

**Mutation Breeding (Exploratory)**

One variety each in finger millet (VL Mandua 149), barnyard millet (VL Madira 207) and Amaranth (VL Chua 44) were subjected to three doses of gamma irradiation (30, 50 and 70 K), chemical mutagen ethyl methane sulphonate (0.15, 0.30 and 0.45%) and one combined treatment (30Kr + 0.30%). The M<sub>1</sub> generation was grown in the season. Germination was good in all the doses but plants survival was very poor in 70Kt treatment. Visible effects of mutagens were observed on the plants.

**2.1.4.2. Crop Protection Investigations**

**Evaluation for disease resistance**

A total of 170 finger millet entries were evaluated for resistance against leaf, neck and finger blast in coordinated and station nurseries whereas in barnyard millet, 41 entries were evaluated against grain smut in different nurseries. Among the IVT entries of finger millet, VL 348, VL 349 and VL 361 were found resistant to neck and finger blast. In AVT entries, VL 953 was resistant to neck and finger blast whereas VL 952 and VL 959 showed resistance to neck blast but were moderately resistant to finger blast. In the VL Disease Screening nursery, 68 entries were screened and VR 402, VR 413, VR 429, VR 448, VR 450, VR 454, VR 456, VR 457, VR 459, VR 461, VR 464, VR 467, VR 468, VR 471, VR 476, VR 477, VR 484, VR 490, VR 492, VR 494, VR 497, VR 500, VR 506, VR 518 were found promising against neck and finger blast. In National Screening Nursery (NSN), BUA 13, GE 1126, GE 4929, GE 4973, GE 5198, GE 6765, GE 6768, GE 6870, TNAU 1198, TNAU 1204, TNAU 1206 and TNAU 1212 were found promising against blast disease.

In barnyard millet, PRB 903 and TNAU 141 were found highly resistant to grain smut whereas VL 172, VL 207, VL 223, VL 224, VL 229, VL 230, VL 232, VL 234, VL 235 were moderately resistant. In station nursery, VB 493 and VB 519 have shown high resistance whereas VB 10, VB 512, VB 514, VB 515, VB 520, VB 521 were found moderately resistant.

**2.1.4.3. Agronomic Investigations**

**Response of Pre-released Finger Millet Varieties to Different Levels of Nitrogen under Rainfed Condition**

Four pre-released medium duration finger millet varieties (DM 7, TNAU 1066, OEB 532 and PPR 2885) were evaluated to different levels of nitrogen (0, 20, 40 and 60 kg N/ha) under rainfed condition. A check variety RAU 8 (2,117 kg/ha) recorded the highest yield among all entries. Highest yield was recorded at 60 kg N/ha (1,925 kg/ha) which was at par with the yield at 40 kg N/ha (1,902 kg/ha).

**Response of Pre-released Barnyard Millet Varieties to Different Levels of Nitrogen under Rainfed Condition**

Three promising pre-released barnyard millet varieties, viz., VL 224, TNAU 141 and PRB 901 were evaluated to different N levels (0, 20 and 40 kg N/ha). VL 224 performed best (2,503 kg/ha) followed by TNAU 141 (2359 kg/ha). Application of 20 kg N/ha produced the highest grain yield (2,312 kg/ha), however, an increase of 20 kg N/ha affected the yield adversely.
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 59.4 thousand ha with an average productivity of 810.30 kg/ha (2009-10). 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

Adaptability Evaluation of Newly Developed Strains

To identify high yielding disease resistant genotypes, 68 new barley strains were evaluated in four different trials. In AVT timely sown rainfall trial, VLB 118 (3,150 kg/ha) performed better than the best check UPB 1008 (2,900 kg/ha) and was in 1st non-significant group. Under the SVT (organic) timely sown rainfall trial, VLB 118 (4,311 kg/ha), PRB 902 (4,122 kg/ha), UPB 1015 (4,101 kg/ha), UPB 1022 (3,883 kg/ha) and UPB 1023 (3,869 kg/ha) performed superior than the best check PRB 502 (3,789 kg/ha). Out of 36 new bulks generated through institute breeding programme and evaluated in station trials under rainfed condition, six promising strains were nominated in to the All India Coordinated Trials of Northern Hill Zone.

Development of New Strains

To develop high yielding disease resistant genotypes, 220 introduced materials were evaluated. Thirty high yielding disease resistant genotypes were selected for further evaluation during the ensuing season.

Off-season Nursery

During kharif 2011, 101 advance lines of the breeding materials were grown at the off-season facility at Dalang 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

One hundred and ninety one barley entries of National Barley Disease Screening nursery (NBDSN) and Elite Barley Disease Screening nursery (EBDSN) from All India Coordinated Barley Network (DWR, Karnal) were evaluated during the year. On the basis of multi-location testing, VL barley entries VLB 123 and VLB 124 were highly resistant to leaf and stem rusts (ACI=0.0) whereas VLB 123 was moderately resistant to leaf blight. VLB 118, VL 124 and VL 127 also showed low ACI to yellow rust. VLB 118 has been found to be resistant to powdery mildew and categorized as confirmed source of resistance for powdery mildew based on two years data under coordinated evaluation.

Three samples of barley yellow rust from Nainital district analyzed at DWR Regional Station, Flowerdale, Shimla, yielded pathotype G (480) in 2 samples and pathotype M (150) in one sample.

2.1.5.3. Agronomic Investigations

Evaluation of Dual Purpose Barley Varieties for One Irrigation in NHZ

Three genotypes of barley, i.e., BHS 169, HBL 276 and HBS 380 were evaluated for dual purpose in different irrigated and cut condition. There was no significant difference for grain yield between one irrigation (3,220 kg/ha) and no irrigation (2,870 kg/ha).

No cut condition provided significantly higher grain yield (3,220 kg/ha) than single cut (2,870 kg/ha) at 70 DAS. Among the genotypes BHS 169 produced significantly higher grain yield (3,440 kg/ha) than rest genotypes. HBL 276 provided significantly higher fodder yield (1,600 kg/ha) than rest genotypes.
2.1.6. Pulses and Oilseeds

Pulses and oilseeds are important rainfed crops for marginal lands. The total pulse production in North-Western Himalayas is 80.3 thousand tones from an area of around 124.1 thousand hectare with an average productivity of 618.6 kg/ha as against national productivity of 630.0 kg/ha. The total oilseed production in North-Western Himalayas is 86.5 thousand tones from the area of 108.1 thousand hectare and the average productivity of oilseed is 724.0 kg/ha against the national productivity of 959.0 kg/ha (2009-10). Development of high yielding varieties suitable for cropping system with matching agro-technology is a challenging area of research for increasing the area and productivity of pulses and oilseed crops in the hills.

2.1.6.1. Varietal Improvement

Three varieties, viz., VL Masoor 514, VL Masoor 133 of lentil and VL Matar 47 of fieldpea were released by SVRC for timely sown rainfed conditions of Uttarakhand hills in 2011. These varieties are suitable for growing under organic conditions.

**VL Masoor 514:** Bold seeded (100 seed weight 3.05 g), brown seed coat with minute spots and globose flat seeded variety developed from the cross VL 501 × VL 103. Its average yield is 1,000-1,200 kg/ha. It has 21.13% protein content, and was found moderately resistant to wilt and rust diseases.

**VL Masoor 133:** It is a high-yielding small seeded variety of lentil, which is developed from the cross VL 103 × DPL 58. Its average yield potential is 1,200-1,600 kg/ha. It has 24.06% protein content, and was found resistant to wilt and moderately resistant to rust.

**VL Matar 47:** VL Matar 47, a high-yielding medium-tall with partly aphillus leaves field pea variety developed from JVP 14 × HFP 4. Its yield potential ranged from 1,100-2,000 kg/ha and matures in about 142-155 days. It has 21.04% protein content and was found resistant to powdery mildew and moderately resistant to rust.

**Varieties Identified**

**VLGN 9:** VLGN 9 is a groundnut genotype suitable for timely sown rainfed conditions of Uttarakhand hills. It has shown significant yield superiority of 71.59% (1,792 kg/ha) over the best check VLGN 1 over three years of testing under organic mode in Uttarakhand hills.

**VLS 73:** VLS 73 is an early soybean genotype suitable for timely sown rainfed conditions of Uttarakhand hills. It has shown significant yield superiority of 35% (1,117 kg/ha) over the best check PRS 1 over three years of testing under organic mode in Uttarakhand hills.

**VLT 8:** VLT 8 is a toria entry, suitable for timely sown rainfed conditions of Uttarakhand hills. VLT 8 has shown significant yield superiority of 21.62% (630 kg/ha) over best check VLT 3 and 64.46% over Pant Toria 503 over three years (2008-09 to 2010-11) of testing under organic mode in Uttarakhand hills. Its yield potential ranged from 500-1,000 kg/ha and it matures in about 140-154 days and oil content 39.43%.

**Variat trials**

Five hundred and ninety-six entries of eight crops, viz., lentil (175), field pea (94), toria (6), flax (7), soybean (176), horse gram (78), groundnut (30) and pigeon pea (30) were evaluated for yield
and other characters during rabi and kharif seasons. Efforts for development of new strains were made in lentil, field pea, soybean and horse gram.

**Lentil**

*Varietal Adaptability Evaluation*

One hundred seventy-five entries of lentil were tested in nine trials along with suitable checks. A total of 25 entries were short listed in advance and initial station trials. VLM 2010-104 (2,000 kg/ha), VLM 2009-6 (1,923 kg/ha) and VLM 204-7 (1,787 kg/ha) were found superior among the bold seeded and VLM 2010-12 (1,956 kg/ha), VLM 2010-19 (1,811 kg/ha) and VLM 2010-22 (1,793 kg/ha) were found superior among the small seeded entries. In joint small and bold seeded SVT trial, 10 entries were evaluated. VL 520 bold seeded genotype showed yield superiority of 16.63% (1,206 kg/ha) over best check VL Masoor 507 (1,034 kg/ha).

**Development of New Strains**

Efforts were made to transfer higher number of pods coupled with high yield from *microsperma* and bold seeded trait from *macroasperma* to genotypes with better tolerance to biotic and abiotic stresses.

Eighty-nine fresh crosses were made involving fifteen purposely selected parents. Fifty-four F1 and one hundred two F2 crosses were advanced to the next generation. 1,739 progenies were selected from F1 to F3 generations. Seventy uniform bulks were selected for further testing in terms of yield and other characters.

**Field Pea**

*Varietal Adaptability Evaluation*

Ninety-four entries of field pea were tested in five trials along with suitable checks. A total of 15 entries were short listed in Advance and Initial Station Trials. VP 2003-19 (1,867 kg/ha) and VP 2006-21 (1,721 kg/ha) were found superior in the Advance Station Trial whereas VP 2010-8 (1,847 kg/ha) and VP 2010-24 (1,569 kg/ha) were superior in Initial Station Trial. In State varietal trial, 9 entries were evaluated. VL 54 (2,310 kg/ha) and VL 55 (2,310 kg/ha) showed yield superiority of 10.26% over best check Pant P 14 (2,095 kg/ha). Both the genotypes were promoted to the next year testing.

**Development of New Strains**

Efforts are continued to develop more productive and disease resistant genotypes. Fifty-four fresh crosses were made involving seventeen selected parents. The parents were selected on the basis of yield and yield components and, resistance to biotic and abiotic stresses. Sixty-two F1 and seventy-three F2 crosses were advanced to the next generation. One thousand seventy-two progenies were selected from F1 to F3 generations. Thirty-four bulk progenies were selected for further testing in terms of yield and other traits.

**Evaluation of Germplasm**

One hundred thirty-six field pea germplasms were grown during rabi 2010-11 and data were recorded on 16 characters. Twenty-two promising accessions were selected which exhibited variation in seed size, plant height (32-180 cm), days to 50% flowering (76-110 days), days to maturity (135-155 days), number of pods per plant (10-20), pod length (3.8-8.0 cm), number of grains per pod (4-6), 100 seed weight (12.5-22.0 g) and seed yield per plant (4.62-18.0 g).

**Soybean**

*Varietal Adaptability Evaluation*

One hundred seventy-six entries of soybean were tested in eight trials along with suitable checks. Four entries, viz., VLS 81, VLSB 201, VLS 75 and VLS 76 are in different stages in coordinated programme. In AVT-II, VLS 75 (2,841 kg/ha) has shown significant yield superiority of 9.2% over best check VLS 63, 16% over VLS 59 and 25% over Bragg, over three years of testing. In AVT-I, there was only one test entry VLS 76 which yielded 2,854 kg/ha in comparison to best check VLS 63 (2,539 kg/ha). In State Varietal Trial, VLS 77 (2,259 kg/ha) has shown significant yield superiority of 13.72% over the best check VLS 63 (1,948 kg/ha). Amongst the various entries tested in the Early Station Trial VS 2007-2
(3,205 kg/ha) and VS 2007-29 (3,010 kg/ha) were found to be earliest in maturity (105 days). A total of 17 entries were short listed in Advance and Initial Station Trials. VS 2008-1 (2,765 kg/ha) and VS 2009-49 (2,592 kg/ha) were found superior in the Advance Station Trial whereas VS 2010-3 (4,074 kg/ha) and VS 2010-12 (3,925 kg/ha) were superior in the Initial Station Trial. Nine entries were selected in bhat advance and initial station trials. VSB 2008-50 (2,617 kg/ha) and VS 2010-115 (2,444 kg/ha) were found superior over the check VL Bhat 65 (1,531 kg/ha).

Development of New Strains

Forty-six fresh crosses were made involving twenty-one 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, quality and resistance to frogeye leaf spot. Seventy-two F1 and eighty-two F2 crosses were advanced to the next generation. One thousand six hundred seventy-seven individual plants were selected from F2 to F3 generations. One hundred fifty bulk progenies selected for further testing in terms of yield and other traits.

Black soybean, popularly known as ‘Bhai’ 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, determinate growth habit, stiff stem and earliness.

Horse Gram

_varietal adaptability evaluation

Seventy-eight entries of horse gram were tested in five trials along with suitable checks. One entry VLG 31 was tested in coordinated programme. A total of twenty-three entries were short listed in the Advance and Initial Station Trials. VLG 2009-135 (805 kg/ha) and VLG 2009-117 (800 kg/ha) were superior in Advance Station Trial whereas VLG 2009-119 (1,185 kg/ha) and VLG 2010-12 (1,081 kg/ha) were superior in Initial Station Trial. Five entries were tested in State Varietal Trial under organic mode. VLG 31 (757 kg/ha) has shown yield superiority of 11.98% over the best check VLG 15 (676 kg/ha).

Development of New Strains

Forty-eight fresh crosses were made involving eight 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, quality and disease resistance. Twenty-eight F1 and eighty-one F2 crosses were advanced to next generation. Two thousand nine individual plants were selected from F2 to F3 generations. Sixty bulk progenies were selected for further testing.

Evaluation of Germplasm

A total of 72 horse gram lines were grown during 2011 and data was recorded on 10 characters. Twenty promising accessions were selected which exhibited variation in seed size, plant height (37-78 cm), days to 50% flowering (56-67 days), days to maturity (89-99 days), number of pods per plant (14-32), pod length (4.2-5.1 cm), number of grains per pod (6-7) and 100 seed weight (2.4-3.6 g).

Groundnut

_varietal adaptability evaluation

Thirty entries of groundnut were tested in three trials along with suitable checks. Seven entries were tested in Initial Station Trial under organic mode. In State Varietal Trial, VLG 13 (2,541 kg/ha) has shown mean yield superiority of 28.90% on the check VL Moongfali 1 (1,958 kg/ha) over three years of testing. Twelve medium maturity entries from ICRISAT were evaluated. None of the entries performed better than check VL Moongfali 1.

Toria

_varietal adaptability evaluation

Six entries were tested in the State Varietal Trial under organic mode. VLT 8 (630 kg/ha) has shown significant yield superiority of 21.62% over best check VLT 3 and 64.46% over the Pant Toria 303 over three years (2008-09 to 2010-11) of period
of testing under organic mode in the Uttarakhand hills. Its yield potential ranged from 500-1,000 kg/ha and matures in 140-154 days.

**Pigeon Pea**

*Varietal Adaptability Evaluation*

Thirty entries of pigeon pea were tested in three trials along with suitable checks. In Initial Station Trial (Non-determinate), two entries ICPL 20329 (2,083 kg/ha) and ICPL 20335 (1,646 kg/ha) were found superior to the check VL Arhar 1 (1,446 kg/ha). In Initial Station Trial (Determinate), only one entry ICPL 20341 (988 kg/ha) was found superior to the check MN 1 (956 kg/ha).

**Flax**

*Varietal Adaptability Evaluation*

Seven entries of flax were evaluated. FT 895 (862 kg/ha), FT 897 (800 kg/ha) and JRF 1 (755 kg/ha) performed well in the trial.

**Genetic Resources**

During 2010-11, a total of 47 accessions of lentil (11), horse gram (13) and soybean/bhat (23) were shared with different scientists for utilization in the breeding programme.

**Evaluation and Maintenance of Genetic Resources**

Two thousand one hundred and ten accessions of different pulse and oilseed crops were maintained during navi 2010-11 and kharif 2011 (Fig. 2.5).

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### Table 2.1.6: Evaluation of Soybean genotypes against Frogeye Leaf Spot disease

<table>
<thead>
<tr>
<th>Category</th>
<th>Genotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistant and High Yielding (R-HY)</td>
<td>PS 1477, MACS 1336, VLS 75, VLS 76, NRC 85</td>
</tr>
<tr>
<td>Resistant and Low Yielding (R-LY)</td>
<td>AMS 243, AMS-MB-5-18, CSB 08-08, DSb 16, DSB 20, KDS 344, MACS 1281, NSO 81, SL 799</td>
</tr>
<tr>
<td>Susceptible and High Yielding (S-HY)/Tolerant</td>
<td>AMS-MB-5-19, PS 1476, SL 871, VLS 2</td>
</tr>
<tr>
<td>Susceptible and Low Yielding (S-LY)</td>
<td>BAUS 40, CSB 08-09, DS 12-5, DS 12-13, DS 26-14, DS 27-11, DSB 18, JS 20-29, JS 20-34, JS (SH) 2003-8, KBS 8, KS 103, MACS 1140, MACS 1201, MACS 1311, MAUS 449, MAUS 453, NRC 86, PS 1466, RKS 63, SL 778, SL 794, SL 795, Shivalik</td>
</tr>
</tbody>
</table>

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In soybean advance station trial, entries VS 2007-31, VS 2009-49, VS 2008-1, VS 2009-43 and VS 2009-8 were found moderately resistant to FLS whereas in bhat VB 2010-105 and VB 2010-115 were most promising.

**Horse gram:** In the horse gram advance station trial, VLG 2008-39, VLG 2008-135, VLG 2009-117,
VLG 2009-118, VLG 2009-136, VLG 2009-138 and VLG 2009-141 were found promising against anthracnose.

**Groundnut:** In groundnut, 16 entries of 12th International Medium Maturity Groundnut Nursery from ICRI SAT were screened against tikkka disease. None of the entries showed resistance, however, only VL Monongali 1 was found to be moderately resistant.

**Lentil:** Lentil entries VLM-2010-105, VLM-2010-123, VLM-2010-132, VLM-2010-137 (all bold seeded), VLM-2010-21, VLM-2010-22, VLM-2010-23, VLM-2010-24 (all small seeded) were found promising against wilt.

**Chickpea:** Thirty entries of International Chickpea Ascochyta Blight Nursery from ICRI SAT, Hyderabad were screened under artificial inoculation conditions. Out of 30 entries, only six entries namely, ICCV 05502, ICCV 05555, ICCV 05557, ICCV 08312, EC 516720 and EC 516874 showed moderately resistant reaction to ascochyta blight.

**Evaluation for Insect Resistance**

**Soybean:** In initial varietal trial, among 42 entries screened, IVT 3, IVT 5, IVT 9, IVT 11, IVT 19, IVT 31, IVT 32 and IVT 33 were found moderately resistant to leaf beetle (*Platypus hystrics*) and sucking bug (*Chauliops chopardi*) damage. In advanced varietal trial, VLS 75 and VLS 76 were found moderately resistant to both the pests.

**2.1.6.3. Agronomic Investigations**

**Response of Lentil Varieties to Seed Rate**

Four lentil varieties, 2 each bold seeded (VL MAsoor 507 and VL 519) and small seeded (VL 138 and VL MAsoor 126) were evaluated with three different seed rates (30, 40 and 50 kg/ha) under field condition at Hawalbagh farm. Between bold seeded variety VL MAsoor 507 produced significantly higher yield (1,430 kg/ha) than VL 519 (1,280 kg/ha) at 30 kg/ha.

Similarly, both small seeded varieties (VL MAsoor 126 and VL 138) produced at par grain yield (1,220 and 1,350 kg/ha) at 30 kg/ha.

**Response of Lentil Varieties to Different Fertility Levels**

Four lentil varieties, 2 each bold seeded (VL MAsoor 507 and VL 519) and small seeded (VL 138 and VL MAsoor 126) were evaluated with three different fertility levels (10:20:10, 20:40:20 and 30:60:30 kg/ha of N:P:K) under field condition at Hawalbagh farm. It revealed that between bold seeded varieties, VL MAsoor 507 resulted higher seed yield (1,810 kg/ha) than VL 519 (1,500 kg/ha) at 20:40:20 of N:P:K kg/ha. Similarly, small seeded VL 138 produced higher yield (1,430 kg/ha) than VL MAsoor 126 (1,280 kg/ha) at 30:60:30 of N:P:K kg/ha.

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

The highest grain yield (3,700 kg/ha) was recorded with VL Soya 63 and was at par with VL Soya 47 (3,650 kg/ha). In case of plant population, VL Soya 47 produced the highest yield (4,500 kg/ha) at 0.6 m/ha.

**2.1.6.4. Physiological Investigations**

**Physiological Basis of Drought Tolerance in Soybean Genotypes at Reproductive Stage**

Due to climate change there is an increase in the drought development for various regions despite the overall increase in precipitation. Soybean is one of the important crops in the North West Himalayas and the drought stress is commonly observed during its growing period. A pot culture experiment was conducted during 2011 in five soybean genotypes, viz., VL Soya 21, VL Soya 47, VL Soya 59, VL Soya 63 and VL Bhat 65 to study the physiological basis of drought tolerance in these genotypes at reproductive stage. During pre-flowering to flowering stage the drought stress was imposed by withholding the irrigation and pots were shielded by polycover structure to avoid rainfall. Physiological observations like leaf angle, relative water content (RWC), membrane stability index (MSI), chlorophyll ‘a’, chlorophyll b’, total chlorophyll, total carotenoid and proline contents, photosystem II efficiency, photosynthesis efficiency (Fv/Fm),
pollen viability, leaf area, leaf weight, stem weight, number of root nodules and soil moisture were recorded immediately after short period of drought stress. Relative water content, MSI, total chlorophyll content, total carotenoid content, photosystem II efficiency, photosynthesis efficiency, pollen viability were found to be reduced by 38, 29, 24, 11, 15 and 16%, respectively under drought compared to that of irrigated (control) condition. However, significant increase in proline content was recorded under drought condition. Among genotypes, VL Soya 47 showed significantly better physiological traits for drought tolerance besides grain yield.

**Physiological Studies in Lentil Varieties under Normal and Late Sown Condition**

An experiment was conducted during 2010-11 with five lentil genotypes, viz., VL Masoor 125, VL Masoor 126, VL Masoor 133, VL Masoor 507 and VL Masoor 514 to study the variations in physiological traits under normal and late sown conditions. The experiment was laid out in factorial randomized block design. Late sown condition resulted in 28 and 32% reduction in grain yield and biomass, respectively compared to that of normal sown condition (Fig. 2.6). Under normal sown condition, VL Masoor 126 and VL Masoor 133 possessed better yield while VL Masoor 125 and VL Masoor 507 recorded poor grain yield. Under late sown condition, VL Masoor 133 and VL Masoor 126 possessed better grain yield while VL Masoor 507 and VL Masoor 514 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 was obtained under late sown condition.

![Effect of drought stress in soybean](image)

**Fig. 2.6. Effect of late sowing on grain yield and biomass in lentil genotypes**
2.1.7. Vegetables

Vegetable cultivation, especially off-season and temperate ones is recognized as highly practicable and profitable venture as compared to cereals, due to niche potentials of hills. The total area under vegetable production is around 82.57 thousand ha with an average productivity of 121.0 q/ha, which is much below the national productivity of 167.0 q/ha (NHB 2009-10). Development of high yielding varieties and hybrids specific to quality and market demands along with package of practices is an eminent area of research activity for the improvement of agriculture scenario of North-Western Himalayas.

2.1.7.1. Varietal Improvement

Variety Notified

**VL Lahsun 2**: It is a long day type, tested under the All India Network Research Project on Onion and Garlic for Zone-I at 5 locations, viz., VPKAS, Almora; CITH, Mukteshwar; UHF, Solan; IARI Station, Katrain and CITH, Srinagar. VL Lahsun 2 out yielded (18,193, 18,435 and 19,060 kg/ha) the national checks G 282, VL Garlic 1 and G 41 by 70.98, 48.87 and 44.74%, respectively in Zone-I. It possessed higher bulb weight (30-38 g/bulb), less storage loss and high TSS (*Brix*) (37.3) in comparison to all entries including checks. Besides high yield and bulb quality, it also possessed resistance against purple blotch and stemphytum blight in field conditions as compared to checks.

**VL Tamatar Hybrid 1 (VLTH 2)**: It is released for Uttarakhand and has shown 27.97% higher yield (22,644 kg/ha) over the check hybrid DARLH 304 (17,690 kg/ha) in State Varietal Trials. It is suitable for both organic and inorganic conditions as well as for polyhouse cultivation.

**VL Shimla Mirch Hybrid 1 (VLCPH 1)**: It is released for the state of Uttarakhand and has shown 23.76 and 40.52% higher yield (13,487 kg/ha) over the check hybrids DARLH 202

Varieties Released

Five varieties were released by the SVRC for Uttarakhand (Tomato: VTG 86, VTG 95 and VLTH 2; Capsicum: VLCP 2 and VLCPH 1).
(10,898 kg/ha) and Bharat (9,598 kg/ha), respectively, in the State Varietal Trials. It is suitable for both organic and inorganic conditions as well as for polyhouse cultivation.

**VL Shimla Mirch 3 (VLCP 2):** An open-pollinated variety, suitable for both organic and inorganic conditions especially during summer-rainy season in hills. It is also suitable for polyhouse cultivation. Fruits are uniform, attractive dark green, medium size (60-70 g), blocky, 3-4 lobes with bright smooth surface. Green fruit yield ranged from 25,000-32,000 kg/ha under main (March sown) crop. has shown 12.1% higher yield (17,540 kg/ha) over the best check Pant Tamatar 3 (15,650 kg/ha) under the State Varietal Trial.

**VL Tamatar 5 (VTG 86):** A semi indeterminate, open-pollinated variety, can be grown under both polyhouse and open-field conditions especially during summer-rainy season in the hills. It has shown 12.3% higher yield (17,590 kg/ha) over the best check Pant Tamatar 3 (15,650 kg/ha). It is suitable for both organic and inorganic conditions.

**VL Cherry Tamatar 1 (VTG 95):** An indeterminate, open-pollinated variety, can be grown under both polyhouse and open-field conditions. Fruits are small, attractive, red colour with oval shape; better in nutritive traits (Vitamin C- 86mg/100g and T.S.S. -7° Brix), good taste. It

**Variedades Identificado**

**VP 434:** Garden pea entry (resistant to powdery mildew) was identified in medium maturity group for Zone I and IV by CVRC.

**Varietal Trials**

Varietal adaptability evaluations were undertaken in six vegetable crops, viz., garden
pea, onion, garlic, french bean, tomato and capsicum. A total of 221 genotypes were evaluated 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 ADAPTABLEITY EVALUATION**

Field trials were conducted to evaluate 63 strains against suitable checks to identify early and medium maturing, high yielding and disease resistant genotype. 10/PEVAR-1 (11.667 kg/ha), 09/PEVAR-4 (11,428 kg/ha), 10/PMVAR-2 (12,024 kg/ha), 08/PMvar-3 (15,000 kg/ha), VP 434 (10,863 kg/ha), VP 625 (10,925 kg/ha) and VP 611 (9,322 kg/ha) recorded maximum green pod yield in IET (early), AVT-I (medium), IET (medium), AVT II (medium), AVT II (FM), SYT organic mode (medium) and (early) trials, respectively. In station trial, VP 906 (12,036 kg/ha) and VP 918 (11,944 kg/ha) in medium maturity group were found to be promising lines.

**DEVELOPMENT OF NEW STRAINS**

Emphasis was given to develop early and medium duration genotypes with high green pod yield potential, resistance to powdery mildew and tolerant to frost (Table 2.1.7). In this endeavour, 58 new F1’s were made among selected parents to combine different traits like earliness, high green pod yield, high shelling percentage, attractive pod color and shape, disease resistance etc. Better performing 54 F1’s were advanced. Besides, selection was practiced in the segregating materials derived from 48 F1’s, 47 F2’s, 40 F3’s, 46 F4’s and 20 F5’s. Based on desirable traits, 1,116 progenies derived from 133 crosses were advanced in F2 to F5 generations. 95 crosses were retained (36 F1’s, 39 F2’s and 20 F3’s) for further selection. Nine new bulks were made based on phenotypic uniformity.

**Onion**

**VARIETAL ADAPTABLEITY EVALUATION**

Two AINRP trials on long day onion were conducted with 36 genotypes to evaluate their yield performance against two checks, viz., VL Piaza 3 and Spanish Brown. ARBO 1030 (39,987 kg/ha) and BRBO 1028 (61,839 kg/ha) recorded maximum bulb yield in IET and AVT-I trials, respectively.

**PURIFICATION OF MAINTAINER (B LINE) OF VL PIAZA 67 F, HYBRID**

Pair crossing was done in fifteen sets of A line and B line. Setting was done in all the fertile plants of maintainers in order to maintain the B line. Seeds from A line crossed with B line were harvested separately and three male sterile lines with maintainer were planted for bulb production.

**Garlic**

**VARIETAL ADAPTABLEITY EVALUATION**

Three AINRP trials on long day garlic were conducted with 20 genotypes to evaluate their yield performance against three checks, viz., VL Garlic-1, G 41 and G 282. AG 103 (21,707 kg/ha) in IET, BG 106 (20,833 kg/ha) in AVT-I and CG 117 (25,832 kg/ha) in AVT-II recorded maximum bulb yield with big cloves.
French Bean

**Varietal Adaptability Evaluation**

Coordinated, pre-varietal and station trials were conducted with 29 genotypes to evaluate their green pod yield performance against checks, viz., Arka Anoop and Arka Komal in coordinated trial and Contender, Arka Komal and VL Bean 2 in pre-varietal and station trials. 09/FEBVAR-5 (10,814 kg/ha), VLFB 813 (13,640 kg/ha) and VLFB 518 (7,592 kg/ha) recorded maximum green pod yield in AVT II (bush), pre-varietal and station trials, respectively.

**Development of New Strains**

Emphasis was given to develop high yielding bush genotype, stringless pods and resistance to angular leaf spot, root rot, anthracnose and rust. In this endeavor, 5 new F₁’s were developed using diverse parents. 119 progenies derived from 14 crosses were advanced in F₂ to F₄ generations. Based on desirable traits, 18 crosses were retained (7 F₁ and 11 F₂’s) for further selection. Twelve new bulks were also made based on phenotypic uniformity.

Tomato

**Varietal Adaptability Evaluation**

Fourteen genotypes were assessed in hybrid station trial against checks to identify high yielding hybrids. VLTH 3 (36,500 kg/ha), VLTH 5 (32,000 kg/ha) and VLTH 7 (31,800 kg/ha) recorded highest fruit yield.

**Development of New Strains**

Emphasis was given to develop high yielding early F₁ hybrids having market acceptability with regard to size and shape. Six F₁’s were made involving diverse parents with regard to yield and other desirable traits like earliness. Twenty seven progenies derived from 7 crosses were advanced in F₂ to F₄ generations and 6 F₂’s and 8 F₄’s were retained for further selection.

Capsicum

**Development of New Strains**

Emphasis was given to develop high yielding early maturing F₁ hybrids having market acceptability with regard to size and shape, suitable for protected cultivation and open field especially under organic conditions. Twelve F₁’s were developed involving diverse parents and will be evaluated with regard to yield and other desirable traits. Thirty three new F₁’s were evaluated with Indra as check and VLCPH 4 (17,500 kg/ha) recorded the highest fruit yield.

Genetic Resources

**Evaluation and Maintenance**

Five hundred twenty four accessions of different vegetable crops were maintained during *rabi* 2010-11 and *kharif* 2011 (Fig. 2.7).

![Fig.2.7 Detail of accessions evaluated and maintained](image_url)

2.1.7.2. Crop Protection Investigations

**Evaluation for Disease Resistance**

**Garden Pea:** Thirty two garden pea entries were screened against diseases. Under natural incidence, entries VL 7, VL 767, VP 1010, VP 1011, VP 1020, VP 1023 and VP 1024 were found promising against Alternaria leaf spot and white rot.

**French Bean:** Twenty-eight french bean entries were evaluated for rust and angular leaf spot diseases. VLFB 8, VLFB 10, VLFB 12, VLFB 29, VLFB 47, VLFB 48, VLFB 97 and VLFB 106 have shown field resistance to rust and angular leaf spot.

**Tomato:** Out of 11 tomato genotypes screened against bacterial wilt, VTG 28, Swarna Samrudhi, Swarna Naveen and BT 5 shown high resistance in sick plot studies.
Capsicum: Twenty-five capsicum genotypes were screened against foliar diseases and Fusarium wilt. The entries VLCP-2, GPC-2, G P Local and Sweirhogil were found promising.

2.1.7.3. Agronomic Investigations

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

Three garden pea varieties/entries (VL Matar 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 resulted higher pod yield (15,100 kg/ha) than 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

VGP 5 resulted significantly higher yield (15,250 kg/ha) than VGP 1 (10,110 kg/ha). Among fertility levels, 100:50:50 NPK kg/ha resulted significantly higher yield (13,790 kg/ha) than others. VGP 5 at 100:50:50 NPK kg/ha resulted the highest yield.
2.1.8. Seed Production Programme

The institute produces four types of seeds to cater to the needs of its clientele. These types 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 seed of important hill crop varieties is the mandate of the institute. Besides, the institute also produces TL and Nucleus seed of various hill crops.

During the period under report, 278.12 q breeder seed of 39 released varieties/inbreds (16 varieties and 3 inbreds of cereals, 2 of finger millet, 1 of barnyard millet, 10 of pulses, 3 of oil seeds, one each of buckwheat, amaranth and 2 of vegetables) was produced. Out of this, 264.81 q breeder seed was supplied to different seed producing agencies to take up further multiplication (Table 2.1.8 & Table 2.1.9).

Around 22.48 q nucleus seed of 38 released varieties was also produced following standard methods to maintain the genetic purity.

Table 2.1.8: Seed Production rabi 2010-11 and Supply during rabi 2011-12

<table>
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<tr>
<th>Crop</th>
<th>Variety</th>
<th>Breeder Seed</th>
<th>TL Seed</th>
<th>Nucleus seed</th>
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<td>Supply (q)</td>
<td>Production (q)</td>
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<td>-</td>
<td>-</td>
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<tr>
<td></td>
<td>VL 834</td>
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<td>VL Gehum 907</td>
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<td>-</td>
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Total 203.35 192.70 25.82 22.14 15.92 4.39

# Produced by Dr. N.K. Hetau, Vegetable Breeder
In addition to this, around 62.71 q truthfully labeled seed of 16 varieties of cereals, 4 of pulses, 3 of oil seeds, 14 of vegetables, 3 of finger millet, 2 of barnyard millet and 1 of amaranth was produced to meet out the demand of institute extension activities. A total of 55.09 q TL seed has been supplied.

Under farmers’ participatory seed production programme, 32 q TL seed of wheat variety, VL Gehun 907 was produced in farmers’ fields at Belpadh (Ramnagar), and a quantity of 26.94 q was supplied from the seed procured.

Table 2.1.9: Seed Production kharif 2010 and Supply during kharif 2011

<table>
<thead>
<tr>
<th>Crop</th>
<th>Breeder Seed</th>
<th>TL Seed</th>
<th>Nucleus seed</th>
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<td>Production</td>
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<td>Production</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Vl Chau 44</td>
<td>0.50</td>
<td>0.54</td>
<td>0.10</td>
</tr>
<tr>
<td>Vl Chau 47</td>
<td></td>
<td></td>
<td>0.85</td>
</tr>
<tr>
<td>Vl Chau 48</td>
<td></td>
<td></td>
<td>0.002</td>
</tr>
<tr>
<td>Tomato</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>74.77</td>
<td>72.11</td>
<td>37.39</td>
</tr>
</tbody>
</table>

* Copy over seed. ** Produced by Dr. L.K. Agarwal and Dr. S.K. Jha, Maize Breeder

Annual Report 2011-2012
2.1.9. Molecular Approaches to Enhance Productivity and Quality in Hill Crops

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. The other MAS products in maize (QPM), and rice (resistance against blast) are under multi-location evaluation. FQH 38, QPM version of Vivek MH 21 was found promising under the SVT, Uttarakhand. Besides we are also working on transformation of maize and rice, allele mining in rice and maize, mapping of agronomically useful genes in rice, maize and MAS in wheat (yellow rust).

2.1.9.1. 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 resistance version of VL Dhan 206, marker assisted selection (MAS) was employed to pyramid Pt 2 and Pt 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. Pt 2 and Pt 9 are the two proven resistance genes for which site specific markers are available. The donor used for Pt 2 was C101A51 and the donor for the Pt 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. The performance of those lines is given in Table 2.1.10. 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.

2.1.9.1. 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 for 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 for the tryptophan content (0.52 and 0.92% protein, respectively) were used to develop the mapping population. A total of 850 SSRs were used for parental polymorphism, of which 23 were found to be polymorphic. Based on the data of the F2 plant marker genotypic data and the tryptophan content of F3 seeds originating from

<table>
<thead>
<tr>
<th>Entry/ Checks</th>
<th>Hawilibag</th>
<th>Chinyalisaur</th>
<th>Average</th>
<th>Advantage over VLD 206 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VL 206 MAS 1</td>
<td>1.706</td>
<td>1.027</td>
<td>1.366</td>
<td>-</td>
</tr>
<tr>
<td>VL 206 MAS 2</td>
<td>2.976</td>
<td>1.111</td>
<td>2.043</td>
<td>16.83</td>
</tr>
<tr>
<td>VL 206 MAS 3</td>
<td>3.016</td>
<td>1.555</td>
<td>2.285</td>
<td>30.67</td>
</tr>
<tr>
<td>VL 206 MAS 4</td>
<td>1.849</td>
<td>1.277</td>
<td>1.563</td>
<td>-</td>
</tr>
<tr>
<td>VL 206 (check)</td>
<td>2.151</td>
<td>1.347</td>
<td>1.749</td>
<td>-</td>
</tr>
</tbody>
</table>
the F23 population, three significant QTLs on chromosome 9 were identified with LOD values more than 2.5 based on the single marker regression analysis and composite interval mapping (CIM) method. These three QTLs together explained 24.8% of phenotypic variance (Fig. 2.8). The QTL between the loci umc1430 and bnlg1401 has an LOD of 6.2 with a phenotypic variance of 9.1%. However, the QTL between the loci bnlg1401 and phi022 has an LOD of 3.1 with a phenotypic variance of 7.3% and the third QTL is near to the loci umc2207 with an LOD of 4.1 with a phenotypic variance of 8.4% (Table 2.1.11).

Table 2.1.11: Mapping QTLs and phenotypic variance for tryptophan content

<table>
<thead>
<tr>
<th>Chromosome Number</th>
<th>Flanking marker loci</th>
<th>LOD value</th>
<th>Phenotypic variance (R²) (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chromosome 9</td>
<td>Umce1430-bnlg1401</td>
<td>6.2</td>
<td>9.1</td>
</tr>
<tr>
<td>Chromosome 9</td>
<td>bnlg1401-phi022</td>
<td>3.1</td>
<td>7.3</td>
</tr>
<tr>
<td>Chromosome 9</td>
<td>Umce2346-Umc2207</td>
<td>4.1</td>
<td>8.4</td>
</tr>
</tbody>
</table>

Fig. 2.8. Graph representing the LOD values of three QTLs on chromosome 9 (TRYAVG – Tryptophan average values, TRYR1 – Tryptophan values for replication1, TRYR2 - Tryptophan values for replication2)
Natural Resource Management for Sustainable Productivity

- Development of Integrated Farming System Modules for Different Farm Holdings (Drs. D. Mahanta, J. K. Bish, B. M. Pandey, B. L. Mina & K. Jeevanandam)

- Enhancing Productivity and Profitability of Major Hill Crops through Crop Diversification and Reduction in Cost of Cultivation (Drs. M.D. Tuti, D. Mahanta, B.L. Mina, J. K. Bish, B.M. Pandey & D.C. Sahoo)


- Characterization and Evaluation of Agriculturally Important Microbes for Enhancing Productivity of Hill Crops (Drs. P.K. Mishra, K. Jeevanandam, G. Singh & J.K. Bish)

- Design and Development of Small Tools and Farm Machineries for Hill Agriculture (Drs. D.C. Sahoo, B.M. Pandey & Pratibha Joshi)

- Wasteland Management with Special Reference to Production of Fodder and Fuelwood (Drs. J.K. Bish, P.K. Mishra, B.M. Pandey, S.C. Pandey & Mr. R.P. Yadav)

- Management of Water Resources for Higher Use-Efficiencies in Crop Production (Drs. S.C. Pandey, B.L. Mina, D. Mahanta, M.D. Tuti & N.K. Hedau)
2.2. Natural Resource Management for Sustainable Productivity

Basic and strategic research pertaining to the farming systems and operational management of inputs for harnessing sustainable production was carried out. This included tillage, water harvesting, intensive cropping, long term fertility management, IPNS, forage and grassland management and farm machinery for sustainable production in hilly region.

2.2.1. Development of Integrated Farming System Modules for Different Farm Holdings

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

Hill agriculture presents extreme variations in crop growing conditions. Cultivated lands in mountain terrains present 360° variation to the sun. Steep hill slopes, foot hills and narrow lands are the contiguous part of hill agro-ecosystems. 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, Hawalbagh, namely, Khakal, Attadhar and Kannigere differ widely in these parameters. The performance of the crops grown in different sites is given in Table 2.2.1. For most cereals, highest yield was obtained in Kannigere site and for vegetables Attadhar site was found most suitable.

The highest green fodder during the year in silvi-pastoral system was obtained from Khakal followed by Attadhar. The contribution to the green forage yield was maximum from hybrid Napier in all the sites (Fig. 2.9).

Table 2.2.1: Performance of different crops under different growing conditions

<table>
<thead>
<tr>
<th>Crop</th>
<th>Kannigere (kg/ha)</th>
<th>Attadhar (kg/ha)</th>
<th>Khakal (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>1,190</td>
<td>1,050</td>
<td>880</td>
</tr>
<tr>
<td>Wheat</td>
<td>1,870</td>
<td>1,560</td>
<td>1,900</td>
</tr>
<tr>
<td>Finger millet</td>
<td>1,020</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lentil</td>
<td>660</td>
<td>1,080</td>
<td>640</td>
</tr>
<tr>
<td>Horse gram</td>
<td>610</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oilseeds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toria</td>
<td>730</td>
<td>660</td>
<td></td>
</tr>
<tr>
<td>Vegetables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garden pea</td>
<td>2,120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Okra</td>
<td>670</td>
<td>1,220</td>
<td>1,500</td>
</tr>
<tr>
<td>Capsicum</td>
<td>2,880</td>
<td>4,000</td>
<td>1,250</td>
</tr>
<tr>
<td>Squash</td>
<td>2,060</td>
<td></td>
<td>1,020</td>
</tr>
</tbody>
</table>

Fig. 2.9. Green fodder yield of grasses under different sites

Nutrient Management in Garden Pea-French Bean-Okra Cropping System

A field experiment was conducted to study the effect of different organic manures, viz., FYM @ 17.5 and 34.9 kg equivalent P/ha with biofertilizers, FYM @ 52.4 and 69.9 kg eqv. P/ha, poultry manure @ 17.5 kg eqv. P/ha (+ biofertilizers) and 34.9 kg eqv. P/ha, Vermicompost @ 17.5 kg eqv P/ha (+biofertilizers) and 34.9 kg eqv. P/ha against recommended NPK, recommended NPK+ FYM 10 t/ha and control in fixed plots.
In garden pea, application of FYM @ 69.9 kg e.q. P/ha recorded significantly higher pod yield (8,450 kg/ha) compared to other treatments in the 8th year. In french bean application of FYM @ 52.4 kg e.q. P/ha produced more pod yield (15,110 kg/ha).

**Evaluation of New Pseudomonas Strains in Wheat-Soybean Cropping System**

*Pseudomonas fragi* and *Pseudomonas sp. strain PGER17* were evaluated individually and in combination with 75% and 50% of the recommended P against recommended P and control in wheat followed by soybean. Application of 75% recommended P + *Pseudomonas sp. strain PGER17* produced 1.5% more grain yield (6,220 kg/ha) than 100% recommended P treated plot (6,130 kg/ha) in wheat. However, in soybean inoculation of both *P. fragi* and *Pseudomonas sp. strain PGER17* with 75% recommended P produced 5.1% more grain yield (3,100 kg/ha) than recommended P (2,950 kg/ha).

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

Three biofertilizers, *viz.*, Azotobacter, 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 yield (3,100 kg/ha in finger millet and lentil, respectively) than FYM 10 t/ha (2,610 kg/ha in finger millet and lentil, respectively).

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

Three nutrient sources, *viz.*, organic (FYM @ 40 kg e.q. P/ha and FYM @ 40 kg e.q. N/ha for lentil and finger millet, respectively), INM (50% of Rec. N:P:K+ FYM @ 20 kg e.q. P/ha and 50% of Rec. N:P:K+ FYM @ 20 kg e.q. N/ha for lentil and finger millet, respectively) and chemical (Rec. N:P:K::20:40:20 kg/ha and 40:20:20 kg/ha for lentil and finger millet, respectively) in main plots and five varieties in sub plot were taken for evaluation in split plot design. In both crops, there was no significant difference among different nutrient source for grain yield.

**2.2.2. Enhancing Productivity and Profitability of Major Hill Crops through Crop Diversification and Reduction in Cost of Cultivation**

**Productivity Evaluation of Soybean-Wheat Crop Rotation under Long Term Fertility Management**

The long-term (38 years) soybean-wheat crop rotation experiment is being conducted at Hauwalbagh farm, Alamara in a sandy loam soil under sub-tropical climatic conditions. The nutrients were applied to the soybean crop and wheat was grown on residual fertility. Unfertilized plot recorded 520 and 730 kg/ha soybean and wheat yield, respectively (mean yield of 38 years). Maximum yields of soybean (2,870 kg/ha) and wheat (1,950 kg/ha) were obtained in the plots under NPK+FYM application. Yield and partial factor productivity (PFP) increased in the plots under NPK+FYM treatment for both the crops. The data revealed that sustainable yield index (SYI) and agronomic efficiency of fertilizers were also higher in plots receiving fertilizer N or NPK along with 10 t/ha FYM (Table 2.2.2). Benefit: Cost ratio of fertilization increased in both soybean and wheat for the plot under NPK+FYM. Combined use of NPK and FYM increased soil

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Soybean (kg/ha)</th>
<th>Wheat (kg/ha)</th>
<th>Soybean-Wheat system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.16</td>
<td>0.40</td>
<td>0.33</td>
</tr>
<tr>
<td>NP</td>
<td>0.23</td>
<td>0.38</td>
<td>0.36</td>
</tr>
<tr>
<td>NK</td>
<td>0.26</td>
<td>0.37</td>
<td>0.38</td>
</tr>
<tr>
<td>NPK</td>
<td>0.38</td>
<td>0.41</td>
<td>0.41</td>
</tr>
<tr>
<td>N+ FYM</td>
<td>0.35</td>
<td>0.41</td>
<td>0.64</td>
</tr>
<tr>
<td>NPK + FYM</td>
<td>0.63</td>
<td>0.45</td>
<td>0.65</td>
</tr>
<tr>
<td>Mean</td>
<td>0.37</td>
<td>0.40</td>
<td>0.46</td>
</tr>
<tr>
<td>LSD (P&lt;0.05)</td>
<td>0.03</td>
<td>0.03</td>
<td>0.04</td>
</tr>
</tbody>
</table>
organic carbon (SOC), total N, Olsen P and ammonium acetate exchangeable K by 48, 31, 13 and 71%, respectively, in the 0–15 cm soil layer, compared to application of NPK through inorganic fertilizers. The application of NPK+FYM also showed the highest levels of soil microbial-biomass carbon and dehydrogenase activity. The results clearly revealed that current mineral-fertilizer recommendations are inadequate, whereas annual applications of FYM along with NPK fertilizers sustain yield and soil productivity.

**Evaluation of Multistorey Colocasia (Taro or Gaderi) based Cropping System**

Colocasia-based relay intercropping systems revealed that potato consumed the highest total input energy (25.084 MJ/ha) and the least was in case of coriander (5.108 MJ/ha). System productivity in terms of colocasia equivalent yield was the highest with colocasia–onion-french bean system (52,380 kg/ha), however, total biomass was the highest with colocasia-coriander-tomato system (1,79,650 kg/ha). Chemical fertilizers (50-62%), seed (8-26%) and irrigation water (11-17%) were the bulk of the input energy for all cropping systems. The total input energy was highest in colocasia-radish-potato (59,919 MJ/ha). Colocasia-onion-french bean having the highest system productivity, have also given the highest energy productivity (1.2 kg/MJ). Colocasia-coriander-tomato produced higher energy ratio (30.4), human energy profitability (2813.4) and energy profitability (29.43) with the highest system biomass. The total energy output of the crop production systems followed the order: colocasia-wheat-okra (13,62,928 MJ/ha), colocasia-coriander-tomato (12,49,136 MJ/ha) and colocasia–gardenpea-frenchbean (8,39,299 MJ/ha). Human energy profitability was highest in colocasia–coriander-tomato (2813.4) followed by colocasia-wheat-okra (2715.0), colocasia–gardenpea-frenchbean (1671.9) indicating that colocasia-coriander-tomato is the most labour energy efficient cropping system. Regarding energy intensiveness the results were contrary to energy ratio (energy use efficiency). Energy intensiveness was higher in colocasia-radish-potato (0.47) followed by colocasia-wheat-okra (0.45). The colocasia-coriander-tomato and colocasia–onion-frenchbean cropping system is more suitable in the North-Western Himalayas for its higher energy use efficiency and energy productivity, respectively.

**Improvement in Wheat Productivity under Moisture Stress Conditions**

Significantly higher grain yield was observed (Fig. 2.10) in all the treatments compared to
conventional practice. Highest grain yield was obtained under seed priming + deep sowing + FYM packing (2,140 kg/ha) followed by deep sowing + FYM packing (1,870 kg/ha). The lowest yield (1,630 kg/ha) was recorded in recommended practice. Similarly, the plant stand was also the highest in seed priming + deep sowing + FYM packing at 15 and 90 DAS with 30 and 23/m. row, respectively.

**Effect of Different Tillage, Crop Residue and Sowing Methods in Rice-Wheat Cropping System**

Average (5 years) yield of rice-wheat crop rotation indicated that the grain yield (Fig. 2.10) of zero-tilled rice (3,160 kg/ha) and wheat (4,460 kg/ha) was similar to that of conventionally tilled rice (3,230 kg/ha) and wheat (4,450 kg/ha). Rice yield (3,140 kg/ha) was higher under 10 cm in contrast to wheat (4,430 kg/ha) under 15 cm crop residue of previous crop. Similarly, higher rice yield (3,160 kg/ha) was recorded under bed sowing than in normal sowing methods (3,030 kg/ha). However, wheat performed better under normal sowing (4,670 kg/ha) than in bed sowing (4,110 kg/ha).

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

Five finger millet varieties, viz., VL Mandua 146, VL Mandua 149, VL Mandua 315, VL Mandua 324 and VL 347 were evaluated for 4 dates of sowing (5 July, 15 July, 25 July and 5 August) under rainfed condition for contingent crop planning in case of late onset of monsoon. Sowing on July 15 (1,758 kg/ha) gave the highest grain yield followed by July 5 (1,708 kg/ha), August 5 (1,396 kg/ha) and July 25 (1,340 kg/ha). VL Mandua 146 was found most suitable variety for sowing on 15 July, however, VL 347 was found best for sowing on 5 July, 25 July and 5 August. Wheat variety VL Gehun 892 was found suitable for a rotation with finger millet crop sown in all above dates.

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

An experiment was conducted to know the effects of with and without application of Sesbania along with 4 levels of fertilizers, [FYM (5 t/ha), FYM (50%) + RDF (50%), RDF (40:20:20 NPK) and control] on yield of finger millet and succeeding wheat crop under rainfed condition. Significant differences were recorded in grain yield during second year due to Sesbania mulching (1,283 kg/ha) as compared to without mulching (1,161 kg/ha). Application of FYM (50%) along with RDF (50%) gave the highest grain yield (1,383 kg/ha) which was at par with other levels except control.

**2.2.3. Improving Nutrient Use Efficiency and Utilization of Biological and Mineral Wastes to Supplement Nutrient Requirement of Hill Crops**

*P Enriched Compost is an Alternative for SSP to Supplement Phosphorus Requirement of Soybean-Wheat Cropping System*

P enriched composting and their evaluation under soybean-wheat cropping system is very relevant to hill agriculture. Pooled analysis of grain yield of soybean indicated that application of phosphorus through SSP, P enriched compost and
P enriched compost + SSP (50% of P through P enriched compost + 50% of P through SSP) gave significantly higher grain yield as compared to rock phosphate and control (Fig 2.12). Response of applied phosphorus varied from 8.2-21.6% over unfertilized plot and the highest response observed with SSP in soybean. Similarly, application of phosphorus through SSP resulted highest grain yield of wheat (5,590 kg/ha), which was comparable to treatment receiving P enriched compost (5,440 kg/ha). However, significantly lower grain yield of wheat was observed under direct application of rock phosphate (4,970 kg/ha) and P enriched compost + SSP (5,260 kg/ha) as compared to SSP. Wheat crop response to applied P varied from 5.7-18.9% over unfertilized control and the highest response observed with SSP. Response of applied P was more in soybean than in wheat.

Phosphorus Management in Soybean-Wheat Cropping System

An experiment on use of rock phosphate along with phosphate solubilizing bacteria (PSB) and mobilizing (VAM) microorganism under soybean–wheat cropping system was conducted. Application of single super phosphate (SSP) to soybean had significantly higher grain yield (3,500 kg/ha) as compared to 100, 125 and 150% of recommended dose of P applied through RP alone and 100% RP along with PSB and VAM. However, application of 125 and 150% of recommended dose of P through RP along with PSB and VAM were comparable with SSP. Similarly, in wheat significantly higher grain yield (5,955 kg/ha) was recorded with SSP as compared to 100, 125 and 150% of recommended dose of P through RP alone or along with PSB and VAM, except combined inoculation of PSB and VAM along with 150% RP. Inoculations of both PSB and VAM in soybean–wheat cropping system had increased 7.9-10.1% grain yield of wheat and 2.4-4.4% grain yield of soybean.

Management of Magnesite Waste Deposited Soil through Integrated Nutrient Management

Four crops (lentil, garden pea, toria and wheat) were evaluated with four nutrient management (Control, FYM, NPK+ Lime and NPK+ FYM+ Lime) under magensite waste deposited field at KVK, Kafigaria. Application of fertilizers...
and manure along with lime had increased wheat equivalent yield of different crops as compared to control plots (Fig. 2.14). Among the crops garden pea (19.770 kg/ha) provided significantly higher wheat equivalent yield.

![Graph showing effect of integrated nutrient management on wheat equivalent yield of different crops](image)

**Fig. 2.14.** Effect of integrated nutrient management on wheat equivalent yield of different crops

**Productivity Enhancement of Hill Crops through Use of Magnesite Waste**

Magnesium is an important essential element in crop production. At the same time, India and Uttarakhand have considerable magnesite deposits (249 and 21 million tonnes, respectively). A magnesite processing factory is located in district Bageshwar and there is a need to explore the economic utilization of magnesite waste, which contains 48% magnesium. Wheat, toria and lentil in rabi season and rice, soybean and finger millet in kharif season were evaluated with five levels of magnesium (0, 25, 50, 75 and 100 kg Mg/ha) along with recommended dose of NPK. Application of magnesite waste along with recommended dose of NPK increased yield of wheat, toria and lentil with increasing levels of magnesium up to 100 kg Mg/ha under pot culture study in rabi season (Fig. 2.15). Among the crops highest response to magnesite application was recorded in toria (75% increase in grain yield) followed by lentil (62%) and wheat (41%). However, in kharif season, application of magnesite waste along with recommended dose of NPK responded upto 75 kg Mg/ha for rice and soybean and 100 kg Mg/ha for finger millet under field condition (Fig. 2.15). The responses to magnesite application were 28.2, 23.7 and 13.9% for finger millet, rice and soybean, respectively.

![Graph showing crop response to magnesite waste application](image)

**Fig. 2.15.** Crop response to magnesite waste application

**2.2.4. Characterization and Evaluation of Agriculturally Important Microbes for Enhancing Productivity of Hill Crops**

**Effect of Azospirillum spp. on N Uptake and Growth of Rice**

Twenty five *Azospirillum* spp. were obtained from the rhizosphere and root surfaces of the selected crops, wild and cultivated grasses. Based on their ability to produce IAA and ammonia, six isolates were selected for their evaluation in rice under pot culture condition. Inoculation with *Azospirillum* sp. A6 enhanced the total chlorophyll (22.7%), available Fe content (34.0%), root length (19.8%) and shoot length (19.1%) at 40 days of transplanting (DAT) over uninoculated control. Rice plants inoculated with *Azospirillum* sp. showed enhanced N, P and K uptake as compared to control. The treatment *Azospirillum* sp. A6 improved available nitrogen in the soil by 5.5 and 10.5% over control at 40 and 60 DAT, respectively. It has also enhanced the N uptake in the plant and root by 23.0 and 38.1%, respectively at 60 DAT.
Effect of Phosphate Solubilizing Bacterial Strains on P Uptake and Growth of Pea

Carrier based formulation of eight cold tolerant P solubilizing bacterial strains were tested for P uptake in pea under pot condition. *Pseudomonas fragi* strain CS11RH1, *P. poae* strain PB2RP1(2) and *Pseudomonas* sp. CS11RP1 improved the number of seeds in pea plants by 10.1 and 7.7%, respectively over uninoculated control. Rock phosphate (RP) application combined with bacterial inoculation improved the number of seeds per plant by 23.8 and 19.0% in *P. fragi* CS11RH4 and *P. poae* NS12RH2(1) and CS11RP1, respectively over the application of RP alone. Bacterial inoculation alone enhanced P uptake (33.8 to 47.3%). Maximum P uptake was recorded by *P. poae* NS12RH2(1) (47.3%), *P. poae* CS11RP1 (44.2%) and *P. fragi* CS11RH4 (40.6%), respectively over uninoculated control (55.4 mg/pot). Rock phosphate application combined with bacterial inoculation improved P uptake by 17.6 to 27.3%. (Fig. 2.16).

Effect of Cold Tolerant Pseudomonads on Plant Growth of Wheat

Bacterization with cold tolerant bacterial strains significantly improved (*P < 0.05*) wheat root length (3.8 to 35.7%), shoot length (9.0 to 35.3%), dry shoot biomass (3.7 to 55.5%) and dry root biomass (7.1 to 28.5% except NARs9, NPR15 and NPR13 strains) over nonbacterized control. Significant enhancement in total chlorophyll (3.0 to 23.7%) except PGERS17, PBRs3, PGR4 and NPR13, anthocyanin (10.1 to 33.7% except PPR4), free proline (1.9 to 2.5 fold), total phenolics (0.6 to 20.4% except PGERS17 and PPR4), starch content (1.01 to 2.86 fold except PPRs23), amino acids (1.34 to 1.77 fold except PPRs4) were observed. However, significant decrease in Na⁺/K⁺ ratio and electrolyte leakage was observed (at 60 DAS) in comparison to nonbacterized control under field condition. Single inoculation of cold tolerant bacterial strains PBRs5, NARs9, PGERS17 and PPRs23 significantly enhanced grain yield by 17.1, 15.2, 11.9 and 11.4%, respectively over uninoculated control (3,060 kg/ha) as well as enhanced grain nutrient content (Fig. 2.17).
2.2.5. Design and Development of Small Tools and Farm Machineries for Hill Agriculture

**Development of VL Syahi Hal**

Generally, traditional ploughs are made of wood causing a negative impact on environment due to deforestation. Besides, low capacity, inefficiency of local plough and frequent break down of different components has created a problem to the farmers. Therefore, local ploughs of different type, viz., Champawat, Chaubatia, Pantnagar, Gramin Vikas Sansthan, Hathnagar type were collected and tested. It was found that Champawat type is most suitable under hill condition. After testing, modifications were done by changing the horis to metallic type. After testing and modification, a complete metallic VL Syahi Hal of 12-14 kg weight was developed. This plough can be used for ploughing as well as for planking with the arrangements to adjust the depth of ploughing as per the height of the farmer and the bullocks.

**Design and Development of Self Propelled Light Weight Seed-cum-Ferti Drill for Hills**

Self propelled seed-cum-ferti drill, was tested for wheat and its capacity was found up to 0.08 to 0.1 ha/hr along with uniformity in the depth of seed placement and better germination. This drill was found suitable for organic farming as well as zero tillage conditions.
### Table 2.2.3: Performance of winnower-cum-cleaner-cum-grader for different crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Capacity (kg/ha)</th>
<th>Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cleaning</td>
<td>Winnowing</td>
</tr>
<tr>
<td>Wheat</td>
<td>250-300</td>
<td>300-350</td>
</tr>
<tr>
<td>Paddy</td>
<td>200-250</td>
<td>350-400</td>
</tr>
<tr>
<td>Lentil</td>
<td>200-250</td>
<td>300-350</td>
</tr>
<tr>
<td>Soybean</td>
<td>250-300</td>
<td>300-350</td>
</tr>
<tr>
<td>Barnyard millet</td>
<td>150-200</td>
<td>200-250</td>
</tr>
<tr>
<td>Finger millet</td>
<td>150-200</td>
<td>200-225</td>
</tr>
</tbody>
</table>

### Design and Development of Winnower-cum-Cleaner-cum-Grader

Prototype of winnower-cum-cleaner-cum-grader for different crops was evaluated. The cleaning capacity, winnowing capacity varied for different crops and it was in the range of 150-300, 200-400 kg/ha, respectively. Similarly, average cleaning and winnowing efficiency varied between 94 to 97% and 96 to 98%, respectively (Table 2.2.3).

### 2.2.6. Wasteland Management with Special Reference to Production of Fodder and Fuel-wood

#### Adaptability and Evaluation

**Winter Grasses**

In winter Fescue grass Hima-14 produced the highest green forage (22,310 kg/ha).

**Setaria Grass**

Under wasteland condition six entries of *Setaria* grass were evaluated. Out of these entries, entry S-20 produced significantly higher (85.544 kg/ha) green biomass than S-18, and S-92 only and significantly higher dry biomass than S-21, S-25 and S-92 only.

Different Hybrid Napier entries were tested and green forage (four cuts) was obtained up to December. Entry NBO-8-2 gave significantly higher green forage (60,225 kg/ha) than rest except NBO-8-4 and NBO-8-7. However, the highest dry fodder (11,722 kg/ha) was produced by NBO-8-4 followed by NBO-8-2.

### Evaluation of Cultivated Fodder

**Cowpea**

In cowpea, entry AVTC-3-3 gave significantly higher green forage (43.431 kg/ha) and dry forage yield (6,798 kg/ha) than the rest.

**Maize**

In dual purpose maize entries/varieties from VPKAS, VL 42 (36,982 kg/ha) has produced the highest green forage but FH 3356 produced the highest baby corn (1,371 kg/ha).

### Dual Purpose Wheat and Barley

#### Effect of Bacterial and Chemical Fertilization on the Dual Purpose Wheat

Dual purpose wheat which provides grain as well as green forage during winter period can be a suitable option for green fodder. To have 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 PGPR can be a good option for it. Wheat cultivars VL Gehun 829 and VL 934 were grown under different N fertilization with bacteria and its consortium, i.e., C1=Un-cut Normal N, C2=Cut with additional 20 kg N/ha after cut, C3=Cut+B1 (*Azotobacter*), C4=Cut+B2 (*Pseudomonas* sp. PGERs17) and C5=Cut+B1+B2. VL Gehun 829 produced at par green forage (6,718 kg/ha) and higher grain yield (3,725 kg/ha) than VL 934. Green forage yield did not affect significantly with different fertilization (Fig. 2.18). However,
application of bacterial consortia with two strains gave the highest green forage (7,320 kg/ha). Grain yield was significantly higher in no cut with normal N (3,646 kg/ha) than individual application of bacteria. Differences in grain yield was nonsignificant among C1, C2 and C5.

**Evaluation of Different Dual Purpose Barley Varieties under Rainfed Mid Hill Condition**

To find out the suitable dual purpose barley variety/strain under rainfed situation, nineteen barley strains were evaluated for green fodder and grain production. VLB 125 gave the highest green forage (3,899 kg/ha) and grain yield (1,768 kg/ha) followed by VLB 127 (3,545 kg/ha) for green forage and VLB 118 (1,754 kg/ha) for grain yield.

**Fodder Production Potential of Grasses**

**Grassland Management**

Fodder trees Quercus leucotrichophora, Grewia optiva, Morus alba, Bauhinia retusa and Melia azedarach along with four grasses, viz., Setaria kuzungula, S. nandi, Congo signal grass and broad leaf Paspalum were tested under silvi-pastoral system. Green forage was obtained from forage trees during winter and from grasses during summer. *Q. leucotrichophora* yielded the highest green biomass (11,680 kg/ha) followed by *M. alba*. The lowest green biomass was harvested from *G. optiva*. During rainy season *S. nandi* produced the highest green forage (5,286 kg/ha) out of three cuts.

**Intercropping of Grasses with Legume**

In hills, farmers are not applying inorganic fertilizer in grasses under wasteland situation. To increase the yield of grasses, intercropping of grasses with legume can be a beneficial option. Therefore, three grasses were grown with desmodium (legume) in 1:1 combination. Yield of grasses increased with the intercropping and the highest green forage (53,585 kg/ha) was obtained from intercropping of Hybrid Napier with desmodium.

**Establishment and Cutting Management in Fodder Trees**

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

In hilly regions the dependence on fodder trees is very heavy during winter months as trees are the only source of green fodder under rainfed conditions. For growing trees we have to utilize the wastelands. 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 year (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 initial years only growth parameters were recorded and fourth year...
onwards green forage. In the sixth year of planting, improved pit showed significantly higher plant height (143.16 cm) than traditional pit (Fig. 2.19). Similarly, improved pit produced significantly higher green biomass (5.72 kg/tree) than the traditional planting.

**Cutting Management of Trees**

For the proper tree canopy management of 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 the branches, pollarding tree at 2 m height (tree cut back nearly to the trunk, so as to produce a dense mass of branches) and lopping of tree leaving top 1/3 portion undisturbed. In *Quercus leucotrichophora*, coppicing of tree was not successful like *Grewia opulifolia* during initial years. Pollarding yielded the highest forage (11,000 kg/ha) followed by local method. Similar trend was recorded in the case of fuel yield (Fig. 2.20).

**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. In fruit based agri-horti system, four fruit plants, hill lemon, pear, plum and apricot were planted with the soybean in *kharif* and dual purpose wheat during *rabi* season. During initial years no significant effect on grain yield was observed with the presence of different fruit trees. Green forage yield varied from 6,400 to 7,400 kg/ha in different treatments.

**Silvi-horti system**

Two varieties of turmeric (*Pant Pitabhi* and *Swarna*) were grown under *Grewia opulifolia*, *Quercus leucotrichophora*, *Bauhinia variegata* and *Celtis australis*. The highest rhizome yield was obtained under *Q. leucotrichophora* (15,240 kg/ha) followed by *B. variegata* (Fig. 2.21). *Pant Pitabhi* gave significantly higher yield (12,956 kg/ha) than *Swarna*.

**Nutrient Management in Forage Based Cropping System**

Treatment combinations with total seven treatments consisted of 100% NPK through inorganic fertilizer and curtailed doses of 100% NPK, doses substituted fully or partially through FYM or bio-fertilizer along with control was studied in setaria-clover based cropping system in hills. The highest green (55,556 kg/ha) and dry (10,270 kg/ha) forage was recorded in bio fertilizer + 75% NPK. Similarly, the highest net return/ha (₹ 42,101/-) and resource use efficiency (41.9%) was obtained from T6 (Bio fertilizer +75% of NPK through inorganic fertilizer).

Nutrient management was also studied in forage based cropping sequences. Total NPK yield
by the cropping sequence was also calculated. Nitrogen, phosphorus and potassium yield (Fig. 2.22) varied significantly in different treatments. The highest NPK yield was obtained from T6 whereas the lowest NPK yield was recorded in control.

(2,790 kg/ha) was recorded with four irrigations, which was at par with 3 irrigations in case of wheat (4,620 kg/ha). The net returns in both the crops were higher in zero tillage (Table 2.2.4). More profile moisture depletion was recorded in 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, baring one treatment where it was grown with recommended NPK. Application of recommended NPK+10 t FYM recorded (Fig. 2.23) significantly higher wheat grain yield.

### 2.2.7. Management of Water Resources for Higher Water Use Efficiencies in Crop Production

**Irrigation Requirement of Rice-Wheat Rotation in Relation to Tillage Alterations**

In a study, direct sown rice-wheat rotation was evaluated with limited irrigation under zero and conventional tillage. Significant increase in yield was recorded with increasing levels of irrigation. The highest yield of wheat (4,810 kg/ha) and rice (2,790 kg/ha) was recorded with four irrigations.

**Fig. 2.23. Wheat grain yield water use efficiency (WUE) and gross returns per mm applied water**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Grain yield (kg/ha)</th>
<th>WUE (kg/ha/mm)</th>
<th>Net returns (000 t/ha)</th>
<th>Grain yield (kg/ha)</th>
<th>WUE (kg/ha/mm)</th>
<th>Net returns (000 t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Tillage</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Zero</td>
<td>4,570</td>
<td>14.3</td>
<td>49.03</td>
<td>2,450</td>
<td>3.7</td>
<td>7.6</td>
</tr>
<tr>
<td>Conventional</td>
<td>4,360</td>
<td>13.3</td>
<td>37.58</td>
<td>2,500</td>
<td>3.7</td>
<td>3.6</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>NS</td>
<td>NS</td>
<td>10.68</td>
<td>NS</td>
<td>NS</td>
<td>2.02</td>
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<tr>
<td><strong>Irrigation</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>4,070</td>
<td>15.5</td>
<td>37.61</td>
<td>2,240</td>
<td>3.7</td>
<td>3.8</td>
</tr>
<tr>
<td>Pre+CRI</td>
<td>4,360</td>
<td>14.4</td>
<td>42.61</td>
<td>2,450</td>
<td>3.8</td>
<td>5.5</td>
</tr>
<tr>
<td>Pre+CRI+Flowering</td>
<td>4,620</td>
<td>13.1</td>
<td>45.29</td>
<td>2,430</td>
<td>3.5</td>
<td>4.7</td>
</tr>
<tr>
<td>Pre+CRI+Flowering+GF</td>
<td>4,810</td>
<td>12.3</td>
<td>47.72</td>
<td>2,790</td>
<td>3.7</td>
<td>8.4</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>285</td>
<td>0.92</td>
<td>3.80</td>
<td>227</td>
<td>NS</td>
<td>2.35</td>
</tr>
</tbody>
</table>
(5,770 kg/ha) followed by N+FYM (5,390 kg/ha). The lowest grain yield was obtained in control (1,750 kg/ha). The average profile moisture was higher due to FYM application in comparison to control and sole application of fertilizer. Water expense efficiency (WEE), gross returns and gross returns per mm applied water followed the same trend as in the case of grain yield.

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

More than 50% higher wheat yield (Table 2.2.5) was obtained with supplementary irrigation (3,480 kg/ha) in comparison to rainfed condition (2,310 kg/ha). The highest yield was obtained with the application of FYM @ 10 t/ha + recommended NPK (4,080 kg/ha) followed by application of FYM @ 10 t/ha + 50% recommended NPK (3,400 kg/ha). Similar trends were observed for gross returns, gross returns per mm water use, water expense efficiency (WEE) and water use efficiency (WUE). In soybean, application of FYM @ 10 t/ha+recommended NPK (3,070 kg/ha) recorded the highest grain yield followed by application of FYM @ 10 t/ha+50% recommended NPK (2,610 kg/ha), and FYM @ 10 t/ha (2,570 kg/ha). Significantly higher yield (2,010 kg/ha) was obtained with supplementary irrigation applied in wheat in comparison to rain fed (1,710 kg/ha). Similar trend was observed with regard to WEE (Table 2.2.6).

**Artificial Recharging Techniques for Hill Springs**

Spring located at VPKAS Hawalbagh farm was selected to revive as its discharge was greatly reduced due to heavy construction on its catchments. The roof water as well as surface water was harvested in trenches, along with plantation on trenches to avoid evaporation and enhance time of concentration of water to increase the water concentration in aquifer recharging zone. The comparative study revealed that the

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Grain yield (kg/ha)</th>
<th>PMC (+)</th>
<th>Irrig. (mm)</th>
<th>WE (mm)</th>
<th>WEE (kg/ha/mm)</th>
<th>WUE (kg/ha/mm)</th>
<th>Gross returns (000 t/ha)</th>
<th>Gross returns (per mm water use)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfed</td>
<td>2,310</td>
<td>-18.0</td>
<td>0.0</td>
<td>212.0</td>
<td>10.9</td>
<td>12.1</td>
<td>34.8</td>
<td>164.0</td>
</tr>
<tr>
<td>Supplementary irrigation</td>
<td>3,480</td>
<td>-15.2</td>
<td>100.0</td>
<td>308.5</td>
<td>11.3</td>
<td>12.1</td>
<td>52.6</td>
<td>170.2</td>
</tr>
<tr>
<td>CD (P = 0.05)</td>
<td>307</td>
<td>NS</td>
<td>NS</td>
<td>3.5</td>
<td>NS</td>
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<tr>
<td>Fertilizer treatments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>1,340</td>
<td>-18.1</td>
<td>50.0</td>
<td>262.1</td>
<td>4.9</td>
<td>5.4</td>
<td>20.2</td>
<td>74.8</td>
</tr>
<tr>
<td>FYM 10 t/ha in both season</td>
<td>2,880</td>
<td>-14.6</td>
<td>50.0</td>
<td>258.6</td>
<td>11.2</td>
<td>12.2</td>
<td>43.5</td>
<td>169.5</td>
</tr>
<tr>
<td>Application of FYM 10 t/ha + NPK in both season</td>
<td>4,080</td>
<td>-16.4</td>
<td>50.0</td>
<td>260.4</td>
<td>15.9</td>
<td>17.3</td>
<td>61.9</td>
<td>241.8</td>
</tr>
<tr>
<td>Application of FYM 10 t/ha + 50% NPK in both season</td>
<td>3,400</td>
<td>-19.3</td>
<td>50.0</td>
<td>263.3</td>
<td>12.8</td>
<td>13.9</td>
<td>51.4</td>
<td>193.6</td>
</tr>
<tr>
<td>NPK in both season</td>
<td>2,420</td>
<td>-15.9</td>
<td>50.0</td>
<td>259.9</td>
<td>9.2</td>
<td>10.0</td>
<td>36.2</td>
<td>137.4</td>
</tr>
<tr>
<td>10t NPK in Kharif + NPK in Rabi</td>
<td>3,280</td>
<td>-15.4</td>
<td>50.0</td>
<td>259.4</td>
<td>12.5</td>
<td>13.6</td>
<td>48.9</td>
<td>185.6</td>
</tr>
<tr>
<td>CD (P = 0.05)</td>
<td>532</td>
<td>1.62</td>
<td>0.62</td>
<td>6.07</td>
<td>18.18</td>
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<td></td>
</tr>
</tbody>
</table>
Table 2.2.6: Grain yield and water use of soybean under different irrigations and fertilizations

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Grain yield (kg/ha)</th>
<th>PMC (+)</th>
<th>Irrig. (mm)</th>
<th>WE (kg/ha/mm)</th>
<th>WEE (kg/ha/mm)</th>
<th>WUE (kg/ha/mm)</th>
<th>Gross returns (000 t/ha)</th>
<th>Gross returns (per mm water use in t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainfed</td>
<td>1,780</td>
<td>-41.7</td>
<td>0.0</td>
<td>866.2</td>
<td>2.0</td>
<td>3.0</td>
<td>36.7</td>
<td>42.3</td>
</tr>
<tr>
<td>Supplementary irrigation</td>
<td>2,010</td>
<td>-44.2</td>
<td>0.0</td>
<td>888.7</td>
<td>2.3</td>
<td>3.4</td>
<td>43.4</td>
<td>50.0</td>
</tr>
<tr>
<td>CD (P = 0.05)</td>
<td>214</td>
<td></td>
<td></td>
<td>0.25</td>
<td>0.37</td>
<td></td>
<td>4.32</td>
<td>5.0</td>
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<tr>
<td>Fertilizer treatments</td>
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<tr>
<td>Control</td>
<td>350</td>
<td>-45.0</td>
<td>0.0</td>
<td>869.5</td>
<td>0.4</td>
<td>0.6</td>
<td>7.5</td>
<td>8.6</td>
</tr>
<tr>
<td>FYM 10 t/ha in both season</td>
<td>2,570</td>
<td>-53.8</td>
<td>0.0</td>
<td>878.3</td>
<td>2.9</td>
<td>4.3</td>
<td>55.4</td>
<td>63.1</td>
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<tr>
<td>Application of FYM 10 t/ha + NPK in both season</td>
<td>3,070</td>
<td>-42.1</td>
<td>0.0</td>
<td>866.6</td>
<td>3.5</td>
<td>5.3</td>
<td>64.7</td>
<td>74.7</td>
</tr>
<tr>
<td>Application of FYM 10 t/ha + 50% NPK in both season</td>
<td>2,610</td>
<td>-43.4</td>
<td>0.0</td>
<td>867.9</td>
<td>3.0</td>
<td>4.5</td>
<td>56.2</td>
<td>64.7</td>
</tr>
<tr>
<td>NPK in both season</td>
<td>700</td>
<td>-36.1</td>
<td>0.0</td>
<td>869.6</td>
<td>0.8</td>
<td>1.2</td>
<td>14.7</td>
<td>17.1</td>
</tr>
<tr>
<td>10 t FYM in Kharif + NPK in Rabi</td>
<td>2,040</td>
<td>-37.5</td>
<td>0.0</td>
<td>862.0</td>
<td>2.4</td>
<td>3.5</td>
<td>41.9</td>
<td>48.6</td>
</tr>
<tr>
<td>CD (P = 0.05)</td>
<td>371</td>
<td></td>
<td></td>
<td>0.43</td>
<td>0.64</td>
<td></td>
<td>7.48</td>
<td>8.65</td>
</tr>
</tbody>
</table>

Rainfall = 624.5 mm; Effective rainfall = 541 mm

Annual discharge of spring was higher 18.9, 68.8, 72.8, 64.6, 141.9 and 160.3% during 2006, 2007, 2008, 2009, 2010 and 2011, respectively in comparison to annual discharge recorded during 2000 before inception of the treatments. Although annual rainfall was below 39, 19.6, 25.8, 26.7 and 9.4% in 2006, 2007, 2008, 2009 and 2011, respectively in comparison to year 2000, however, it was 14% higher in 2010 as compared to 2000 (Fig. 2.24).
Integrated Pest Management


- Development of Low cost Eco-friendly Technologies for the Management of White Grubs (Mr. A.R.N.S. Subbanna, Drs. J. Stanley & P.K. Mishra)

- Bio-diversity of *Bacillus thuringiensis* in Himalayan Hills and their Utilization in Insect Control (Mr. A.R.N.S. Subbanna, Drs. J. Stanley, K. Jeevanandam & P.K. Agrawal)
2.3. Integrated Pest Management

Integrated pest management is now considered to be the key component for sustainable crop production. Development of environmentally safe and integrated methods of management assumes importance in hill ecosystem. Thus, major thrust have been on biological control with specific agents, organic amendments, enhanced varietal resistance and use of safe and cost effective chemicals besides undertaking survey for identification of important diseases and insect pests of major hill crops.

2.3.1. Disease and Insect-Pest Scenario

Severe incidence of wheat yellow rust was observed during the year in entire north western Himalayan region due to prevalent congenial weather conditions throughout the wheat growing season. Rice blast and brown spot of rice, tucicum and maydis leaf blight of maize, frogeye leaf spot of soybean and tikka disease of groundnut were also recorded in moderate to severe intensities. Higher incidence of sclerotinia rot in lentil and field pea were also observed. Monitoring of different crops with respect to insect pest incidence showed moderate incidence of aphids in crucifers during February and March, sporadic infestation of cabbage butterfly, Pieris brassicae in crucifers, red pumpkin beetle, Aulacophora foveicollis in summer squash during April-May and severe infestation of sucking bug, Chrysopogon chuprai in soybean were recorded. Moderate infestation of borer, Sesamia inferens in rice, blister beetles, Mylabris sp. in okra, maize and french bean, fruit flies, Bactrocera sp. in squash, capsicum and tomato were also noticed. Severe infestation of sucking pests like white flies in tomato, cucurbits and capsicum, mites and thrips in capsicum and ornamental crops in polyhouses were noticed.

Field Evaluation of IPM and Non-IPM Modules for Rice Cultivation under Farmer’s Field Condition

As a collaborative programme with NCIPM, New Delhi, a trial consisting of IPM components and corresponding non-IPM/farmers practices was undertaken at villages Raulshera and Bajnath under irrigated transplanted conditions to evaluate the effect of IPM practices on rice production. The IPM components were applied on varieties, Pant Dhan 12, Taichung, Thapachini and a Local variety in Raulshera and varieties, VL Dhan 62, VL Dhan 82, VL Dhan 86 and VL Dhan 65 in Bajnath. The IPM interventions consisted of in-situ green manuring with Dhaichan, balanced fertilizer application, collection and destruction of egg masses/infested plant parts, seedling root dip with chlorpyriphos @ 0.02%, two sprays of fungicides, one with tricyclazole (600 g/ha) and one with mancozeb (2.5 kg/ha) for control of blast and brown spot, respectively, affixing of trichocards and harvesting close to the ground. A light trap was also installed to monitor the photoactive insect pests.

The insect pest severity was comparatively low in all the tested 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 tested, the improved variety Pant Dhan 12 was less susceptible to pest and diseases in comparison to varieties Taichung, Thapachini and local variety (Table 2.3.1). The maximum yield gain of 950 and 900 kg/ha was observed in Taichung and Thapachini, respectively when IPM treatments were followed. In Bajnath, IPM treatments were applied in improve varieties VL Dhan 62, VL Dhan 82, VL Dhan 86 and VL Dhan 65 which were less susceptible to diseases and pests. Therefore, yield gain varied between 300 to 700 kg/ha when IPM treatments were followed. The comparison between average yields showed an increase of 27.6 and 17.9% in IPM implemented fields over non-IPM fields in villages Raulshera and Bajnath, respectively.
Table 2.3.1: Disease and insect pest status in IPM and Non-IPM fields in Rice at village Raulisheba

<table>
<thead>
<tr>
<th>Variety</th>
<th>Pest status</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Leaf blast</td>
<td>Neck blast</td>
<td>Brown</td>
<td>Stem borer</td>
<td>Leaf folder</td>
</tr>
<tr>
<td></td>
<td>(%)</td>
<td>(%)</td>
<td>spot (%)</td>
<td>(No./m²)</td>
<td>(No./m²)</td>
</tr>
<tr>
<td>Taichung</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Thapachini</td>
<td>2</td>
<td>4</td>
<td>7</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pant Dhan 12</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Local</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>IPM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taichung</td>
<td>10</td>
<td>12</td>
<td>20</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Thapachini</td>
<td>12</td>
<td>12</td>
<td>22</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Pant Dhan 12</td>
<td>8</td>
<td>5</td>
<td>9</td>
<td>1.5</td>
<td>1</td>
</tr>
<tr>
<td>Local</td>
<td>20</td>
<td>25</td>
<td>25</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td><strong>Non-IPM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Field Monitoring of Virulence of Pyricularia grisea

Monitoring of virulence pattern of the rice blast pathogen Pyricularia grisea was conducted in a nursery comprising of 62 entries. Entries like Raminad str 3, Tadukan, Tetep and BL-122/ARBN 141 were highly resistant, however, C 101 LAC, C 101 A51, BL-245, IR 64 and A57-115-4/ARBN 148 showed R to MR reaction.

Comparison of Helicoverpa armigera Moth Catches in Light Trap and Pheromone Trap

A comparison was made on the trapping efficiency of light 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 except for peak emergence time, i.e., 3rd and 4th weeks of April (Fig. 2.25). H. armigera catch increased progressively from 2nd week of March and peaked by 3rd week of April and became zero by 2nd week of May onwards in both light and pheromone traps. The peak catch was recorded during 4th week of April with 338 and 662 moths per week in pheromone and light traps, respectively.

2.3.2. Development of Integrated Pest Management Modules for French Bean and Cauliflower

Evaluation of Trichoderma and Pseudomonas Isolates for the Management of Damping-off in Cauliflower

In a field study, five fluorescent Pseudomonas isolates, viz., Pf30, 96, 118, 151 and 163, two Trichoderma harzianum isolates in combination (T11+T28) and carbendazim were tested against damping-off disease of cauliflower. A reduction of > 68% damping off incidence over control was observed in Trichoderma (T11+T28) + carbendazim treated plot. Among Pseudomonas isolates, a reduction of > 58% damping-off incidence was observed with the application of Pf 30 followed by Pf 118 (42%), T11+T28 (38%) and PF151 (34%).

![Fig. 2.25. Comparison of light and pheromone trap catches of Helicoverpa armigera.](image)
Efficacy of Fungicides in the Control of Foliar Diseases of French Bean

Based on the performance of the previous studies, three best fungicides, viz., Azoxystrobin (Amistar 23 SC) @ 0.1%, Difenoconazole (Score 25 EC) @ 0.025% and Propiconazole (Tilt 25 EC) @ 0.05% were tested with one, two and three sprays separately to find out the optimal spray schedule required for effective management of foliar diseases of French bean. 

Table 2.3.2: Effect of different fungicidal sprays on foliar diseases of french bean

<table>
<thead>
<tr>
<th>Fungicides</th>
<th>Rust (%)</th>
<th>Angular Leaf Spot (%)</th>
<th>Yield (kg/ha)</th>
<th>% increase in yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azoxystrobin @ 0.1% one spray</td>
<td>8.2 (16.55)</td>
<td>8.2 (16.55)</td>
<td>5.897</td>
<td>95</td>
</tr>
<tr>
<td>Difenoconazole @ 0.025% one spray</td>
<td>10.7 (18.89)</td>
<td>12.1 (20.3)</td>
<td>7.717</td>
<td>75</td>
</tr>
<tr>
<td>Propiconazole @ 0.05% one spray</td>
<td>13.8 (21.76)</td>
<td>12.2 (20.38)</td>
<td>7.583</td>
<td>72</td>
</tr>
<tr>
<td>Azoxystrobin @ 0.1% two sprays</td>
<td>4.5 (12.19)</td>
<td>5.0 (12.46)</td>
<td>9.550</td>
<td>117</td>
</tr>
<tr>
<td>Difenoconazole @ 0.025% two sprays</td>
<td>9.5 (17.93)</td>
<td>9.9 (18.28)</td>
<td>8.179</td>
<td>86</td>
</tr>
<tr>
<td>Propiconazole @ 0.05% two sprays</td>
<td>11.5 (19.80)</td>
<td>9.5 (17.93)</td>
<td>7.817</td>
<td>78</td>
</tr>
<tr>
<td>Azoxystrobin @ 0.1% three sprays</td>
<td>3.3 (10.47)</td>
<td>4.2 (11.36)</td>
<td>10.123</td>
<td>130</td>
</tr>
<tr>
<td>Difenoconazole @ 0.025% three sprays</td>
<td>7.3 (15.67)</td>
<td>7.0 (15.25)</td>
<td>9.342</td>
<td>112</td>
</tr>
<tr>
<td>Propiconazole @ 0.05% three sprays</td>
<td>10.9 (17.17)</td>
<td>8.2 (16.55)</td>
<td>9.094</td>
<td>107</td>
</tr>
<tr>
<td>Control</td>
<td>46.5 (41.34)</td>
<td>39.5 (24.04)</td>
<td>4.400</td>
<td></td>
</tr>
<tr>
<td>CD (P = 0.05)</td>
<td>2.86</td>
<td>3.92</td>
<td>1.677</td>
<td></td>
</tr>
</tbody>
</table>

*Figures in the parentheses are angular transformed values

Table 2.3.3: Evaluation of IPM modules against french bean foliar diseases and pests

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Rust (%)</th>
<th>Angular leaf spot (%)</th>
<th>No. of bugs per three leaves</th>
<th>% reduction in bug popul.</th>
<th>Yield (kg/ha)</th>
<th>% increase in yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST with Th11+28+SA Lantana+FS Cow dung extract @ 50%+FS BSKE @ 10%</td>
<td>19.85</td>
<td>12.28</td>
<td>2.75</td>
<td>84.29</td>
<td>5.500</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>(26.19)</td>
<td>(20.12)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST with Th11+28+SA Lantana+FS Azoxystrobin @ 0.1+FS Cartap hydrochloride</td>
<td>3.70</td>
<td>2.90</td>
<td>1.75</td>
<td>90</td>
<td>9.550</td>
<td>145</td>
</tr>
<tr>
<td></td>
<td>(10.77)</td>
<td>(9.66)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST with Th11+28+SA Lantana+Panchgaya FS @ 3%+BSKE FS @ 10%</td>
<td>20.89</td>
<td>11.58</td>
<td>2.74</td>
<td>84.34</td>
<td>6.600</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>(26.64)</td>
<td>(19.58)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST with Th11+28+SA Pathenium+Azoxystrobin FS @ 0.1+Cartap hydrochloride FS</td>
<td>3.50</td>
<td>2.20</td>
<td>1.68</td>
<td>90.40</td>
<td>9.660</td>
<td>148</td>
</tr>
<tr>
<td></td>
<td>(10.65)</td>
<td>(8.33)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST with Th11+28+SA Pathenium+Cow dung extract FS @ 50%+FS BSKE FS @ 10%</td>
<td>17.89</td>
<td>12.42</td>
<td>2.8</td>
<td>84.00</td>
<td>6.530</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>(24.88)</td>
<td>(20.42)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST with Th11+28+SA Pathenium+Panchgaya FS @ 3%+BSKE FS @ 10%</td>
<td>18.89</td>
<td>10.50</td>
<td>2.68</td>
<td>84.69</td>
<td>6.400</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>(25.63)</td>
<td>(18.68)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST Carbendazim+Azoxystrobin FS @ 0.1+cartap hydrochloride FS</td>
<td>3.50</td>
<td>2.50</td>
<td>1.5</td>
<td>91.43</td>
<td>9.489</td>
<td>143</td>
</tr>
<tr>
<td></td>
<td>(10.71)</td>
<td>(8.97)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Untreated control</td>
<td>35.6</td>
<td>19.0</td>
<td>17.5</td>
<td>-</td>
<td>3.650</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(32.57)</td>
<td>(25.63)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD (P = 0.05)</td>
<td>7.14</td>
<td>6.94</td>
<td></td>
<td>1,705</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figures in the parentheses are angular transformed values
ST=Seed treatment, SA=Soil amendment, FS=Foliar spray, BSKE = Bhawin Seed Kernel Extract
french bean foliar diseases (Table 2.3.2). The least rust severity (3.3%) was recorded from the plot sprayed with three sprays of azoxystrobin followed by two sprays of azoxystrobin, difenoconazole three sprays and azoxystrobin one spray. Three and two sprays of azoxystrobin were at par. Similarly, for angular leaf spot, three sprays followed by two sprays of Azoxystrobin, three sprays of difenoconazole and one spray of azoxystrobin and three sprays of propiconazole were found effective. An increase of >130% yield over control was observed with three sprays of azoxystrobin followed by two sprays of azoxystrobin, three sprays of difenoconazole and three sprays of propiconazole. Thus, Azoxystrobin @ 0.1% was found most effective in controlling french bean rust and angular leaf spot.

**Development of IPM module in french bean**

Six different IPM management options involving different organic/inorganic substrates/chemicals/biogents in different combinations along with all pesticide treatment and untreated control were tested against french bean diseases and pests (Table 2.3.3). Lowest rust and angular leaf spot severity was found in treatments where fungicide azoxystrobin @ 0.1% sprays involved (Table 2.3.3). More than 90% reduction in sucking bug Chasicocephus chuprai population was found in carap hydrochloride applied treatments followed by BSKE @ 10% treatments. Similarly, increase in yield of french bean (143-148%) over control was obtained with treatments where pesticides were involved along with soil amendments and bio-agent seed treatment. However, 64-69% yield increase was also observed in treatments with no pesticide sprays, but foliar sprays with panchgavaya, cow dung extract and batain kernel seed extract (BSKE) along with reasonable control of diseases and sucking bug. Thus, these IPM packages also hold promise.

**2.3.3. Integrated Management of Bacterial Wilt in Solanaceous Crops**

**Evaluation of Bacterial Antagonists and Organic Substrates/Composts with Suppressive Activity against Tomato and Capsicum Wilt**

In a pot culture studies, 12 antagonistic *Pseudomonas* isolates along with chemical treatment (copper oxy-chloride + Streptocycline) and untreated control were evaluated against bacterial wilt of tomato and capsicum. Chemical treatment showed least wilt incidence both in tomato and capsicum. In tomato, *Pseudomonas* isolate PF11 showed least wilt incidence. Other isolates PF17, PF 3 and PF 131 were also found effective. In capsicum, *Pseudomonas* isolate PF17 showed least wilt incidence followed by PF11, PF 151 and PF 3.

In a separate pot studies, eight organic substrates/composts incorporated in pot soil were tested for their efficacy to control bacterial wilt of tomato and capsicum. A reduction of more than 90% bacterial wilt incidence was observed with COC+ streptocycline treatment followed by mustard straw residue (82%), mustard cake (73%) and neem cake (64%) in tomato and same treatments were also found effective in capsicum.

**2.3.4. Development of Low Cost Eco-friendly Technologies for the Management of White Grubs**

**Light Trap Catches of Different Species of White Grubs**

A total of 28,320 beetles were trapped in light traps in the experimental farm, Hawalibagh of which 146 beetles in May, 12,283 beetles in June, 11,039 beetles in July, 1,071 beetles in August and 1,071 beetles in September 2011. A maximum of 82.35% of total catch was recorded during June-July. Diversity of beetle catches comprised of 25 species of which 67.25% was the predominant species, *Athona dimidita*.

**Studies on Pheromonal Attraction of Scarabaeid Beetles**

Anisole is found to attract male beetles of *Holotrichia sericollis* in the field. Its attraction was estimated as far as 150 m as revealed by trapping of marked beetles. The emergence of beetles started in the second week of May and continued up to 4th week of July. Peak emergence was noted during third and fourth weeks of May, 2011. Pheromonal trap with anisole, VL trap with anisole and VL trap with anisole and light were tested for the attraction of the beetles. Beetle catches in
pheromone trap was very low (8.1 beetles/trap/day) compared to VL trap with anisole (24.8/trap/day) and VL trap with light and anisole (26.3/trap/day). Though VL trap with light and anisole trapped more number of beetles but was not significantly higher than that trapped in traps only with anisole.

Studies on Kairomonal Attraction of Scarabaeid Beetles

Volatiles were extracted from different host plants of white grubs, viz., *Zinnia elegans*, *Rosa* sp., *Rubus ellipticus*, *Sapindus sibiferum*, *Carya illinoensis* etc. using air entrainment/head space sampling technique. The volatiles obtained were studied for the attraction of white grub adults, *Anomala dimidiata*, *Holotrichia longipennis*, *Mecolontha* sp. and *Sophrops* sp. A significant attraction with an attraction index of 0.42 was exhibited by *Sophrops* beetles to pecan nut leaf extract (Table 2.3.4).

Table 2.3.4: Attraction index of adult beetles to volatile extracts from different plants

<table>
<thead>
<tr>
<th>Plant</th>
<th>Attraction index</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>A. dimidiata</em></td>
<td><em>H. longipennis</em></td>
<td><em>Sophrops</em> sp.</td>
</tr>
<tr>
<td><em>Zinnia elegans</em></td>
<td>0.158</td>
<td>0.123</td>
<td>0.143</td>
</tr>
<tr>
<td>Pecan nut</td>
<td>-0.235</td>
<td>-</td>
<td>0.423</td>
</tr>
<tr>
<td>Butter tree</td>
<td>0.330</td>
<td>-</td>
<td>-0.220</td>
</tr>
<tr>
<td>Rose sp.</td>
<td>0.170</td>
<td>0.126</td>
<td>0.330</td>
</tr>
<tr>
<td><em>Rubus ellipticus</em></td>
<td>0.260</td>
<td>-</td>
<td>-0.350</td>
</tr>
</tbody>
</table>

Studies on Toxicity of Different Insecticides on Scarabaeid Beetles

Toxicity of different insecticides was tested against white grub beetles by leaf dip bioassay in the laboratory. Dichlorvos was found to cause 100% mortality in 24 hr and was very effective against *Anomala dimidiata* beetles followed by chlorpyrifos. Though imidacloprid is used for grub management it was not found effective against the beetles (Table 2.3.5).

2.3.5. Biodiversity of *Bacillus thuringiensis* in Himalayan Hills and their Utilization in Insect Control

Isolation of *Bacillus thuringiensis* from Environment Samples

With a view of isolating new stains of *Bt*, a total of 66 environmental samples including soil, leaf and water samples were collected from Raulshera, Basulishera, Someshwar, Binta, Darchula, Munsyari, Matok, Champawat areas of Uttarakhand and Kullu area of Himachal Pradesh. An extensive screening of these samples yielded a total of 12 new *Bt* isolates. Spore crystal formulation was prepared for all the isolates for further studies.

Profile of cry genes in *Bacillus thuringiensis* Isolates

Fifteen *Bacillus thuringiensis* isolates purified from root nodules of different varieties of soybean, Table 2.3.6: cry gene combinations in nodule inhabitant *Bt* isolates

<table>
<thead>
<tr>
<th>Isolate</th>
<th>cry 1</th>
<th>cry 1Ab</th>
<th>cry 1Ac</th>
<th>cry 1C</th>
<th>cry 1D</th>
<th>cry 2</th>
<th>cry 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>VLS72.1</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>VLS72.2</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>VLS72.3</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>VLS64.1</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>VLS64.2</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>VLS64.3</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<td>+</td>
<td>-</td>
</tr>
<tr>
<td>VLS64.4</td>
<td>+</td>
<td>+</td>
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<td>+</td>
<td>-</td>
</tr>
<tr>
<td>VLS21</td>
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<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>VRB1</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<td>VLS21</td>
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<td>VLS21</td>
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<td>VLS21</td>
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<td>VLS21</td>
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<td>VLS21</td>
<td>+</td>
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<td>-</td>
</tr>
</tbody>
</table>

Table 2.3.5: Per cent mortality of scarabaeid beetles using different insecticides

<table>
<thead>
<tr>
<th>Insecticides</th>
<th>Per cent mortality at different hours of treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12 h</td>
</tr>
<tr>
<td>Chlorpyrifos</td>
<td>69.4</td>
</tr>
<tr>
<td>Pherofoomos</td>
<td>25.0</td>
</tr>
<tr>
<td>Imidacloprid</td>
<td>35.0</td>
</tr>
<tr>
<td>Malathion</td>
<td>23.0</td>
</tr>
<tr>
<td>Monocrotophos</td>
<td>05.0</td>
</tr>
<tr>
<td>Dichlorvos</td>
<td>80.0</td>
</tr>
</tbody>
</table>
ricebean, gahat and lentil were characterized based on cry gene combinations through PCR studies. The amplification of the cry genes showed existence of a combination of cry 1 (cryLAb, 1Ac, 1C and 1D) and cry 2 genes in nine isolates (Table 2.3.6). The remaining six isolates showed the existence of only cry 8 gene, which were isolated from soybean. No isolate showed the existence of vip 3, cry 3 and cryLAa genes. The presence of this combination of genes predicts their toxicity against lepidopteran insect pests, which can be exploited in development of a potential microbial biocontrol agent.

Studies on the Existence of VIP Gene

Vegetative insecticidal proteins (VIPs) are the insecticidal toxic proteins produced during vegetative growth phase of the bacterium with no resemblance with the cry toxins. The present study aims at identifying the isolates with VIP gene among the 106 native Bt isolates from Uttarakhand. In this study Bt strain HD-1 was used as a reference and PCR methodology was used to identify the gene with vip 3 primers. The PCR amplification showed the presence of vip 3 gene (1.1 kb) in only one isolate, VLBr-2 (Fig. 2.26).

Fig. 2.26. PCR amplification with vip 3 primers
Socio-economic Studies and Transfer of Technology

- Information Technology System Management (Mr. K.K.S. Bisht & Dr. Mukesh Kumar)
- Study on Adoption of Improved Crop Varieties of the Institute in Mandate Area (Dr. M.L. Roy, Mr. K.K.S. Bisht, Drs. Mukesh Kumar, Lakshmi Kant & Nirmal Chandra)
- Economics of Hill Farming Systems and Its Implication on Efficiency, Employment and Investment Pattern (Dr. Nirmal Chandra, Mr. H.L. Kharbikan, Dr. Renu Jethi & Dr. Pratibha Joshi)
- Development of Need-based Computer Program (Dr. Mukesh Kumar)
2.4. Socio-Economic Analysis and Transfer of Technology

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 Technology System Management

Conversion of technical bulletin "Uttar Pashchim Patra Parvatiya Kshetra mein Premwali Dalhan Pahaloni ki Kheti ke Liye Unnat Takmeelen" in CD ROM format completed. E-book was created in PDF format. This makes reading easy since the user can choose the depth up to which the information is desired. The e-book contains information on technologies developed for production of pulses. Agricultural database for major crops for North-West and North-East Himalayan states was updated to 2009-10. The institute website was updated regularly. About 800 photographs were added to the digital photo repository. Personnel Management Information System for ICAR (PERMISnet) database for the institute was updated regularly. Project Information Management System for ICAR (PIMMSICAR) database was updated. 1 and 2 Mbps internet leased lines were obtained for Haridwar and Almora campuses, respectively. AKMU provided hardware, software, antimalware, intranet and Internet support to the institute.

2.4.2. Study on Adoption of Improved Crop Varieties of the Institute in Mandate Area

Data collected from Bageshwar district revealed that VL Dhan 62 and VL Dhan 65; VL Gehun 829, VL Gehun 832, VL Gehun 892 and VL Gehun 616; VL Ahar 1; VL Masoor 4; VL Mandua 315 and VL Mandua 149; and VL Tamatar 4 were most adopted crop varieties. VPKAS was ranked first by farmers in terms of the trustworthiness of sources of seeds. In a study on level of adoption of modern agricultural technologies in Kumaon hills, 60 farmers (30 farmers each from Bhagartola and Maniagar villages of Almora district) were interviewed and it was found that 65% farmers were cultivating improved varieties of cereal crops, 46.67% farmers were cultivating improved varieties of pulses, 71.67% farmers were cultivating improved varieties of vegetables and 30% farmers were cultivating improved varieties of millets.

Lack of awareness in wide section of the hill farming community is one of the major constraints in diffusion of improved varieties. The availability of seeds at proper time and place is another limiting factor for diffusion. In hill regions, it is a great problem to supply the seeds at each farmer’s door step. In kharif, rabi and other Kisan Mela participating farmers are provided quality seeds at a reasonable rate. Besides, extension leaflets are also distributed amongst the farmers.

Status of Adoption of Modern Agricultural Technologies in Kumaon Hills

This study involved a VPKAS adopted and a non-adopted village. It was found that majority of the farmers in adopted village belonged to high or medium level of adoption (96.67%) whereas all farmers in non-adopted villages belonged to low and medium level of adoption (100%). Out of 16 agricultural technologies selected for this study, the five most adopted technologies were found to be as improved variety of vegetables (71.67%), improved variety of cereals (65%), improved fodder cultivation (51.67%), water harvesting tanks (46.67%) and poly-house (43.33%). The five least adopted technologies were identified as mushroom production (1.67%), use of weedicides (18.33%), seed treatment (23.33%), line sowing (26.67%) and honey bee rearing (30.00%). The adoption index for adopted & non-adopted villages was 64 & 38%, respectively. The study revealed that the variables like risk bearing ability, change-proneness, level of aspiration, annual income and economic
motivation were the most significant determinants of adoption.

**Impact of Adoption of Modern Agricultural Technologies**

The data was collected on 15 independent variables, viz., age, education, category, 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. The result showed that no farmer from the non-adopted village was having high level of risk bearing ability whereas 36.66% of farmers from the adopted village were reported having high level of risk bearing ability. None of the farmers from the non-adopted village was found having high level of change-proneness whereas 23.33% of farmers from the adopted village were reported having high level of change-proneness. The mean scores of the level of aspiration in adopted and non-adopted village were found to be 17.47 and 12.33%, respectively. The difference in average annual income between adopted and non-adopted village was reported to be ₹12,000/- and the percentage of high income category was four times higher in adopted village than that of the non-adopted village. No farmer from the non-adopted village was having high level of economic motivation while 46.67% of farmers from the adopted village were having high level of economic motivation.

**Limiting Factors in Adoption of Improved Agricultural Technologies**

Factors limiting the adoption of improved agricultural technologies were identified as weather vagaries (83.33%), lack of irrigation facility (73.33%), wildlife damage (68.33%), disease and insect attack (66.67%) and fragmented landholding (55.00%).

**2.4.3. Economics of Hill Farming Systems and its Implication on Efficiency, Employment and Investment Pattern**

Economics of crop production for various crops was worked out and the following results were obtained:

Wheat is the main crop of summer season grown in Uttarakhand hills. It was found that after meeting the requirement of seed (9.19%), labour payment (0.83%) and gift (0.46%), remaining 89.62% of the total production was kept for the home consumption in addition to that they had to purchase about 2.00 kg per year per household from market. It was found that in cultivation of wheat net return over cost C1 was only ₹ 547.82 per ha, but when we exclude the family labour, net return was found to be ₹ 4482.82 per ha.

Under improved farming situation net income received from wheat cultivation in rainfed condition was ₹ 19,773.00 per ha whereas in irrigated condition net income was ₹ 35,493.00 per ha.

Paddy is an important crop of kharif season which is grown across the region both in irrigated and rainfed conditions. It was found that 301.86 kg/household (92.31%) out of the total production was available for the home consumption and additional 51.60 kg rice per year per household was purchased from the market to meet out the total household requirement. 21.61 kg (6.6%) of paddy was kept by each farm family for seed in the study area. It was found that in cultivation of paddy, the net return over cost C1 was ₹ 1,942.87 per ha. After excluding the family labour (cost B1), the returns from paddy cultivation was ₹ 7,223.24 per ha.

Under the improved farming situation net income received from paddy cultivation in rainfed condition was found to be ₹ 2,178.00 per ha whereas in irrigated condition it was ₹ 23,907.00 per ha.

Finger millet (ragi) is an important food crop and also is a good source of fodder for cattle. It was found that after meeting the household requirement (62.8%), seed (2%) and other obligations, about 14.06 kg produce was available as marketable surplus. It was found that in cultivation of ragi the net return over cost C1 was negative (₹ -657.51/ha). After excluding the family labour (cost B1), the return from ragi cultivation was ₹ 4437.85 per ha.
The most remunerative cropping sequences prevailing in the region were found to be as Rice-Torria-Potato and Rice-Wheat (irrigated situation). These cropping sequences gave a net income of ₹ 71,800/- and ₹ 59,400/- per ha, respectively. In rainfed situation, soybean-lentil and finger millet-lentil gave a net income of ₹ 17,500/- and ₹ 16,000/- per ha, respectively.

Agriculture combined with livestock and horticulture was found to be the major occupation which engaged about 77.9% of sample population. Agriculture was the main occupation of 65.18% of the population whereas 12.47% had it as secondary occupation. Service was found to be the second major occupation on which about 18% households were dependent. About 7.59% population had business as their main occupation. None of the family had livestock rearing and horticulture as their main occupation.

**Ergonomic Assessment of Agricultural Activities**

To assess the musculoskeletal risk associated with farm women while performing agricultural activities were collected with REBA worksheet. Rapid Entire Body Assessment (REBA) is a whole body assessment tool which was initially designed to provide a pen and paper postural analysis tool to be used in the field by direct observations (Hignett & Mc Atamney 2000). In the present study, it was used to assess the type of unpredictable working postures found in agricultural operations. Data were collected about the body postures, force used, type of movement or action, repletion and coupling. A final REBA score is generated giving an indication the level of risk and urgency with which action should be taken on a five-point action category scale of 0 to 4 (AL0 to AL4), from no action required to action necessary now (Fig. 2.27).

- **AL0**: Scoring 1 (negligible risk, no action is necessary)
- **AL1**: Scoring 2 or 3 (low risk, further action may be needed)
- **AL2**: Scoring 4 to 7 (medium risk, change is required soon)
- **AL3**: Scoring 8 to 10 (high risk, action necessary now)
- **AL4**: Scoring 11+ (very high risk, action necessary now)

The results of experiment show that:

- In the weeding activity 53% of respondent were found to be in high risk (AL4) followed by 27% in medium risk (AL3), 13% in low risk (AL2) and only 7% in negligible risk.
- In the fodder cutting activity 67% of respondents were in high risk (AL4) followed by 20% in medium risk (AL3), 7% in low risk (AL2) and 7% in very high risk (AL4).
- In the harvesting activity 53% of respondent were found to be in high risk (AL4) followed by 20% in medium risk (AL3), 20% in low risk (AL2) and only 7% in negligible risk.
- As an interesting issue of very few respondents in AL0 corresponding to the fact that few subjects worked in an acceptable posture are really a matter of concern.

![Fig. 2.27. REBA analysis of postural assessment](image)

**Assessment of Nutritional Status of Hill Farm Women**

In order to assess nutritional status of hill farm women, daily dietary intake and Body Mass Index (BMI) was worked out. The data were collected from 35 farm women of Bhagartola (adopted village) and 35 farm women of Maniyagar (non-adopted village) in Almora district. It was found
that daily calorie intake of farm women in non-adopted village was 1932 kcal which was deficit by 293 kcal (on the basis of Recommended Dietary Allowances (RDA), ICMR). Iron, riboflavin and β-carotene consumption was found to be deficient among the farm women of both the villages. In adopted and non-adopted villages 37 and 63% farm women had lower BMI, respectively. Pulse consumption in farm women of adopted and non-adopted villages was 47 g and 31 g, respectively, whereas RDA is 70 g. Consumption of green leafy vegetables, other vegetables and sugar was also less than the RDA.

2.4.4. Development of Need-based Computer Program

Genetic stock module database was developed for rice and finger millet crops. The system comprises of three main modules, viz., data entry, query and report generation. The user can retrieve the information on parameters such as sample location, collection year, accession number, tray number and passport information, if available.

The information system for participation by scientists/officers in different events was improved. The user can now retrieve the data in more efficient manner.
Externally Funded Projects

Horticulture Mission for North East & Himalayan States Projects

- Production of Quality Seed and Planting Material (Vegetables) (Dr. N.K. Hedau)
- Standardization of Improved Vegetable Production Technologies under Protected Cultivation (Dr. N.K. Hedau)
- Purification and Seed Multiplication of Underutilized Important Hill Vegetables (Dr. N.K. Hedau)
- Multiplication of Quality Planting Material of Important Cut Flowers of Uttarakhand (Dr. N.K. Hedau)
- On Farm Sustainable Production and Dissemination of Fruits and Vegetables based Farming System in Uttarakhand (Dr. J.K. Bish)
- Efficient Water Management through Micro-irrigation System in Terraced Land for Growing Vegetable (Dr. D.C. Sahoo)
- Dissemination of Growing Off-Season Vegetable Technology under Protected Environment (Mr. K.K.S. Bisht)
- Refinement and Dissemination of Mushroom Production Technologies (Dr. K.K. Mishra)
- Quality Seed Production of Capsicum and Squash under Protected Condition (Dr. M.D. Tuti)
- 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 & Market Opportunities in the State of Uttarakhand (Dr. Renu Jetali)
- Training in Mechanization of Horticulture (Dr. D.C. Sahoo)

DBT Projects

- Rapid Conversion of Normal Maize Inbreds to Quality Protein Maize and Further Enhancement of Limiting Amino Acids in Allied Inbreds through Marked Assisted Selection (Dr. P.K. Agrawal)
- Pyramiding Multiple Resistance Genes using MAS for Durable Resistance against Blast in the North-West Himalayas (Dr. P.K. Agrawal)
• Marker Assisted Selection for Durable Resistance against Yellow Rust in Wheat Suitable for the North-Western Himalayan Region (Dr. N.K. Saini)

• Development of Micro-nutrient Enriched Maize through Molecular Breeding-Phase-II (Dr. P.K. Agrawal)

Network Project on Transgenics

• Development of Transgenic Maize with Resistance to Stem Borer (Dr. P.K. Agrawal)

NAIP Projects

• Enhancement of Livelihood Security through Sustainable Farming Systems and Related Farm Enterprises in N-W Himalaya (Dr. P.K. Agrawal)

• Enabling Small Holders to Improve their Livelihoods from Carbon Finance (Dr. D. Mahamud)

• Bio-prospecting of Genes and Allele Mining for Abiotic Stress Tolerance (Rice and Maize) (Dr. P.K. Agrawal)

All India Coordinated Research Projects

• Post Harvest Technology for Value Addition and Marketing of Agricultural Produce (Dr. D.C. Sahoo)

• Use of Plastics in Agriculture Particularly in Protected Cultivation, Water Harvesting and Packaging (Dr. D.C. Sahoo)

AMAAS Projects

• Development of Bacterial Consortium to Alleviate Cold Stress (Dr. P.K. Mishra)

• Development of a Cold Tolerant Phosphate Solubilizing Bacterial Inoculant (Dr. P.K. Mishra)

DUS Project

• DUS Characterization of Maize Inbreds, Hybrids and Composites (Dr. A. Gupta)

CWC Project

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

The projects under Horticulture Mission for North East and Himalayan States (HMNEH), Department of Bio-technology (DBT) funded projects, Network Project Transgenics, National Agriculture Innovative 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. HMNEH Projects

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

During 2011-12, a total of 2,145.85 kg quality seeds of french bean, okra, tomato, garden pea, onion and garlic were produced against the target of 1,889.00 kg under the project.

2.5.1.2. Standardization of Improved Vegetable Production Technologies under Protected Cultivation

- Tomato hybrid To-1438 was the best with respect to maximum fruit yield, fruit diameter, TSS, etc.
- Capsicum hybrid Lucky Star was found to be the most suitable cultivar giving the highest value of fruit length, pericarp thickness, number of fruits and fruit yield.
- Chilli powder (2g/pit) was found best to control nematodes.
- Maximum BC ratio and highest energy productivity was recorded with cropping sequence tomato/capsicum nursery-tomato-soil treatment-cucumber.

2.5.1.3. Purification and Seed Multiplication of Underutilized Important Hill Vegetables

- Seeds obtained from four diverse lines of Daonagiri radish (local type) were grown in isolation.
- Four local collections of Brassica juncea (leafy type) were grown for purification and maintenance.

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

- Three local type Delphiniums were collected from different parts of Uttarakhand.
- Mother blocks of gerbera, chrysanthemum and carnation were developed and maintained.
- 2680 plants were multiplied, supplied and distributed to different clientele.
- 46 varieties/lines were collected in carnation, chrysanthemum and gerbera and a few promising hybrids were developed and being evaluated.

![Gerbera hybrids developed under HMNEH-MM1](image)

2.5.1.5. On-Farm Sustainable Production and Dissemination of Fruits and Vegetables based Farming System in Uttarakhand

During the year, six polyhouses and three polytanks were constructed. Vegetables worth
₹ 12.46 lakh were sold from open (₹ 4.88 lakh) and protected environment (₹ 7.58 lakh) this year.

The traditional cropping component of cereals and pulses were improved by interventions 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 7.25 ha during the year.

Animal husbandry component was also taken up for the integrated development of the farming system. Under this deworming of animals was done along with feed supplementation to enhance the milk yield and improved growth.

For skill development and capacity building, 11 on-farm trainings/visits were organized.

Activities under On-Farm Sustainable Production project

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

Seven training-cum-demonstration (257 farmers) were conducted at different places including the cooperating center (GBPUA&T, Ranichauri). Water storage capacity of 980 m³ was created and MIS was installed in 0.3 ha in the farmers' fields.

2.5.1.7. Dissemination of Growing Off-Season Vegetables Technology under Protected Environment

This project has been operational in Dwarahat block of Almora district and Dhari, Ramgarh, Bhimtal and Batalghat blocks of Nainital district.

A total of 371 demonstrations covering 6.75 ha area were laid during February-March (Table 2.5.1). The table shows that the protected cultivation of tomato and capsicum resulted in more than 70 and 400% increase in yield compared to open condition.

Table 2.5.1 Detail of demonstrations conducted during February-March 2011

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Demonstrations</th>
<th>Area (ha)</th>
<th>Avg. yield (kg/ha)</th>
<th>Avg. price (₹/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>French bean (February sown)</td>
<td>1</td>
<td>0.27</td>
<td>11,500</td>
<td>18</td>
</tr>
<tr>
<td>Tomato (open)</td>
<td>85</td>
<td>1.92</td>
<td>33,500</td>
<td>20</td>
</tr>
<tr>
<td>Tomato (polyhouse)</td>
<td>13</td>
<td>0.14</td>
<td>57,200</td>
<td>20</td>
</tr>
<tr>
<td>Capsicum (open)</td>
<td>74</td>
<td>1.12</td>
<td>7,500</td>
<td>300</td>
</tr>
<tr>
<td>Capsicum (polyhouse)</td>
<td>5</td>
<td>0.03</td>
<td>37,700</td>
<td>300</td>
</tr>
<tr>
<td>Cabbage (March sown)</td>
<td>112</td>
<td>3.10</td>
<td>47,000</td>
<td>4.50</td>
</tr>
<tr>
<td>Summer squash</td>
<td>71</td>
<td>0.12</td>
<td>60,000</td>
<td>15</td>
</tr>
<tr>
<td>Cucumber (polyhouse)</td>
<td>10</td>
<td>0.05</td>
<td>67,300</td>
<td>15.50</td>
</tr>
<tr>
<td>Total</td>
<td>371</td>
<td>6.75</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
During April-October 2011, 190 demonstrations on 5.96 ha were conducted in four crops (Table 2.5.2). A comparison of cauliflower grown under protected and open conditions shows that protected cultivation not only increased the yield by 40% but also enhanced the consumer appeal, thereby fetching more than double the price.

Table 2.5.2 Detail of demonstrations conducted during April-October 2011

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Demonstrations</th>
<th>Area (ha)</th>
<th>Avg. yield (kg/ha)</th>
<th>Avg. price (₹/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabbage (May sown)</td>
<td>16</td>
<td>0.70</td>
<td>25,000</td>
<td>6</td>
</tr>
<tr>
<td>French bean (June sown)</td>
<td>50</td>
<td>1.12</td>
<td>6,000</td>
<td>25</td>
</tr>
<tr>
<td>French bean (September sown)</td>
<td>110</td>
<td>3.76</td>
<td>12,000</td>
<td>11-18</td>
</tr>
<tr>
<td>Cauliflower (open, August sown)</td>
<td>2</td>
<td>0.18</td>
<td>21,000</td>
<td>14.50</td>
</tr>
<tr>
<td>Cauliflower (polyhouse, August sown)</td>
<td>1</td>
<td>0.02</td>
<td>29,400</td>
<td>30</td>
</tr>
<tr>
<td>Garden pea (polyhouse, August sown)</td>
<td>11</td>
<td>0.18</td>
<td>14,773</td>
<td>50</td>
</tr>
<tr>
<td>Total</td>
<td>190</td>
<td>5.96</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Additionally, 565 demonstrations (26.5 ha) were conducted during November 2011 - March 2012 and the results are awaited.

Seven low-cost polyhouses, covering about 700 m² floor area, were constructed and six training-cum-exposure programmes for farmers were conducted for the adopted villages, in which 334 farmers and farm women participated.

2.5.1.8. Refinement and Dissemination of Mushroom Production Technologies

Refinement of Spawn Production Technology for Oyster and Milky Mushrooms

Locally available grains, viz., finger millet, barnyard millet and wheat were used to refine spawn production technology of *Pleurotus sajor-caju*, *P. florid* (oyster mushroom) and *Calocybe indica* (milky mushroom). It was found that all the grains were colonized by above fungi very well and could be used for spawn preparation. However, barnyard millet grains resulted in early colonization (13 days) by *P. sajor-caju* and shortened the incubation period by 8 days in comparison to wheat grains. Finger millet grains resulted in early colonization by *P. florid* (13 days) and *C. indica* (12 days) and shortened the incubation period by 9 days and 5 days compared to wheat grains, respectively.

Effect of Grain Extract Spray on Yield of Pleurotus spp.

The extracts of finger millet, barnyard millet and wheat grains, were sprayed with various concentrations at the time of pinhead initiation. It was found that increase in concentration of grain extracts resulted in increased yield of both *P. sajor-caju* and *P. florid*. Spray of finger millet grain extract (100% conc.) resulted in maximum yield of *P. sajor-caju* (BE 102.5%) and *P. florid* (BE 98.2%), followed by barnyard millet grain extract (BE 100.4 and 95.0%, respectively).

Cultivation of King’s Oyster Mushroom (*Pleurotus eryngii*)

*P. eryngii* was cultivated using the substrate wheat straw cased with five different casing materials, viz., spent compost (SC), farm yard manure (FYM), SC+ FYM (1:1 w/w), FYM + sandy soil (1:1 w/w), SC + FYM + sandy soil (1:1:1 w/w) and wheat straw alone (check).
Maximum yield was obtained in case of wheat straw cased with spent compost (200 g/200 g dry substrate; BE 100%), however, weight per fruit body was maximum in wheat straw cased with SC+FYM.

**Training and Demonstrations**

Eleven training programmes on different aspects of mushroom cultivation, like importance and uses of mushrooms, spawn production technology, production technologies of various mushrooms, value addition of mushrooms were organized at farmers’ sites as well as at Hawalbarg Farm in which 316 farmers participated. Fourteen demonstrations of oyster and thirteen of button mushrooms were conducted at farmers’ sites. The biological efficiency of oyster mushroom varied from 50-97%, whereas 15-19% BE was observed in case of button mushroom at different farmers’ site.

2.5.1.10. Deployment of Entomopathogens and Light Traps for the Management of Scarabaeids in Uttarakhand Hills

White grubs (Coleoptera: Scarabaeidae) are the most destructive insect pests of agricultural and horticultural crops in hill ecosystem. A two-progressive strategy involving an efficient, light based insect trap for mass trapping of the adult beetles and an entomopathogen, *Bacillus cereus* strain WGFSB-2 for management of grubs was used. Under the project, this management plan was demonstrated on community basis in 17 villages of low, mid and high altitude areas, including two at experimental farms, in Uttarakhand hills. VPKAS took up seven villages to demonstrate the technology with 100 light traps (VL White Grub Beetle Trap-1) installed at strategic locations, which trapped a total of 0.81 lakh beetles during 2011.

The tala-based formulation of *B. cereus* WGFSB-2 was applied in compost and FYM pits and a significant reduction of the grub population was recorded in all the adopted villages. The mean white grub occurrence ranged between 0.0 to 1.1/m² in the adopted villages whereas it was 11.8 to 20.4/m² in a non-adopted village of mid hills. The technology is, thus, capable of managing white grubs in hills. Besides, 132 kg of tala based formulation of WGFSB 2 was prepared and 141 kg of the formulation was applied at farmers’ fields. Likewise, *Brevibacterium frigoritolerans* HSB-15, another entomopathogenic bacterium, was also produced (11 kg) for demonstration and trial purposes. Both the cost effective and environmentally safe technologies have gained popularity and are being advanced under the network project at three centers located at low, mid and high altitudes of Uttarakhand.

2.5.1.11. 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 villages in 2006 under this project. The farmers were trained at the institute and their sites regarding honeybee monitoring and management of bee colonies during dearth. 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 the planned honeybee pollination an increase in the crop yield was realized in the adopted villages. The mean increase in seed yield was 12.50, 16.65, 26.96, 14.10 and 11.56% in honeybee pollinated onion, coriander, toria, radish and fenugreek, respectively, 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 village, with the introduction of honeybees, a substantial increase was noticed in fruit set to the tune of 13.79% in apple, 10.29% in apricot and 21.21% in plum.

### 2.5.1.12. Status of Horticulture and Market Opportunities in the State of Uttarakhand

Primary data were collected from 76 farmers of three clusters of villages, viz., Bhagartola, Dubhkar and Dunagiri. Fig. 2.28, Fig. 2.29 and Fig. 2.30 represent the composition of area allocation by farmers in three clusters.

Crop performance indicates that the yields under protected condition in case of cucumber, tomato, capsicum and cauliflower were 662, 584, 377 and 321 q/ha which were 78, 349, 252 and 157% higher than their respective open condition counterparts. The benefit cost ratio was highest for cucumber (2.59), followed by capsicum (2.26).

The yields of cucumber, cabbage, radish, tomato, cauliflower, potato, capsicum, french bean and pea were 372, 205, 132, 120, 125, 124, 107, 91 and 83 q/ha under open condition with benefit cost ratio 2.30, 1.3, 1.48, 1.45, 1.53, 1.01, 1.67, 1.37 and 1.47, respectively. Due to wild boar problem, the area under potato crop has reduced from 58% in 2010-11 to 53% in 2011-12 in Bhagartola cluster.

Market exposure training was conducted for farmers’ club and SHGs members. In order to reduce problems faced by farmers in marketing of vegetables in nearby markets, one retail outlet has been started by farmers’ club with financial assistance from NABARD.

### 2.5.1.13. Training in Mechanization of Horticulture

Seven training programmes were organized at different villages of Almora and Champawat districts for demonstration of various small, lightweight improved agricultural tools and equipments in which 283 farmers participated. Secateurs,
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.

The yield potential of the QPM is as good as normal maize. Under the present project, three maize inbreds, viz., VQL 1, VQL 2 and VQL 17, parents of two elite maize hybrids, Vivek QPM 9 and FQH 38 were selected and were crossed with QPM donors CML180, CML170 and CML189, respectively in order to improve the nutritional quality and to enhance the tryptophan and lysine level further of the selected elite inbreds.

Based on the foreground selection, background selection and phenotypic selection, 30 plants from each population were selected and grown at Hyderabad in December, 2010 (rabi season). The BC1F1 populations were backcrossed with their respective parents to generate the BC1F1 populations. More than 200 plants from each population were selected from respective backcross population (VQL 1, VQL 2 and VQL 17) for background selection. The background selection was done with more than 30 SSR markers covering all the chromosomal regions (Fig. 2.31).

The genome recovery ranged between 62 to 90% in each population. The tryptophan content within the progenies ranged from 0.43 to 1.1% of the total protein in the VQL 1 derived backcross population whereas it was 0.49-0.97 in VQL 2 and 0.39 to 1.15 in VQL 17. The BC1F1 populations were grown in kharif 2011 at Haulbagh farm of VPKAS, Almora. More than 500 plants were used for foreground and background selection.

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 productivity of rice in this region of hills was 1.921 kg/ha whereas the average national productivity was 2.125 kg/ha. Among many rice cultivars grown in this region, two elite cultivars, viz., VL Dhan 207 and VL Dhan 85 cover a sizable area. Even if both of these cultivars were resistant to blast when released, they have become susceptible at some locations. Hence there is a need to incorporate resistance in these cultivars by pyramiding two or more resistance genes using MAS so that the cultivars may have durable resistance against the blast isolates prevalent in this region.

Breeding Populations for MAS

Different crosses were made and are in different generations (Table 2.5.3). The off-season crop was raised at the Central Rice Research Institute, Cuttack. The foreground and background selections were made in these populations.
Table 2.5.3: The breeding population grown in *rubi* 2011-12 for MAS

<table>
<thead>
<tr>
<th>Crosses</th>
<th>Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(VLD 207 × C101.LAC (F1))</td>
<td>VLD 207</td>
</tr>
<tr>
<td>(VLD 207 × G. ama. Der: (F1 × F1))</td>
<td>VLD207</td>
</tr>
<tr>
<td>VLD 207 MAS 73Q379</td>
<td>F1</td>
</tr>
<tr>
<td>(VLD 85 × C101.LAC (F1))</td>
<td>VLD 85</td>
</tr>
<tr>
<td>(VLD 85 × O. mini. der: (F1 × F1))</td>
<td>VLD 85</td>
</tr>
<tr>
<td>VLD 85 × MAS 39 (F1K)</td>
<td>F1</td>
</tr>
</tbody>
</table>

**Foreground Selection**

Parental polymorphism between the recipient and donor parents were completed for Pi 9, Pi 1 and Pi K80 (Fig. 2.32). The marker for Pi 9 is available right within the gene whereas Pi 1 and Pi K80 are highly close to the gene of interest. Foreground selection was successfully conducted using linked markers like RM 206 for Pi K80, P 28 and NBS LRR markers for Pi 9.

![Fig. 2.32. Parental polymorphism between the donor and recipient for Pi 1 using marker RM224](image)

Lane 1 = C101LAC; 2 = VLD-85; 3 = C101LAC; 4 = VLD-207; L = 50 Kb Ladder

**Background Selection**

A set of 500 DNA markers were used to find polymorphic markers between respective recipient and donor parents. After final evaluation, a set of 100 polymorphic markers for each of the combinations will be selected for the background selection. The PCR conditions for all the polymorphic markers have been standardized. The background selections are under progress.

2.5.2.3. Marker Assisted Selection for Durable Resistance against Yellow Rust in Wheat Suitable for the North Western Himalayan Region

Yellow rust is a devastating disease of wheat in the hilly areas of NW Himalayan states. A well adopted awnless wheat variety from VPKAS, VL Gehun 738 has off late become susceptible to two prevalent pathotypes of yellow rust - 46S119 and 78S84. *Yr5* (*Triticum spelta* album) and *Yr10* (Moro) two yellow rust resistance genes were found to be effective to most of the known pathotypes including these two. The pyramiding of these genes will help in developing durable resistance against this disease. Hence, this project aimed to utilize broad spectrum resistance genes *Yr5* and *Yr10* for transferring yellow rust resistance to VL Gehun 738 using MAS. SSR markers located on different chromosomes were used to study the genome recovery in the BC1F3 population. The genome recovery ranged from 60 to 90% in both the BC1F3 populations. Twenty nine plants for *Yr5* and 25 for *Yr10* were selected on the basis of genome recovery, morphological traits and reaction to disease pressure created by artificial epiphytotic conditions. The harvesst of these selected plants were grown in the off-season nursery at the regional station of DWR at Dalang Maidan, Lahaul Spiti, H.P. in May 2011. A total of about 425 seeds of each BC1F3 population were sown where 30% could germinate. The foreground and background selections were done using SSR markers. In case of *Yr5*, 54 plants were found to possess allele for resistance whereas in case of *Yr10*, 60 plants were found positive. The genome recovery ranged from 80 to 97% in *Yr5* population while it was 75 to 97% in *Yr10* population. The plants having more than 90% recipient genome recovery in case of *Yr5* and 88% in case of *Yr10*, were selected to generate the BC1F3 population. Seventeen plants from *Yr5* and 21 plants from *Yr10* population were selected for the advancement of the breeding generation. About 350 seeds of each population were planted in *rubi* 2011-12. The foreground selection was completed with gene-linked markers (Fig. 2.33). On completion of the background selection, selected plants will be
intercrossed based on their genotypic, phenotypic and resistance reaction to prevailing pathogen strains and populations.

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

Eradication of poverty and hunger, reduction of child mortality and improvement of maternal health are the integral part of the Millennium Development Goals (MDGs) as adopted by the General Assembly of the UN (UN, 2000; UNSCN, 2004). Among the mineral elements, Fe and Zn are the most common elements that have been found to be deficient in human diet. 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 VQ13 were found to be stable and promising genotypes for kernel Fe concentration. In case of kernel Zn, BAJIM-06-10, CM129, V340 and VQ11 were identified as the stable genotypes. Considering both Fe and Zn concentration, CM129, V340 and VQ11 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 population, V336 × 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. 2.34). In addition, analysis of F2 plant harvests (120 F2 seeds) of four populations (V336×VQL1, V336×VQL2, VQL1×V336, VQL2×V336) for kernel Fe content showed several individuals with transgressive segregation. Two crosses, CM145 × lpa1 and V334 × lpa2 were generated for transferring low phytate trait through MAS. The level of homozygosity among the best 10 plants for the cross CM 145 × lpa 1 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 BC1F2 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, 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 1,00,000 seeds (approx.) of VQL 2 were placed for callus induction. The node-derived calli were cultured under 80 µ Mol light resulted in whole plant regeneration with excellent embryogenesis. These 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. *Agrobacterium* mediated transformation of maize calli was also done at the NRCPB, New Delhi under the guidance of Dr. P. A. Kumar, Director, NRCPB. Different visits were made to the NRCPB and the co-cultivation and further regeneration were done at the transformation laboratory at the NRCPB.

### 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

Thirty two major interventions were taken up for enhancement in the agricultural productivity through proven technological interventions whereas 10 interventions were undertaken for the upgradation and management of natural resource base in Champawat district. Technologies found suitable are as follows:

**Introduction of HYVs and Improved Production Technology**

Replacement of local varieties with HYVs and suitable production technology increased the crop yields by 25-48% resulting in surplus foodgrains, after meeting the family requirement.

**Adoption of Oyster and Button Mushroom Cultivation at Champawat**

Farmers were trained to grow oyster and button mushroom which gave an extra income of ₹ 2962-45000 (depending on the number of bags used for mushroom cultivation). Encouraged by the results, 27 farmers have made permanent structures and more than 60 farmers are involved in mushroom cultivation for livelihood security.

**Degraded Land Rehabilitation**

Twelve locally valued multipurpose tree species were introduced as mixed plantation to ensure conservation of biodiversity while providing nutritious fodder to the livestock. After fourth year of plantation, fodder biomass worth ₹ 3.25 lakhs was harvested. This has helped in enhancing awareness among the villagers for the management of the degraded land.

**Backyard Poultry**

Backyard poultry for meat and egg production gave a net profit of ₹ 250 per bird per year.

**Diversification in Agriculture**

With the introduction of vegetable crops in the area, a substantial decrease in cereal based...
cropping systems acreage has been noticed in the operational areas. Off-season cultivation of vegetable crops provided net profit of ₹2-2.5 lakhs per ha as compared to the cereal crops.

Besides, the representatives of SHGs and group of farmers participated in 5 Farmers' Fairs and Agricultural Exhibitions in various locations, viz., Hawalbagh, KVK Sui (Champawat), Devidhura and Lohaghat.

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

Five hundred soil samples have been collected from different places of the grid area for baseline carbon stock estimation. The highest total C content of the grid area was 2.16% (fertile agricultural land) and the lowest value was 0.20% (wasteland). The C:N ratio was estimated from different land use pattern of the grid area and it varied from as low as 4.40 in wasteland to as high as 41.83 in grassland. The total N content varies from 0.026 to 0.795% in these soil samples. A total of 11,300 fruit saplings of mango, guava, pomegranate, lemon, malta, kinnow, orange and gooseberry have been planted in private lands of different villages. As carbon sequestration intervention 5925 forest trees (Quercus leucotrichophora, Alnus nepalensis, Grewia optiva, Bauhinia variegata, Sapindus mukorossii, Cinnamomum tamala, Terminalia chebula, Morus alba and Betula utilis) have been planted in community land of grid area. 30 solar lanterns, 10 solar cookers and 1920 CFL bulbs were distributed as carbon emission reduction interventions. 12 vermi-compost pits were constructed for preparation of vermi-compost and substituting use of chemical fertilizers. Soybean, finger millet, wheat and lentil were sown with zero tillage in 10 ha area.

2.5.4.3. Bio-prospecting of Genes and Allele Mining for Abiotic Stress Tolerance (Rice and Maize)

Differential Responses of Rice Genotypes to Drought and Cold Stress

Seventy three diverse rice genotypes were used for the study. A period of twelve days drought stress was recorded during grain filling stage and cold stress was also recorded in late sown (one month delayed sown) rice genotypes. In these genotypes decrease/increase in different yield traits were recorded (Fig. 2.35).

![Fig 2.35. Percent decrease/increase of rice yield traits due to drought and cold stress in 73 diverse rice genotypes](image)

Under drought condition, there was a significant decrease in chlorophyll content, carotenoid content, photosystem efficiency and photosynthetic efficiency. Chlorophyll 'a' content, chlorophyll 'b' content, total chlorophyll content, total carotenoid content, photosystem II efficiency and photosynthetic efficiency were found to be reduced by 31.18, 39.23, 32.63, 21.45, 20.66 and 15.84%, respectively, compared to that under irrigated condition. Chlorophyll stability index was recorded to be 70.01%.
**Transformation of Calli following Biolistic Approach**

More than 200 calli were bombarded with a test construct with gus and hpt. Five putative plants have been regenerated in Vivek Dhan 65. Similarly, putative transgenic plants have been generated for VL Dhan 206. These plants are being analysed for their expression and gene integration. More number of calli are being bombarded with the same test construct (Fig. 2.36).

![Modified VL Paddy Thresher](image)

**Molecular Profiling and Allele Mining**

The genomic DNA of 84 varieties of maize was extracted. The candidate gene was amplified using different gene specific markers. Three drought specific primers, viz., ASR-I (ABA-water stress-ripening induced protein), ZmPIP (Zea mays plasma membrane integral protein) and Vg-I (Vegetative to generative transition 1) were used to amplify different drought related genes.

2.5.5. AICRP Projects

2.5.5.1 Post Harvest Technology for Value Addition and Marketing of Agricultural Produce

**Modification in the Design of the Existing Paddy Thresher**

A manual operated paddy thresher was developed for hills. It works on the principle of impact on the grain through the threshing drum fitted with a wire loop as a beating device. In the modified model, the weight of the thresher was reduced from 42 to 25 kg (about 40%). It is easily portable and user friendly with 80-100 kg/hr threshing capacity and 98% efficiency. To have better ergonomic, arrangements were made to minimize the vibrations of the machine.

![Fig. 2.36. Regeneration of putative transgenic plants of VL Dhan 65 (a) and VL Dhan 206 (b) after one month of selection under media containing 30 ppm, Regenerated plants in magenta boxes (c, d) modified VL Paddy Thresher](image)

**Performance Evaluation of Developed Barnyard Millet Dehuller**

Vivek millet dehuller was developed for threshing and pelting of finger millet and barnyard millet. Threshing and pelting capacities of finger millet and dehusing capacity of barnyard millet are 40, 80 and 4 kg/hr, respectively.

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

**Use of Plastic in the Development and Fabrication of Pedal Operated, Winnower-cum-Cleaner-Grader and Small Hand Tools**

Introduction of PRP sheet was found to reduce mechanical vibrations in pedal operated, winnower-cum-cleaner-grader in comparison to older model with MS sheet parts. This machine was tested for wheat, paddy, lentil and soybean. The cleaning capacity ranged from 250-300 kg/hr in case of wheat and soybean, and 200-250 kg/hr
for paddy and lentil. The winnowing capacity ranged from 300-350 kg/hr for the said crops.

2.5.6. Projects under AMAAS

2.5.6.1. Development of a Bacterial Consortium to Alleviate Cold Stress

*Cold Tolerant Plant Growth Promoting Bacterial Consortia for Enhancing Chilling Tolerance, Growth and Productivity of Wheat*

Carrier based formulation of eight cold tolerant bacterial consortia were tested under field condition on growth, nutrient uptake and yield of wheat variety VL 804. Inoculation with cold tolerant bacterial consortia had significantly improved root length (3.1-21.7%), shoot length (34.8-69.2%), dry shoot biomass (14.2-76.1%, except C1), dry root biomass (14.2-42.8%, except C3) over control (nonbacterized) at 60 DAS. Bacterization significantly improved the level of cellular metabolites like total chlorophyll (6.5-28.6%), anthocyanin (1.04-1.65 fold), free proline (5.7-77.1%), total phenolics (2.7-31.3%), starch content (0.9-72.5%) and amino acids (2.7-42.5% except C4, C5, C6). Other parameters like relative water content increased, membrane injury reduced and Na+/K+ ratio and electrolyte leakage was decreased at 60 DAS. These parameters are the sign of alleviation of cold stress in wheat plants. Cold tolerant bacterial consortia C1, C7, C5 and C6 significantly increased wheat yield by 17.0, 13.0, 11.1 and 10.1%, respectively, over uninoculated control (38.4 q/ha).

2.5.6.2. Development of a Cold Tolerant Phosphate Solubilizing Bacterial Inoculant

*Effect of Cold Tolerant P solubilizing bacterial consortia on wheat (VL 804) under field condition*

Eight cold tolerant P solubilizing bacterial consortia were evaluated on wheat (VL 804) growth, P uptake and productivity under field condition. Inoculation with cold tolerant bacterial consortia had significantly improved wheat root length (25.0-75.0%), shoot length (8.8-18.8%), dry shoot biomass (11.1-38.8% except C4 and C3), dry root biomass (8.3-25.0% except C3 and C4) over control (nonbacterized) at 60 DAS. Bacterization with P solubilizing bacterial consortium C7, C1 and C5 significantly enhanced P uptake by 55.1, 54.8 and 36.6% respectively, over control. Bacterial consortium C7 recorded maximum seed protein content (11.9%) as compared to uninoculated control (9.38%). Cold tolerant P solubilizing bacterial consortia C7, C6, C4 and C8 significantly increased wheat yield by 21.7, 19.2, 18.2 and 17.4%, respectively, over uninoculated control.

2.5.7 DUS Project

2.5.7.1. DUS Characterization of Maize Inbreds, Hybrids and Composites

To establish distinctness among maize varieties, the descriptor of essential characters (Table 2.5.4.) were used in sequential manner. Of the 21 inbreds studied, 19 were found to be distinct, while, CM 212 and VQL 1 were found
Table 2.5.4: Details of essential characters studied

<table>
<thead>
<tr>
<th>Character</th>
<th>Descriptor state</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ear silk colour</td>
<td>1a Absent, 1b Present</td>
</tr>
<tr>
<td>Plant length</td>
<td>2a Short, 2b Medium, 2c Long</td>
</tr>
<tr>
<td>Type of grain</td>
<td>3a Flint, 3b Semi-flint, 3c Dent</td>
</tr>
<tr>
<td>Anthocyanin colouration of sheath</td>
<td>4a Absent, 4b Present</td>
</tr>
<tr>
<td>Leaf attitude</td>
<td>5a Straight, 5b Drooping</td>
</tr>
<tr>
<td>Anthocyanin colouration at base of glume</td>
<td>6a Absent, 6b Present</td>
</tr>
<tr>
<td>Anthocyanin colouration of glume excluding base</td>
<td>7a Absent, 7b Present</td>
</tr>
<tr>
<td>Leaf angle</td>
<td>8a Narrow, 8b Wide</td>
</tr>
<tr>
<td>Tassel attitude</td>
<td>9a Straight, 9b Curved</td>
</tr>
<tr>
<td>Anthro colour</td>
<td>10a Absent, 10b Present</td>
</tr>
<tr>
<td>Leaf width</td>
<td>11a Narrow, 11b Medium, 11c Broad</td>
</tr>
<tr>
<td>Ear shape</td>
<td>12a Conical, 12b Conico-cylindrical, 12c Cylindrical</td>
</tr>
</tbody>
</table>

Similarly, among 12 hybrids studied, 10 hybrids were found to be distinct, while, Vivek QPM 9 and Vivek Maize Hybrid 9 were found morphologically similar. Composite varieties were found mixture of plants with variable characters.

2.5.8 CWC Project

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

Under the project, 51 multilayered cross laminated film lined tanks (total capacity 3000 m³ and normative command area 2.8 hectare) were constructed with farmers participation along with installation of micro irrigation system in 2.56 ha area in different villages of Almora and Pithoragarh districts. A total of 125 demonstrations were laid on 2 ha area involving 200 farmers on production technology of improved cereal and vegetable crop varieties for efficient water utilization in kharif. Demonstrations on high yielding varieties of wheat (VL Gehun 829, VL Gehun 802, VL Gehun 892 and VL Gehun 907), line sowing with power seed drill, microbial inoculation, etc. are conducted in 10 ha area involving 200 farmers. Besides, two training programmes and exposure visits each, to VPKAS, Almora were organized for the adopted farmers.

Fig. 2.37. Distinctness in maize inbreds
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 feed back 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 Chinyalisa, Uttarkashi

3.1.1. Trainings

Krishi Vigyan Kendra, Chinyalisa, Uttarkashi offered 93 training courses for the practicing farmers, farm women, rural youth, extension functionaries and conducted sponsored trainings on various topics (Table 3.1.1) with an objective to improve skills and expertise of under privileged farmers through improvement in agriculture production and allied enterprises. All training programmes were fully “skill development” oriented and conducted following the principle of “Teaching by doing” and “Learning by doing”.

Table 3.1.1: Training programmes conducted

<table>
<thead>
<tr>
<th>Scientific description</th>
<th>No. of courses</th>
<th>No. of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Crop Improvement</td>
<td>20</td>
<td>306</td>
</tr>
<tr>
<td>Horticulture</td>
<td>26</td>
<td>417</td>
</tr>
<tr>
<td>Plant Protection</td>
<td>16</td>
<td>225</td>
</tr>
<tr>
<td>Animal Science</td>
<td>21</td>
<td>258</td>
</tr>
<tr>
<td>Sponsored training</td>
<td>10</td>
<td>189</td>
</tr>
<tr>
<td>Total</td>
<td>93</td>
<td>1,375</td>
</tr>
</tbody>
</table>

Trainings conducted at KVK Chinyalisa

3.1.2. Front Line Demonstrations (FLDs)

FLD’s on oilseeds, pulses, other crops and livestock were conducted at the farmers’ fields on
35.6 ha benefiting 711 farmers. These farmers were supported with high quality seed material of newly released varieties with recommended package of practices and effective field oriented training programmes. In all the cases, improved technology fared better than the local counterpart. Details of demonstration are presented in Tables 3.1.2 and 3.1.3.

**Table 3.1.2: Details of FLDs conducted**

<table>
<thead>
<tr>
<th>Crops</th>
<th>Variety/technology</th>
<th>Area (ha)</th>
<th>No. of farmers</th>
<th>Average yield (kg/ha)</th>
<th>Increase in yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khurif</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paddy</td>
<td>Application of ZnSO4</td>
<td>1.0</td>
<td>20</td>
<td>3,240</td>
<td>2.630</td>
</tr>
<tr>
<td>Maize</td>
<td>Vivek Sankul Makka 35</td>
<td>3.0</td>
<td>76</td>
<td>2,660</td>
<td>1,750</td>
</tr>
<tr>
<td>Barnyard Millet</td>
<td>VL Madira 172</td>
<td>2.0</td>
<td>24</td>
<td>1,730</td>
<td>1,320</td>
</tr>
<tr>
<td>Finger millet</td>
<td>VL Mandua 315</td>
<td>0.5</td>
<td>10</td>
<td>1,560</td>
<td>1,310</td>
</tr>
<tr>
<td>Horse gram</td>
<td>VL Gahat 8</td>
<td>3.0</td>
<td>77</td>
<td>760</td>
<td>590</td>
</tr>
<tr>
<td>Soybean</td>
<td>VL Soya 47</td>
<td>2.0</td>
<td>36</td>
<td>1,940</td>
<td>1,490</td>
</tr>
<tr>
<td>French bean</td>
<td>Improved cropping system</td>
<td>1.1</td>
<td>26</td>
<td>9,150</td>
<td>6,350</td>
</tr>
<tr>
<td>Okra</td>
<td>VL Bhindi 2</td>
<td>2.0</td>
<td>58</td>
<td>9,730</td>
<td>6,000</td>
</tr>
<tr>
<td>Hybrid Napier</td>
<td>CO 3</td>
<td>2.0</td>
<td>37</td>
<td>28,000</td>
<td>-</td>
</tr>
<tr>
<td>Sub-total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>16.6</strong></td>
<td><strong>364</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rabi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>VL Gehun 829</td>
<td>10.0</td>
<td>136</td>
<td>3,280</td>
<td>2,630</td>
</tr>
<tr>
<td>Toria</td>
<td>PT 303</td>
<td>2.0</td>
<td>37</td>
<td>780</td>
<td>420</td>
</tr>
<tr>
<td>IPM</td>
<td></td>
<td>1.0</td>
<td>25</td>
<td>720</td>
<td>460</td>
</tr>
<tr>
<td>Lennil</td>
<td>VL Masoor 4</td>
<td>2.0</td>
<td>44</td>
<td>1,400</td>
<td>1,020</td>
</tr>
<tr>
<td>Bencem</td>
<td>Meskavi</td>
<td>1.0</td>
<td>16</td>
<td>38,000</td>
<td>-</td>
</tr>
<tr>
<td>Vegetable pea</td>
<td>Vivek Matar 10/11</td>
<td>1.0</td>
<td>35</td>
<td>9,350</td>
<td>7,500</td>
</tr>
<tr>
<td>Cabbage</td>
<td>INM (flocex)</td>
<td>1.0</td>
<td>29</td>
<td>20,650</td>
<td>1,600</td>
</tr>
<tr>
<td>Potato</td>
<td>INM (Zinc sulphate)</td>
<td>1.0</td>
<td>25</td>
<td>23,520</td>
<td>18,500</td>
</tr>
<tr>
<td>Sub-total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>19.0</strong></td>
<td><strong>347</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grand Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 3.1.3: Details of FLDs conducted on livestock and poultry**

<table>
<thead>
<tr>
<th>Category</th>
<th>Thematic area</th>
<th>Technology</th>
<th>No. of farmers</th>
<th>No. of animals/birds</th>
<th>Conception rate (%)</th>
<th>Survival</th>
<th>BeC ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Demo (D) Check (C)</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>Buffalo</td>
<td>Nutrition management</td>
<td>Suppl. of mineral mixture with dewormer</td>
<td>55</td>
<td>100</td>
<td>76.5</td>
<td>34.0</td>
<td>1.29</td>
</tr>
<tr>
<td>Poultry</td>
<td>Evaluation of breeds</td>
<td>Backyard poultry production</td>
<td>14</td>
<td>330</td>
<td>85</td>
<td>60</td>
<td>2.40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>69</strong></td>
<td><strong>430</strong></td>
<td></td>
</tr>
</tbody>
</table>
3.1.3 Seed/Seedling Production

The detail of seed/seedling production is given in Table 3.1.4.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Production (q)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>VL Gehun 829 &amp;</td>
<td>5.00</td>
</tr>
<tr>
<td></td>
<td>VL Gehun 802</td>
<td></td>
</tr>
<tr>
<td>Amaranth</td>
<td>VL Chaa 44</td>
<td>0.10</td>
</tr>
<tr>
<td>Maize</td>
<td>Vivek Sankul Makka 35</td>
<td>2.00</td>
</tr>
<tr>
<td>Finger millet</td>
<td>VK Mandhu 315</td>
<td>0.30</td>
</tr>
<tr>
<td>Oilseeds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybean</td>
<td>VL Soya 47 &amp; VL Soya 63</td>
<td>6.50</td>
</tr>
<tr>
<td>Pulses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pigeon pea</td>
<td>VL Arhar 1</td>
<td>1.00</td>
</tr>
<tr>
<td>Horse gram</td>
<td>VL Gabat 8</td>
<td>2.50</td>
</tr>
<tr>
<td>Lentil</td>
<td>VL Masoor 103 &amp;</td>
<td>3.00</td>
</tr>
<tr>
<td></td>
<td>VL Masoor 125</td>
<td></td>
</tr>
<tr>
<td>Field pea</td>
<td>VL Matar 42</td>
<td>1.50</td>
</tr>
<tr>
<td>Vegetables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Okra</td>
<td>VL Brindia 2</td>
<td>0.70</td>
</tr>
<tr>
<td>Tomato</td>
<td>VL Tamatar 4</td>
<td>0.02</td>
</tr>
<tr>
<td>French bean</td>
<td>VL Bauni bean 2</td>
<td>0.05</td>
</tr>
<tr>
<td>Garden pea</td>
<td>Vivek Matar 10 &amp;</td>
<td>3.50</td>
</tr>
<tr>
<td></td>
<td>Vivek Matar 11</td>
<td></td>
</tr>
<tr>
<td>Onion</td>
<td>VL Pyaz 3</td>
<td>0.10</td>
</tr>
<tr>
<td>Radish</td>
<td>Pusa Chetki</td>
<td>0.04</td>
</tr>
<tr>
<td>Spinach</td>
<td>All green</td>
<td>0.01</td>
</tr>
<tr>
<td>Flower</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marigold</td>
<td>Pusa Narangi</td>
<td>0.01</td>
</tr>
<tr>
<td>Fodder</td>
<td>Hybrid Napier Co 3</td>
<td>36.00</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>127.33</td>
</tr>
<tr>
<td></td>
<td>Seedling produced (number)</td>
<td>1,38,820</td>
</tr>
</tbody>
</table>

Plant Breeding Trials

Nine plant breeding trials were conducted at KVK under AICRP and State Varietal Trials, which included three trials of soybean and one each of horse gram, black gram, paddy, lentil, toshia and wheat.

Other Extension Activities

The KVK organized 75 kisan gosthi, one kisan melas, three exhibitions, one field day and 105 advisory services at the different villages of the district. Forty two of these activities got coverage in newspapers. Nearly 8,700 farmers were benefitted by these activities. SMS and staff members attended the Krishak Mahasabha organized by Uttarakhand Govt. during kharif 2011 and rabi 2011-12 benefitting 15,000 farmers and state government officials.

3.2. KVK Kafligair, Bageshwar

3.2.1. Trainings

The KVK organized 88 training programmes, with 1,910 beneficiaries, for the practicing farm women, rural youth and extension functionaries

<table>
<thead>
<tr>
<th>Discipline</th>
<th>No. of courses</th>
<th>No. of trainees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop production</td>
<td>3</td>
<td>Male 58 Female 17</td>
</tr>
<tr>
<td>Horticulture</td>
<td>15</td>
<td>174 137 311</td>
</tr>
<tr>
<td>Agricultural Extension</td>
<td>16</td>
<td>174 155 329</td>
</tr>
<tr>
<td>Home Science</td>
<td>17</td>
<td>95 204 299</td>
</tr>
<tr>
<td>Animal Science</td>
<td>17</td>
<td>217 244 461</td>
</tr>
<tr>
<td>Sponsored training</td>
<td>20</td>
<td>246 189 435</td>
</tr>
<tr>
<td>programmes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>88</td>
<td>964 946 1,910</td>
</tr>
</tbody>
</table>

Annual Report 2011-2012
on various topics, including 20 sponsored training programmes (Table 3.1.5).

3.2.2. Front Line Demonstrations

Front line demonstrations on various kharif and rabi crops were conducted on 47.67 ha area which benefited 1,933 farmers. These FLDs resulted in increasing the yield from 8.33-66.67% in various hill crops (Table 3.1.6).

Apart from this, FLDs were also conducted on poultry rearing and fodder production (Table 3.1.7).

3.2.4. On-Farm Trials

Yield Enhancement of Onion through Balanced Fertilization

Crop grown with FYM @ 20 t/ha + NPK @ 150:50:80 (through urea, SSP and MOP) gave

Table 3.1.6: Details of FLDs conducted

<table>
<thead>
<tr>
<th>Crops</th>
<th>Variety</th>
<th>Area (ha)</th>
<th>No. of farmers</th>
<th>Average yield (kg/ha)</th>
<th>Increase in yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Demo</td>
<td>Farmers practice</td>
</tr>
<tr>
<td>Kharif</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paddy</td>
<td>VL. Dhan 65</td>
<td>2.20</td>
<td>34</td>
<td>3,250</td>
<td>3,000</td>
</tr>
<tr>
<td></td>
<td>Vivek Dhan 154</td>
<td>3.55</td>
<td>102</td>
<td>2,600</td>
<td>1,600</td>
</tr>
<tr>
<td>Maize</td>
<td>VL. Sankal Makka 31</td>
<td>1.66</td>
<td>111</td>
<td>3,400</td>
<td>2,500</td>
</tr>
<tr>
<td>Mandua</td>
<td>VL. Mandua 315</td>
<td>2.84</td>
<td>64</td>
<td>1,550</td>
<td>1,200</td>
</tr>
<tr>
<td>Pigeon pea</td>
<td>VL. Ashar 1</td>
<td>15.03</td>
<td>247</td>
<td>1,500</td>
<td>-</td>
</tr>
<tr>
<td>Soybean</td>
<td>VL. Soya 47</td>
<td>5.16</td>
<td>203</td>
<td>1,500</td>
<td>1,000</td>
</tr>
<tr>
<td>Summer green gram (Moong)</td>
<td>SML 668</td>
<td>0.60</td>
<td>28</td>
<td>860</td>
<td>-</td>
</tr>
<tr>
<td>Horse gram</td>
<td>VL. Gahat 8</td>
<td>2.64</td>
<td>121</td>
<td>890</td>
<td>700</td>
</tr>
<tr>
<td>French bean</td>
<td>VL. Bean 2</td>
<td>0.70</td>
<td>110</td>
<td>8,800</td>
<td>-</td>
</tr>
<tr>
<td>Okra</td>
<td>VL. Bhindi 2</td>
<td>1.10</td>
<td>178</td>
<td>11,000</td>
<td>-</td>
</tr>
<tr>
<td>Summer squash</td>
<td>Australian green</td>
<td>2.00</td>
<td>189</td>
<td>34,000</td>
<td>-</td>
</tr>
<tr>
<td>Ginger</td>
<td>Rio-de-generio</td>
<td>1.10</td>
<td>245</td>
<td>7,800</td>
<td>5,700</td>
</tr>
<tr>
<td></td>
<td>Sub-total</td>
<td>38.58</td>
<td>1632</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rabi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>VL. Gehun 829</td>
<td>6.73</td>
<td>137</td>
<td>3,340</td>
<td>2,500</td>
</tr>
<tr>
<td>Mustard</td>
<td>Pusa bold</td>
<td>0.18</td>
<td>9</td>
<td>1,200</td>
<td>720</td>
</tr>
<tr>
<td>Garden pea</td>
<td>Arkel</td>
<td>2.18</td>
<td>155</td>
<td>8,900</td>
<td>6,200</td>
</tr>
<tr>
<td></td>
<td>Sub-total</td>
<td>9.09</td>
<td>301</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grain Total</td>
<td>47.67</td>
<td>1,933</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.1.7: FLDs on other aspects

<table>
<thead>
<tr>
<th>Enterprises</th>
<th>Aspects</th>
<th>Area (ha)/No.</th>
<th>No. of farmers</th>
<th>Parameters</th>
<th>Demonstrations</th>
<th>Local check</th>
<th>% change in the parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poultry</td>
<td>Cotter</td>
<td>200 Chicks</td>
<td>10</td>
<td>SR* - 70%</td>
<td>SR* - 60%</td>
<td>10</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GR* - 2.0 kg in 4 months</td>
<td>GR* - 1.5 kg in 4 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Feed consumption - 3.5 kg + local grasses + worms</td>
<td>Feed consumption - 5 kg + local grasses + worms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fodder production</td>
<td>Hybrid</td>
<td>0.38</td>
<td>10</td>
<td>EP* - 85</td>
<td>EP* - 75</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Nature</td>
<td></td>
<td></td>
<td>Yield - 400 q/ha</td>
<td>Yield - 200 q/ha</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* SR - survival rate; GR - growth rate; EP - establishment %
highest yield of 26,500 kg/ha that was 28.0% higher than farmers’ practice (FYM only). The B:C ratio of the technology assessed was 1.81, while farmers’ practice had B:C ratio of 1.55.

3.3. Institute Headquarters’ Endeavour on Transfer of Technology

3.3.1 Trainings

Thirty three training programmes were organized for the state officers, farmers and adopted farmers of SSB of Uttarakhand, Uttar Pradesh and Jammu and Kashmir on different aspects of hill agriculture, like organic farming, seed production, off-season vegetable production, mushroom cultivation, use of plastics in hill agriculture, benefiting 1,870 farmers.

3.3.2. Front Line Demonstration

**Rice**: Demonstrations of released varieties, viz., VL Dhan 85 and VL Dhan 65, were conducted among 135 farmers on 9.82 ha area distributed over 20 villages of Almora and Bageshwar districts. The overall yield advantage of VL Dhan 85 and VL Dhan 65 was 35.36 and 52.71%, respectively, over local checks.

**Wheat**: During *rabi* 2010-11, FLDs were conducted, using VL Gehun 907, on 14 ha area involving 133 farmers of Nainital and Almora districts. VL Gehun 907 gave an average yield of 3,385 kg/ha, which was 89.6% higher than the local check.

**Horse gram**: FLDs on two improved varieties were conducted among 88 farmers in 17 villages on 2.66 ha. VL Gahat 15 and VL Gahat 19 showed significant yield advantage (45.60 and 65.00%, respectively) over local cultivars.

**Pigeon Pea**: Eighty eight FLDs on VL Arhar 1, on 3.5 ha, were conducted in 20 villages of Bageshwar, Nainital and Pithoragarh districts. The yields recorded in these villages ranged from 600 to 1,425 kg/ha with a mean of 945 kg/ha.

*Annual Report 2011-2012*
Soybean: FLDS on improved cultivars conducted among 29 farmers in 5 villages (2 ha) in the Nainital, Almora and Pithoragarh districts. VL Soya 63, VL Soya 59, VL Soya 47 and VL Bhat 65 showed higher yield of 59.24, 35.67, 61.27 and 104.27%, respectively, over local cultivars.

3.3.3. Krishi Samriddhi (कृषि समृद्धि)
   This institute sponsored programme aims at providing the farmers 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 Fairs/ Melas
   • Dr. M.L. Roy and Mr. H.L. Kharbikar participated in Prakshyeta Divas/Geeta under ATMA Programme, Kapharkhan, Almora, June 13.
   • Institute put a stall at Nanda Devi Mela, Almora, September 8-12.
   • Mr. H.L. Kharbikar and Mr. M.C. Pant participated in Pannagar Kisan Mela for rabi at GBPUA&T, Pannagar, October 12-15.
   • Drs. B.M. Pandey and D.C. Sahoo participated in Shardotsav, Lohaghat (Champawat), November 9.
   • Dr. M.L. Roy and Mr. H.L. Kharbikar participated in Gouchar Audyogik Vikas Evam Sattvik Mela 2011, Gouchar, Chamoli, November 14-20.
   • Drs. M.L. Roy and Salej Sood participated in Pusa Krishi Vigyan Mela IARI, New Delhi, March 1-3.
   • Mr. H.L. Kharbikar and Mr. M.C. Pant participated in Pannagar Kisan Mela for kharif at GBPUA&T, Pannagar, March 15-18.
4.1 Training of Institute's Staff at Other Institutes

The following institute personnel were deputed for different HRD programmes during 2011-12.

<table>
<thead>
<tr>
<th>Duration</th>
<th>Participant</th>
<th>Topic</th>
<th>Venue</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 4-6</td>
<td>Dr. J.C. Bhart</td>
<td>Employees' Perspective on Labour Related Laws</td>
<td>NAARM, Hyderabad</td>
</tr>
<tr>
<td></td>
<td>Mr. Beerr Singh &amp; Maheish Lal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>September 27</td>
<td>Dr. J. Stanley</td>
<td>Winter School on Br Rice: Evaluation and Deployment Strategy</td>
<td>D.R.R., Hyderabad</td>
</tr>
<tr>
<td>November 22-26</td>
<td>Dr. Udaya Bhashar Khetinini</td>
<td>Training on Seed Quality Assurance</td>
<td>IARI, New Delhi</td>
</tr>
<tr>
<td>December 11-14</td>
<td>Drs. R. Arun Kumar, M. L. Roy, Rema Jethi &amp; Mr. H. L. Kharbikar</td>
<td>PRA Approaches for Documenting Community Perceptions, Responses and Adaptive Capacity to Change</td>
<td>G.B.P.U.A &amp; T, Pantnagar</td>
</tr>
<tr>
<td>January 24 to April 23</td>
<td>Mr. Shash Kumar Das</td>
<td>Three months Professional Attachment Training in All India Network Project on Pesticide Residue</td>
<td>IARI, New Delhi</td>
</tr>
<tr>
<td>January 28 to April 24</td>
<td>Mr. Athol Killa, G.A.</td>
<td>Three months Professional Attachment Training</td>
<td>IIHR, Bangalore</td>
</tr>
<tr>
<td>March 12-14</td>
<td>Mr. Kamal Kumar Pandey</td>
<td>Training on Recent Advances in Production of Horticulture Crops</td>
<td>GBPUA&amp;T, Pantnagar</td>
</tr>
<tr>
<td>March 12-14</td>
<td>Dr. Ravindra Kumar Tiwari</td>
<td>Training on Breeding related problems in Animals</td>
<td>SAMETI GBPUA&amp;T, Pantnagar</td>
</tr>
<tr>
<td>March 13-26</td>
<td>Ms Shefali Amrapali</td>
<td>Training on Applications of Geo-informatics and Crop Simulation Models in Agricultural Management</td>
<td>NAARM, Hyderabad</td>
</tr>
<tr>
<td>March 19-30</td>
<td>Mr. H.L. Kharbikar</td>
<td>Training Workshop on Quantitative Techniques for Agriculture</td>
<td>NCAP, New Delhi</td>
</tr>
</tbody>
</table>
AWARDS AND RECOGNITION

- Dr. J.K. Bisht has recognized as the Fellow by Range Management Society of India at IGFRI, Jhansi, September 11.
- Dr. P.K. Agrawal was awarded the best poster on maize biofortification at the 11th Asian Maize Conference on addressing climate change effect and meeting maize demand for Asia, Nanning, China, November 7-11.
- Dr. K.K. Mishra, Senior Scientist (Plant Pathology) received the Young Scientist Award for presentation entitled Biodiversity and Utilization of Medicinal Mushrooms of Uttarakhand Hills with particular reference to Ganoderma lucidum and Cordyceps sinensis at Uttarakhand State Science and Technology Congress, Almora, November 14-16.
- Ms. Pooja Ruwari received Young Scientist award for poster presentation entitled Alleviation of cold stress by psychrotolerant plant growth promoting bacterial consortium on pea (Pisum sativum L.) seedlings at Uttarakhand State Science and Technology Congress, Almora, November 14-16.
- Dr. V.P. Mani, retired Principal Scientist received Joginder Singh Memorial Award in Maize Genetics and Plant Breeding, which was awarded by Indian Society of Genetics and Plant Breeding, New Delhi for Original and Meritorious Research Work in Maize Genetics and Breeding during the biennium 2009-10.
- The institute received Krishi Saasthan Samman under the Mahindra Samridhi India Agri Award 2012 for its outstanding contribution in the field of development and extension of agricultural technologies. The award was given by Agriculture Minister, Govt. of India Shri Sharad Pawar ji to the Director of the institute Dr. J.C. Bhatt. The award was for the newly developed technologies of dual purpose wheat and early pigeonpea variety and its extension to farmers' fields. One lakh rupees, momento and certificate were given under this award, New Delhi, February 21.
The Institute has effective linkage and collaboration with the following organizations:

6.1. Local Institution in the Area

6.2. National Institutes and Agricultural Universities
- Indian Agricultural Research Institute, New Delhi.
- Indian Institute of Pulses Research, Kanpur.
- Central Rice Research Institute, Cuttack.
- Directorate of Wheat Research, Karnal.
- Directorate of Rice Research, Hyderabad.
- Directorate of Maize Research, New Delhi.
- G.B. Pant University of Agriculture and Technology, Pantnagar.
- C.S.K. Himachal Pradesh Krishi Vishwa Vidyalaya, Palampur, H.P.
- Y.S. Parmar University of Horticulture and Forestry, Solan, H.P.
- Sher-e-Kashmir University of Agriculture Science & Technology, Srinagar, J&K.
- Sher-e-Kashmir University of Agriculture Science & Technology, Jammu, J&K.

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

6.4. Extension and Development Agencies
- State Department of Agriculture, Uttarakhand.
- Indian Farmers Fertilizer Cooperative
- National Agricultural Bank for Rural Development.
- Mahindra and Mahindra Subh Labh Services.
- Private agencies.
- NGOs.
IMPORTANT COMMITTEES OF THE INSTITUTE

7.1. राजमात्रा कार्य-न्याय समिति

कप. जगदीश सहम, भट, निदेशक — अध्यक्ष
श्री ए.जयराम, प्रमुख, पं. मुनीन, मैथिलिक — सदस्य
श्री मोहन पाल, प्रशिक्षण संस्थान सहकारी — सदस्य
श्रीमती हरीश, मोहनसांगी, मित्र एवं लेखा अधिकारी — सदस्य
श्री रे. बहुवर्षीय पत्र, तिककीकारी — सदस्य
(
राजमात्रा)

7.2. Institute Joint Council

Chairman – Director

Members (Official Side) – Ds. Gyanendra Singh, Senior Scientist; N. Saini, Senior Scientist; Mr. A.R.N.S. Subraman, Scientist; Dr. K. Jeevanesan, Scientist; Administrative Officer and Finance & Accounts Officer

Members (Staff Side) – Mr. Bahadur Ram, Assistant Administrative Officer (Member CJSC); Mr. Santosh Dua, Assistant; Mr. Davendra Lal, T-3; Mr. Jiwand Singh Bish, T-3; Mr. Vishwa Raj Pandey, Skilled Supporting Staff (Member CJSC w.e.f. July 30) and Mr. Surendra Singh Gwal, Skilled Supporting Staff.

7.3. Study Leave Committee

Chairman – Dr. Lakshmi Kant, Principal Scientist

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

7.4. Institute Technology Management Committee

Chairman – Director

Members – Heads, Crop Improvement and Crop Production Divisions; Dr. K. S. Negi, Principal Scientist (NBIPGR Regional Station, Bhawan), Dr. J.K. Bish, Principal Scientist and Coordinator (PME Cell)

Member Secretary – Dr. P.K. Agarwal, Principal Scientist and Chairman (ITMU)

7.5. Institute Technology Management Unit

Chairman – Dr. P.K. Agrawal, Principal Scientist

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

7.6. 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, Principle Scientist, Mukes Kumar, Scientist

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

7.7. PERMISNET/PIMSCAR/HYPMP

Nodal Officer – Dr. Mukes Kumar, Scientist

7.8. Research Advisory Committee (RAC)

Chairman – Dr. B. Mishra, 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, CRU AFF; Dr. Sain Das, Former Director, DMR; Dr. R.A. Singh, Former Prof. and Head, Plant Pathology, GBPWA&T, Pantnagar; Dr. M.C. Nautiyal, Former Dean, College of Forestry, GBPWA&T, Ranichaur Campus; Prof. T.C. Thakur, National Professor, Deptt. of Farm Machinery and Power Engineering, GBPWA&T, Pantnagar; Dr. I.D. Tyagi, Former Professor, CSAU&T, Kanpur; Shri Vikram Singh Negi (Member IMC); Shri Jayendra Singh Rana (Member IMC).

Member Secretary – Dr. J.K. Bisht, Principal Scientist
7.9. Institute Management Committee (IMC)
Chairman – Director
Members – Assistant Director General (FFC); Director, Agriculture HP; Director Research GBPUA&T, Pantnagar; Joint Director, Agriculture UK; Chief Finance and Accounts Officer, IVRI, Bareilly; Dr. J.K. Bisht, Principal Scientist; Dr. D.K. Garg, Principal Scientist, NCIPRM, New Delhi; Dr. Y.P. Sharma, Principal Scientist and Head, IARI Regional Station, Shimla; Dr. K. S. Hooda, Principal Scientist, DMR, New Delhi; Shri Vikram Singh Negi; Shri Jayendra Singh Rana.
Member Secretary – Mr. Mahesh Lal, Administrative Officer

7.10. Institute Research Council
Chairman – Director
Members – All the Scientists of VPKAS, Almora
Member Secretary – Coordinator (PME Cell)

7.11. Committee for Monitoring of Field Experiments
Chairman – Director
Members – Heads, Principal Scientists and Coordinator (PME Cell)

7.12. Vigilance Cell
Dr. J.K. Bisht, Principal Scientist

7.13. Purchase Advisory Committee
Chairman – Dr. S.K. Jain, Principal Scientist
Members – Drs. N. Saini, Senior Scientist; Mr. A.R.N.S. Subbanna, Scientist; FAO; OIC (Store)/AAO

7.14. Standing Purchase Committee
Chairman – Dr. P.K. Mishra, Senior Scientist
Members – Dr. Mukesh Kumar, Scientist; FAO; OIC (Store)/AAO

7.15. Institute Bio-safety committee (ISBC)
Chairman – Director
Members – Dr. Anil Kumar, Head, Molecular Biology and Genetic Engineering GBPUA&T, Pantnagar (Outside Expert); Dr. A.S. Gusain, Medical Officer, Almora
Member Secretary – Dr. P.K. Agrawal, Principal Scientist and Head

7.16. 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
Member Secretary – Mr. T.B. Pal, Technical Officer

7.17. Public Information Cell
Public Information Officer – Dr. J.K. Bisht, Head; Dr. Gyanendra Singh, Senior Scientist; Mr. Mahesh Lal, Administrative Officer.

Public Information Officer (KVK, Chinylissur and Bageshwar):
Program Coordinator, KVK Bageshwar.
Program Coordinator, KVK Uttarkashi.
LIST OF PUBLICATIONS

8.1. Book Chapters

8.2. Scientific Paper Published in Journals

8.2.1. International Journals


S.1.2. National Journals


8.3. Popular Article

8.4. Institute Publications

- कृषि भौगोलिक 2011–12
- VPEAS Newsletter Vol. 15 (No. 1 & 2)
- वहांतीय कृषि दर्पण, वार्षिक 8 एवं 9 (Hindi)
- Vision 2030
- Annual Report 2010-11

8.5. Extension Literature

- कृषि भौगोलिक व्रेंड, उत्तरकाशि - एक परिचय
LIST OF ONGOING PROJECTS

9.1 Institute’s Core Research Projects

a. Enhancement in the Productivity of Major Hill Crops

Projects
2. Genetic Enhancement for Productivity and Quality in Maize.
7. Enhancing Quality and Resistance to Biotic Stress through Molecular Breeding.

b. Natural Resource Management for Sustainable Productivity

Projects
9. Enhancing Productivity and Profitability of Major Hill Crops through Diversification and Reduction in Cost of Cultivation.
12. Design and Development of Small Tools and Farm Machineries for Hill Agriculture.
13. Wasteland Management with Special Reference to Production of Podder and Fuelwood.

c. Integrated Pest Management

Projects
18. Biodiversity of Bacillus thuringiensis in Himalayan Hills and their Utilization in Insect Control.

d. Socio-economic Studies and Transfer of Technology

Projects
19. Information Technology System Management.
20. Study on Adoption of Improved Crop Varieties of the institute in the Mandate Area.
22. Development of Need-based Computer Programmes.

9.2. Externally Funded Projects

Horticulture Mission for North East & Himalayan States Projects
1. Production of Quality Seed and Planting Material (Vegetables).
2. Standardization of Improved Vegetable Production Technologies under Protected Cultivation.
3. Purification and Seed Multiplication of Under-utilized Important Hill Vegetables.
5. On Farm Sustainable Production and Dissemination of Fruits and Vegetables based Farming System in Uttarakhand.
8. Refinement and Dissemination of Mushroom Production Technologies.
9. Quality Seed Production of Capsicum and Squash under Protected Condition.
11. Planned Honey Bee Pollination for Improvement in Horticultural Crop Production.

DBT Projects
1. Rapid Conversion of Normal Maize Inbreds to Quality Protein Maize and further Enhancement of Limiting Amino Acids in Allied Inbreds through Marker Assisted Selection.
2. Pyramiding Multiple Resistance Genes using MAS for Durable Resistance against Blast in the North-West Himalayas.
3. Marker Assisted Selection for Durable Resistance against Yellow Rust in Wheat Suitable for the North-Western Himalayan Region.
4. Development of Micro-nutrient Enriched Maize through Molecular Breeding-Phase-II.

Network Project on Transgenics

NAIP Projects
2. Enabling Small Holders to Improve their Livelihoods from Carbon Finance.
3. Bio-prospecting of Genes and Allele Mining for Abiotic Stress Tolerance (Rice and Maize).

All India Coordinated Research Projects
2. Use of Plastics in Agriculture Particularly in Protected Cultivation, Water Harvesting and Packaging.

AMAAS Projects
2. Development of bacterial consortium to alleviate cold stress.

DUS Project
1. DUS Characterization of Maize Inbreds, Hybrids and Composites.

CWC Project
1. Demonstration of Storage and Application System for Efficient Water Utilization in Major Crops of Uttarakhand Hills through Participatory Approach-Phase-II.
## Consultancy, Patents, Commercialization of Technology

<table>
<thead>
<tr>
<th>Year</th>
<th>Royalty</th>
<th>Name of Technology</th>
<th>Address of the company</th>
</tr>
</thead>
<tbody>
<tr>
<td>April, 2011</td>
<td>₹ 21,000</td>
<td>VL White Grub Beetle Trap-I</td>
<td>M/s Doon Trunk House, Jakhan Devi, Almora</td>
</tr>
<tr>
<td>Sept., 2011</td>
<td>₹ 3,20,000</td>
<td>Vivek QPM 9 - An Early Maturing QPM Maize Hybrid for the Himalayan States and Peninsular India</td>
<td>Sampoorana Seeds, 15/465, Cocha Hospital Road, Adoni- 518301, Andhra Pradesh</td>
</tr>
</tbody>
</table>
11 QRT, RAC, IMC AND IRC MEETINGS

11.1. Research Advisory Committee (RAC) Meeting

The XVI Research Advisory Committee (RAC) meeting of VPKAS, Almora was held on October 15-16, 2011 under the Chairmanship of Dr. B. Mishra, Vice Chancellor, SKUAST-J, Jammu. The other RAC members namely, Dr. H.S. Sen, Former Director, CRDF, Barrackpore; Dr. Sain Dass, Former Director, Directorate of Maize Research, New Delhi; Prof. T.C. Thakur, National Professor, Deptt. of Agricultural Engineering of GBPIA&T, Pantnagar; Dr. M.C. Naufial, Former Dean, College of Forestry, GBPIA&T (Ranichauri Campus), Pantnagar; Dr. R.A. Singh, Former Professor and Head, Plant Pathology, GBPIA&T, Pantnagar; Dr. I. D. Tyagi, Former Professor, CSAAU&T, Kampil; Shri Vikram Singh Negi (Farmer's representative) and Shri J.S. Rana (Farmers' representative), attended the meeting along with all the scientific staff of the institute.

11.2. Institute Research Council (IRC) Meeting

The meeting of Institute Research Council of VPKAS for Rabi 2011 and Kharif 2011 were held during May 23-24, 2011 and October 20-21, 2011 under the Chairmanship of Director, VPKAS.

11.3. Institute Management Committee (IMC) Meeting

The meetings of the Institute Management Committee were held on May 21, October 17, 2011 and March 13, 2012.

11.4. Evaluation of Experiments by Field Monitoring Team

The monitoring of field experiments conducted in Rabi 2010-11 and Kharif 2011 were done on April 7-8 and September 27-28, 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

<table>
<thead>
<tr>
<th>Participants</th>
<th>Programme</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>International</strong></td>
<td>11th Asian Maize Conference on Addressing Climate Change Effects and Meeting Maize Demand for Asia, Nanning, China, November 7-11.</td>
</tr>
<tr>
<td>Dr. N.K. Singh</td>
<td>Workshop on Mountain Agriculture in Himalaya Region: Status, Constraints and Potential, CSWCRTI, Dehradun, April 2-3.</td>
</tr>
<tr>
<td>Drs. Lekhmali Kant &amp; S.K. Jain</td>
<td>NAIP-BAM Review Meeting and CAC Meeting, New Delhi, May 2-4.</td>
</tr>
<tr>
<td>Dr. B.M. Pandey</td>
<td>Annual Review Meeting of the AMAAS project, NIBA, Mau Nabh Bhanjan (UP), May 14-15.</td>
</tr>
<tr>
<td>Dr. S.C. Pandey</td>
<td>National Seminar on Status, Issues and Challenges of Agricultural Marketing in Mountain States of the Country, Kumaon University, Nainital, June 3-4.</td>
</tr>
<tr>
<td>Participants</td>
<td>Programme</td>
</tr>
<tr>
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</tr>
<tr>
<td>Dr. D.C. Sahoo</td>
<td>Workshop on Protected Cultivation of High Value Vegetables and Cut flowers, KVK Lohaghat, Champawat, June 9.</td>
</tr>
<tr>
<td>Dr. R.M. Pandey</td>
<td>Meeting of Scientific Advisory Committee of KVK Kafagajir, Bageshwar, June 10.</td>
</tr>
<tr>
<td>Dr. S.C. Pandey</td>
<td>Biennial Scientists Meet of AICRP on Water Management at GBPUA&amp;T, Pantnagar, June 10-12.</td>
</tr>
<tr>
<td>Dr. Lakshmi Kant</td>
<td>Rabbi Seed Availability Meeting at Directorate of Agriculture, Dehradun, July 11.</td>
</tr>
<tr>
<td>Dr. J.C. Bhatt</td>
<td>State Level Sichon Committee Meeting for RKVY, Dehradun, August 11.</td>
</tr>
<tr>
<td>Dr. J.K. Bisht</td>
<td>RAG meeting of Uttarakhund Forestry Research Institute, Dehradun, August 27.</td>
</tr>
<tr>
<td>Drs. S.K. Jain, Lakshmi Kant &amp; D. Mahanta</td>
<td>50th All India Wheat and Barley Research Workers Meeting, NASC, New Delhi, September 1-4.</td>
</tr>
<tr>
<td>Dr. J.K. Bisht</td>
<td>AICRP on Fodder National Group Meet, IGBRI, Jhansi, September 8-9.</td>
</tr>
<tr>
<td>Dr. J.K. Bisht</td>
<td>National Symposium on Rangeland Management, IGBRI, Jhansi, September 10-12.</td>
</tr>
<tr>
<td>Dr. P.K. Agrawal</td>
<td>DBT Taskforce Meeting on Maize Bio-Fortification, New Delhi, September 10.</td>
</tr>
<tr>
<td>Drs. P.K. Agrawal &amp; Lakshmi Kant</td>
<td>Review Meeting of DBT Funded MAS (Wheat) Project, IARI, New Delhi, September 17.</td>
</tr>
<tr>
<td>Dr. M.D. Tikti</td>
<td>Annual Workshop of AICRP on MULLarP sabi pulses, SKRAU, ARS, Durgapura, Jaipur, September 17-18.</td>
</tr>
<tr>
<td>Dr. Lakshmi Kant</td>
<td>Review Meeting of ICAR Seed Project, IARI, New Delhi, September 19-20.</td>
</tr>
<tr>
<td>Dr. R. Arun Kumar</td>
<td>National Stakeholder Consultation on Climate Change Platform, CRIDA Hyderabad, September 19-20.</td>
</tr>
<tr>
<td>Dr. S.K. Jain</td>
<td>Round Table Conference on Climate Resilient Farming Systems for Livelihood Security, ICAR Research Complex for NEH, Barapani, Meghalaya, September 30-October 1.</td>
</tr>
<tr>
<td>Dr. B.L. Mina</td>
<td>Meeting organized by Directorate of Agriculture to Finalize Microbial Inoculums, Dehradun, October 3.</td>
</tr>
<tr>
<td>Dr. S.C. Pandey</td>
<td>Water Platform, NBFGR Lucknow, October 18.</td>
</tr>
<tr>
<td>Dr. Mukesh Kumar</td>
<td>Workshop on Installation of SAS software, IVRI, Izatnagar, October 28-29.</td>
</tr>
<tr>
<td>Dr. D.C. Sahoo</td>
<td>Biennial Workshop of AICRP on AYA, College of Agricultural Engineering and post-harvest technology, CAU, Guntur, November 4-6.</td>
</tr>
<tr>
<td>Dr. Renu Jetbi</td>
<td>International Conference on Innovative Approaches for Agricultural Knowledge Management-Global Extension Experience, NASC Complex, New Delhi, November 8-12.</td>
</tr>
<tr>
<td>Participants</td>
<td>Programme</td>
</tr>
<tr>
<td>------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Ms. Shefali Agrawal</td>
<td>Review Meeting of DUS-Test Centres and Projects and the 7th Foundation Day</td>
</tr>
<tr>
<td>Dr. J.K. Bisht</td>
<td>Celebration of PPV&amp;FRA, NBPGR, New Delhi, November 11-12.</td>
</tr>
<tr>
<td>Dr. V.K. Sachan</td>
<td>RAG Meeting of Forest Research Institute, Dehradun, November 17-18.</td>
</tr>
<tr>
<td>Dr. R.K. Agrawal</td>
<td>National Workshop of KVK, JNKVV Jabalpur, December 3-5.</td>
</tr>
<tr>
<td>Dr. S.P. Agrawal</td>
<td>National Symposium on Biodiversity and Food Security - Challenges and</td>
</tr>
<tr>
<td>Dr. P.K. Agrawal</td>
<td>Devising Strategies, Kanpur, December 10-11.</td>
</tr>
<tr>
<td>Dr. M.D. Tuti</td>
<td>Brain Storming Session on Agroecology in Future, GBPUA&amp;T, Pantnagar,</td>
</tr>
<tr>
<td>Dr. Lakshmi Kant</td>
<td>December 16.</td>
</tr>
<tr>
<td>Dr. R.K. Thakur</td>
<td>National Stakeholder's Consultation Meeting on seed Platform, ANGRAU</td>
</tr>
<tr>
<td>Dr. Kanta Kant</td>
<td>University, Hyderabad, December 17.</td>
</tr>
<tr>
<td>Dr. R.K. Thakur</td>
<td>Wheat and Barley Stakeholder's Meeting, DWR, Karnal, December 19.</td>
</tr>
<tr>
<td>Dr. P.K. Agrawal</td>
<td>Midterm review and QRT meeting, GBPUA&amp;T, Pantnagar, December 26-28.</td>
</tr>
<tr>
<td>Dr. J.C. Bhattacharya</td>
<td>DBT Review Meeting, DOR, Hyderabad, December 28.</td>
</tr>
<tr>
<td>Dr. Udaya Bhaskar Khetan</td>
<td>National Symposium on Vegetable Science, GBPUA&amp;T, Pantnagar, January 10.</td>
</tr>
<tr>
<td>Dr. N.K. Heda</td>
<td>Breeder Seed Review meeting for kufir 2012, Dehradun, January 10.</td>
</tr>
<tr>
<td>Dr. N.K. Heda</td>
<td>National Seminar on Protected Cultivation of Vegetables and Flowers- A</td>
</tr>
<tr>
<td>Dr. S.K. Deepak</td>
<td>Value Chain Approach at GBPUAT, Pantnagar, January 11-12.</td>
</tr>
<tr>
<td>Dr. J.C. Bhattacharya</td>
<td>AICRP- Vegetable Crops Group meeting, GBPUAT, Pantnagar, January 13-16.</td>
</tr>
<tr>
<td>Dr. N.K. Heda</td>
<td>International Conference on Climate Change, Sustainable Agriculture and</td>
</tr>
<tr>
<td>Dr. J.K. Bisht &amp; Lakshmi Kant</td>
<td>Public Leadership, NASC, New Delhi, February 7-9.</td>
</tr>
<tr>
<td>Dr. J.K. Bisht &amp; Lakshmi Kant</td>
<td>Orientation Meeting of RFD of Crop Science, Krishi Bhawan, New Delhi,</td>
</tr>
<tr>
<td>Dr. J.S. Stanley</td>
<td>February 21.</td>
</tr>
<tr>
<td>Dr. N.K. Heda</td>
<td>National Steering Committee Meet and Annual Review Meet for Global</td>
</tr>
<tr>
<td>Dr. P.K. Agrawal</td>
<td>Pollinator Project, GBPHED, Mahal Kunta, H.P., February 21-22.</td>
</tr>
<tr>
<td>Dr. P.K. Agrawal</td>
<td>International Conference on Plant Biotechnology for Food Security: New</td>
</tr>
<tr>
<td>Dr. N.K. Heda</td>
<td>Frontiers, NASC, New Delhi, February 21-24.</td>
</tr>
<tr>
<td>Dr. D. Mahanta</td>
<td>National Symposium on Rice-based Farming Systems for Livelihood Security</td>
</tr>
<tr>
<td>Dr. Raghav B.K.</td>
<td>under Changing Climate scenario, College of Agriculture, Chiplima,</td>
</tr>
<tr>
<td>Dr. J.K. Bisht</td>
<td>(OUAT), Sambalpur, February 27-29.</td>
</tr>
<tr>
<td>Dr. R.K. Agrawal</td>
<td>Field Day, DWR, Karnal, February 29.</td>
</tr>
<tr>
<td>Dr. S.K. Deepak</td>
<td>HYPM Sensitization cum Workshop, IASRI, New Delhi, March 3.</td>
</tr>
<tr>
<td>Dr. P.K. Agrawal</td>
<td>CIC Meeting of NAIP-SRLS, Palampur, March 11-12.</td>
</tr>
<tr>
<td>Dr. S.K. Deepak</td>
<td>Global Conference on Women in Agriculture, NASC Complex, New Delhi,</td>
</tr>
<tr>
<td>Dr. P.K. Agrawal</td>
<td>NAIP-SRLS Review Meeting, Kalyani, West Bengal, March 15-16.</td>
</tr>
<tr>
<td>Dr. S.K. Deepak</td>
<td>Annual Zonal Workshop of NICRA Project, ZPD, Zone IV Kamrup, March 19-20.</td>
</tr>
<tr>
<td>Dr. R.K. Agrawal</td>
<td>National Workshop on Health Benefiting Phytochemicals from Vegetables,</td>
</tr>
<tr>
<td>Dr. P.K. Agrawal</td>
<td>Fruits and Non-food Crops, IARI, New Delhi, March 21-23.</td>
</tr>
<tr>
<td>Dr. S.K. Deepak</td>
<td>42nd Annual Group Meeting of AICRP on Soybean, CSK-HPKV, Palampur,</td>
</tr>
<tr>
<td>Dr. P.K. Agrawal</td>
<td>March 22-24.</td>
</tr>
<tr>
<td>Dr. R.K. Agrawal</td>
<td>NAIP-SRLS Meeting, New Delhi, March 26.</td>
</tr>
<tr>
<td>Dr. R.K. Agrawal</td>
<td>SVT Meeting, Dehradun, March 28.</td>
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<td>Dr. J.C. Bhattacharya</td>
<td>Review Meeting of HMNEH MM-I, New Delhi, March 28.</td>
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Inauguration of KVK Uttarkashi Administrative Building

Dr. S. Ayyappan, Secretary (DARE) and Director General (ICAR) inaugurated the administrative building of KVK Uttarkashi at Chinyalisour on May 16, 2011 in the presence of Dr. K. D. Kokate, DDG (Agri. Extension) ICAR; Dr. J.C. Bhatt, Director, VPKAS, Almora, Dr. A.K. Singh, Zonal Project Director, Zone-IV, Kanpur and public personnel. On this occasion, the DG emphasized on integration of secondary agriculture such as mushroom cultivation, protected cultivation, off-season vegetable cultivation with primary agriculture for increasing the economic profitability of hill farmers.

The project on “National Initiative on Climate Resilient Agriculture” was also launched at village Dunda, Uttarkashi. On this occasion, Dr. Ayyappan addressed the farmers emphasizing on importance of the project in relation to agricultural productivity. Dr. K.D. Kokate told about mitigation of the effect of changing climate and informed that ICAR has launched this project at 100 KVKs including KVK, Uttarkashi.

- Zonal meeting of the wheat and barley research workers of Northern hills Zone was held during April 18-22, 2011. The group comprising of 11 wheat and barley research workers from DWR, Karnal, IARI RS, Shimla, CSK HPKV, Palampur, GBPUA&T, Paninagar and VPKAS (ICAR), Almora monitored 14 wheat, 10 barley and 1 triticale trials by visiting Nagau-Chakrata, Ranichauri, Gagar, Majhera and Hawalbagh, Almora.

- The 88th foundation day of the institute was celebrated on July 4, 2011. On the occasion, Dr. J.C. Bhatt, Director while presenting the achievements of past one year, emphasized on the need for diversification of hill agriculture to attain prosperity. Sushree Radha Bhatt, Chairperson, Gandhi Peace Foundation, New Delhi and Seva Seva Singh, Wardha (Maharashtra) graced the occasion as the Chief Guest. She expressed deep concern over the migration of rural youth to seek employment elsewhere. To stop the migration, there is need to make the hill agriculture profitable, sustainable and compatible with environment. Chairman of the function, Swami Somadevanand of Ramkrishna Mission, Almora threw light on the life of Swami Vivekananda and appreciated the
institute for following his thoughts. At this occasion, meritorious institute staff’s children were honored. Retired institute personnel, dignitaries from other institute/departments, farmers and families of the staff also attended the celebration which ended with traditional mango feast.

- A Biodiversity and Environment Day was celebrated at Experimental Farm, Hawalbough on July 18, 2011. The saplings (351) of Quercus kwainichophora and Q. glaucides were planted on the degraded sloping land. Besides, the institute has initiated a campaign for removal of Parthenium hysterophorus, nettle, tantana and cowraha at nearby areas of its Experimental Farm. The weeds were uprooted and used for preparation of compost.

- A *Kisan Divas* was organized at village Bhagartola for the farmers of Jageshwar area on July 30, 2011. Inaugurating the programme and appreciating the efforts of the farmers towards vegetable production, Dr. J.C. Bhatt, Director, stressed up on the need of farmer-to-farmer dissemination of agricultural technology. Mr. B.S. Bisht, DDM, NABARD, congratulated Vivekananda Kisan Club, Deogrigooth, for receiving State Level Best Farmers’ Club Award. Scientists of the institute provided training on protected cultivation of vegetables, pest management, management of soil fertility and animal care etc. District Horticulture Officer, Almora, informed the farmers about various

- Forty-two mushroom growers from Palampur district of Himachal Pradesh visited the institute on July 25, 2011 to obtain information about the improved mushroom cultivation technology. They were appraised about various aspects of mushroom production.
horticulture related schemes of government for farmers. The programme was attended by more than 50 farmers including farm women.

- *'Rabi Kisan Mela'* was organized at Experimental Farm, Hawalbagh on September 24, 2011. Dr. M.M. Kimothi, Director, Uttarakhanda Space Application Centre, Dehradun, was the chief guest of the function. Dr. Kimothi and the dignitaries visited the farm and appreciated the technologies developed by the institute. Twenty five exhibition cum sale stalls were put by the line departments, institutes, companies and NGOs. More than 1,000 farmers participated in Mela. Farmers from distant localities including the tribal areas participated in the event. A farmers-scientists interaction meet was also organized. Besides, Kharif Kisan Mela was also organized at institute's farm on March 24, 2012. Padmabhusan Shri Chand Prasad Bhattji, Renowned Environmentalist and Founder of Dasoli Gram Swaraj Sangh, Gopeshwar (Chamoli) was the Chief Guest of the function. On this occasion VL Syahi Hal and Krishi Calendar 2012-13 was also released.

- *Arhar Diwas/ Kisan Diwas* was organized at Nagbar village of district Bageshwar on October 8, 2011. A seed meeting was held on October 9 involving the NSC officials.

- Field day on Summer Moong was organised at Tana on 24.06.2011 (60 participants).

- Brain Storming Session sponsored by Uttarakhand Council of Science and Technology under USSTC 2011 on “Hill Agriculture: Try to Challenges and Beyond” was organized on November 14, 2011 at the Institute. Dr. Mangla Rai, Agricultural Advisor to the Chief Minister, Govt. of Bihar and Former Secretary, DARE & DG, ICAR presided over the session. Dr. H.S. Gupta, Director, IARI, New Delhi delivered the key lecture. Vice Chancellors of Agricultural Universities, Directors of the different Agricultural Research Institutes from north-western Himalayas, scientists of VPKAS, Almora, students and farmers participated in the brainstorming meet.

- Workshop on Exploring Partnership on November 30, 2011.

- Quarterly meeting of Hindi Rajbhasha Karyavah Samiti on December 28, 2011.

- Stakeholder’s meeting and a workshop on Plant Protection of Varieties and Farmers’ Right were organized at the institute on February 2, 2012 & 3, 2012, respectively.

- Farmer Fairs were organized on March 17 and March 18 in tribal areas of Dharchula and Munysari in district of Pithoragarh in Uttarakhanda, respectively, under Tribal Sub Plan.
DISTINGUISHED VISITORS

- Dr. P.D. Mayee, National Level Monitor, Ministry of Rural Development, Govt. of India on April 27.
- Dr. S. Ayyappan, Secretary (DARE) and Director General (ICAR) visited KVK Uttarkashi on May 16.
- Dr. K.D. Kokate, DDG (Agril. Extension) ICAR visited KVK Uttarkashi on May 16.
- Dr. A.K. Singh, Zonal Project Director, Zone-IV, Kanpur visited KVK Uttarkashi on May 16.
- Dr. R. Rajesh Kumar, IAS, CDO, Pithoragarh on May 26.
- Shri Radha Bhatt, Chairperson Gandhi Peace Foundation, New Delhi and Sarva Sewa Sangh, Wardha on July 4.
- Dr. M.M. Kimothi, Director, Uttarakhand Space Application Centre, Dehradun on September 24.
- Dr. N. Nadrajjan, Director, IIHR, Kanpur on October 8.
- Dr. B. Mishra, Vice Chancellor, SKUAST, Jammu (J&K) on October 16.
- Dr. Mangala Rai, Former DG, ICAR and Advisor to Chief Minister, Bihar on November 14.
- Dr. H.S. Gupta, Director, IARI, New Delhi on November 14.
- Dr. B.S. Bishi, Vice Chancellor, GBUAUAT, Pantnagar on November 14.
- Dr. Mathew Prasad, Vice Chancellor, BCSGUHF, Bharsar, Uttarakhand on November 14.
- Dr. Harbans Singh, Ex-Vice Chancellor, Sher-e-Kashmir Agriculture University on November 14.
- Dr. Raj Gupta, Consultant, CIMMYT India Centre, New Delhi on November 15.
- Dr. Shiv Kumar Agrawal, Lentil Breeder, ICARDA, Aleppo, Syria on December 3.
- Shri Sudhir, DIG, SSB on February 18.
- Shri Shyam Singh, IG, SSB on February 29.
- Shri M.I. Negi, Commandant, SSB on February 29.
- Padmabhusan Shri Chandi Prasad Bhatt, Environmentalist and Founder Dasauli Gram Swaraj Sangh, Gopeshwar (Chamoli) on March 24.
LIST OF SCIENTIFIC, TECHNICAL
AND ADMINISTRATIVE STAFF

Dr. J.C. Bhatt, Director

Crop Improvement Division
Dr. P.K. Agarwal, Principal Scientist & Head
Dr. Lakshmi Kant, Principal Scientist (Plant Breeding)
Dr. N.K. Singh, Principal Scientist (Plant Breeding)
Dr. Arun Gupta, Senior Scientist (Economic Botany) (upto March 29)
Dr. Gyanendra Singh, Senior Scientist (Plant Breeding)
Dr. N.K. Hedau, Senior Scientist (Horticulture-vegetable Science)
Dr. Navinder Saini, Senior Scientist (Biotechnology)
Mr. B. Kalyan Babu, Scientist (Biotechnology)
Dr. R. Arun Kumar, Scientist (Plant Physiology)
Dr. Jay Prakash Aditya, Scientist (Plant Breeding)
Dr. Anuradha Bhartiya, Scientist (Plant Breeding)
Dr. Shailendra Kumar Jha, Scientist (Plant Breeding)
Dr. Udai Bhaskar Khetinini, Scientist (Seed Science and Technology)
Dr. Salej Sood, Scientist (Plant Breeding)
Mr. Ramesh Singh Pal, Scientist (Biochemistry)
Dr. Raghu B.R., Scientist (Genetics and Plant Breeding) (w.e.f. Sept. 5)
Ms. Shephalika Armapali, Scientist (Economic Botany and Plant Genetics) (w.e.f. Sept. 5)

Crop Production Division
Dr. J.K. Bish, Principal Scientist & Head
Dr. S.C. Pandey, Senior Scientist (Soil Science)

Dr. P.K. Mishra, Senior Scientist (Microbiology)
Dr. B.M. Pandey, Senior Scientist (Agronomy)
Dr. D.C. Sahoo, Senior Scientist (Land and Water Management)
Er. Sukhbir Singh, Senior Scientist (Farm Machinery and Power) (w.e.f. March 19)
Dr. Sher Singh, Senior Scientist (Agronomy) (w.e.f. March 23)
Mr. Ranjan Bhattacharya, Scientist (Soil Physics and Soil Water Conservation) (upto July 8)
Mr. B.L. Mina, Scientist (Soil Science)
Mr. Mangal Deep Tuti, Scientist (Agronomy)
Mr. Dibakar Mahanta, Scientist (Agronomy)
Dr. K. Jeevanandan, Scientist (Agril. Microbiology)
Mr. Ram Prakash Yadav, Scientist (Forestry)
Mr. Shaon Kumar Das, Scientist (Agri. Chemistry) (w.e.f. December 26)

Crop Protection Section
Dr. S.K. Jain, Principal Scientist (Plant Pathology) and I/c Head
Dr. R.M. Srivastava, Senior Scientist (Agril. Entomology) (up to April 2)
Dr. K.K. Mishra, Senior Scientist (Plant Pathology)
Dr. J. Stanley, Scientist (Agril. Entomology)
Mr. A.R.N.S. Subbanna, Scientist (Agril. Entomology)
Dr. Chandrashekara C., Scientist (Plant Pathology)

Social Science Section
Dr. Nirmal Chandra, Principal Scientist (Agril. Extension) I/c Head

Videhavedha Parmatme Vridhi, Asevakshan Sambandha
Mr. K.K.S. Bisht, Scientist (Agril. Statistics)
Dr. Mukesh Kumar, Scientist (Computer Application)
Dr. Manik Lal Roy, Scientist (Agril. Extension)
Dr. Renu Jethi, Scientist (Home Science)
Mr. Hujumraj Laxmanrao Kharbikar, Scientist (Agril. Economics)
Dr. Pratibha Joshi, Scientist (Home Science and Family Resource Management)
Mr. Antheegulla, G.A., Scientist (Agril. Extension) (w.e.f. December 26)

Coordinator
Library & AKMU
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. B.D. Pandey
Mr. N.C. Belwal
Mr. D.S. Gosai
Mr. P.C. Verma
Mr. Shankar Lal Arya
Mr. M.S. Khati

Mr. L.D. Melkani
Mr. Shiv Singh
Mr. G.S. Bisht
Mr. G.S. Bankoti
Mrs. Renu Sanwal
Mr. Sanjay Kumar Arya
Mr. M.C. Pant
Mr. D.S. Panchpal
Mr. D.C. Mishra
Dr. G.S. Bisht

Administration and Finance
Administrative Officer
Mr. Mahesh Lal

Assistant Administrative Officers
Mr. M.M. Joshi (upto November 30)
Mr. Bahadur Ram
Mr. Shambhu Dutt Bisht (w.e.f. December 1)

Finance & Accounts Officer
Mrs. Shakku Goswami

Stores
Mr. Mahesh Lal

Managerial Staff at KVK, Chinyalisaur
Dr. V.K. Sachan, Programme Coordinator
Mr. Hari Govind, SMS, Plant Breeding
Mr. Pankaj Nautiyal, SMS, Horticulture
Dr. Deepak Rai, SMS, Plant Pathology (upto August 20)
Dr. Ravindra Kumar Tewari, SMS, Animal Science
Dr. (Mrs.) Veenika Singh, SMS, Home Science (upto April 17)

Managerial Staff at KVK, Bageshwar
Dr. Vijay Avinashilingum, Programme Coordinator (w.e.f. May 20)
Dr. Ramanjeet Singh, SMS, Crop Production (upto August 11)
Dr. N.K. Singh, SMS, Veterinary Science
Mr. Kamal Kumar Pandey, SMS, Horticulture
Ms. Shobha, SMS, Home Science
Dr. Ram Prakash Sahu, SMS, Agril. Extension

New Colleagues
- Dr. Vijay Awinashilingam, Program Coordinator, KVK Bageshwar on May 20.
- Ms. Shefali Amrapali, Scientist (Economic Botany) on September 5.
- Dr. Raghu B.R., Scientist (Plant Breeding) on September 5.
- Dr. Narendra Kumar Singh, Principal Scientist (Plant Breeding) on October 4.
- Mr. Shon Kumar Das, Scientist (Agricultural Chemistry) on December 26.
- Mr. Atheequlla G.A., Scientist (Agricultural Extension) on December 26.

Selection
- Dr. J.K. Bisht, Principal Scientist joined as Head, Crop Production Division, VFKAS on June 10.
- Dr. Ramanjeet Singh, SMS (Crop Production) as ARS Scientist on August 11.

Retirement
- Mr. Heera Lal Sah, SSS on May 31.
- Mr. Mohan Singh, SSS on November 1.
- Mr. M.M. Joshi, Assistant Administrative Officer on November 30.

Resignation
- Dr. R.M. Srivastava, Senior Scientist (Agril. Entomology) resigned on 02.04.2011 to join at GBUAT, Pantnagar.

Promotion
- Mr. Sunder Singh Kanwal, Senior Clerk to Assistant w.e.f. April 1, 2011.
- Mr. Shambhu Dutta Bisht promoted to the post of Assistant Administrative Officer on Dec. 1.

Transfer
- Dr. Vennika Singh, SMS transferred to IISR KVK Lucknow on April 17.
- Dr. Ranjan Bhattacharyya, Scientist transferred to NRL Division, IARI, New Delhi on July 8.
- Mr. Deepak K. Rai, SMS transferred to IISR KVK Lucknow on August 20.
- Mr. M.C. Pathak, Assistant transferred to IVRI, Bareilly on August 25.
- Dr. Arun Gupta, Senior Scientist transferred to DWR, Karnal on March 29.

Termination
- Mr. Deepak Singh Pilkhal, Jr. Clerk on March 16.

Regularisation
- Mr. Diwan Lal, SSS on December 9.
- Mr. Dayal Chandra Joshi, SSS on December 9.
- Mr. Prakash Lal Arya, SSS on December 9.
- Mr. Shiv Kumar, SSS on December 9.
- Mr. Basant Singh, SSS on December 9.