ANNUAL REPORT
2010-2011
Annual Report
2010 - 2011

Vivekananda Parvatiya Krishi Anusandhan Sansthan
(Vivekananda Institute of Hill Agriculture)
Indian Council of Agricultural Research
ALMORA - 263 601, Uttarakhand
Guidance
Dr. J.C. Bhatt, Director

Compilation and Collation
Dr. J.K. Bish, Pr. Scientist

Editorial Board
Dr. P.K. Agrawal, Dr. J.K. Bish, Dr. Nirmal Chandra, Dr. S.K. Jain & Mr. K.K.S. Bish

Summary in Hindi
Mr. T.B. Pal

Editing Assistance & Graphics
Mrs. Renu Sanwal

Word Processing and Layout
Mr. R.K. Kanojia

Vivekananda Parvatiya Krishi Anusandhan Sansthan (ICAR)
Almora - 263 601, Uttarakhand

Correct Citation
Annual Report 2010-2011
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ALMORA - 263 601, Uttarakhand

Designed & Printed at
Venus Printers and Publishers
B-62/8, Naraina Industrial Area, Phase II, New Delhi 110 028
Ph: 25891444, 45576780 Mobile: 98110 89097, 20451501
E-mail: pawanand2000@yahoo.co.in, pawanand2@gmail.com
Swami Vivekananda Ji

The statue unveiled by Dr. S. Ayyappan, Secretary (DARE) and DG (ICAR) in presence of Dr. S.K. Datta, DDG (CS) (ICAR) on January 1, 2011 at VPKAS (ICAR), Almora
Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, an institute of ICAR from 1974, has been engaged in agricultural research for fulfilling the needs of farmers of north-western Himalayas with the mission of enhancing productivity and ecological sustainability of hill agriculture through niche-based diversification. The institute has developed considerable research infrastructure to support basic and strategic research for the agricultural development of north-western Himalaya. This annual report describes the project-wise salient research achievements of the Institute for the year 2010-11.

During this period, three varieties (one each in garden pea, tomato and capsicum), developed by the institute were notified. To realize the yield potential, the matching production technology for these varieties were also developed. Besides, one genetic stock of maize inbred line, V 373 with light orange flint, flat and bold grain was registered with the NBPGR, New Delhi (INGR 10002).

A total of 265.88 q breeder seed of 46 released varieties / inbred lines was produced during the period where as a total of 235.13 q breeder seed was supplied to different seed producing agencies. Besides, 20.83 q nucleus seed of 39 released varieties was also produced. More than 10 q of Vivek QPM 9 seeds were produced and supplied to different government and non-government agencies. In addition to this around 64.87 q truthfully labeled seed of 12 cereals, 3 pulses, 2 oil seeds, 14 of vegetables, 3 of finger millet, 1 of barnyard millet, 1 of buckwheat and amaranth varieties were also produced to meet out the demand of institute extension activities.

The Institute scientists got ICAR Outstanding Team Research Award in the subject area of Natural Resource Management (Soil Science, Agronomy, Agro-forestry) for the biennium 2007-08. Apart from this, scientists of the institute were honoured with many other prizes.

During 2010-11, besides 24 institutional projects, 10 projects under Horticulture Mini Mission-1, two each under DBT, AMAAS & AICRP and three under NAIP were also being run at the Institute. The institute has successfully generated the farmer-oriented technologies and their gradual dissemination to the ultimate stakeholders. Also, they are likely to play significant role in enhancing the yield potential of field, fruit and vegetable crops in N-W Himalayan region. These were possible due to sincere efforts & hard work of its scientists and staff, with the unstinted support and valuable guidance from the Council in general and Division of Crop Science in particular.

I place on record my sincere thanks to the DG, DDG (Crop Science) and ADG (Food & Fodder Crops), ICAR for their support to VPKAS. I also express my sincere appreciation to 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.

Place: Almora
Date: June 28, 2011

(J.C. Bharti)
Director
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वर्ष 2010–11 के दौरान विभिन्न प्रकार की कुल तीन प्रौद्योगिकीय (सल्मा) मंत्र की विभिन्न स्तर 11, प्राधिकृत की जी. एच. नामक प्रौद्योगिकीय 4 व विभिन्नता मंत्र की जी. एच. नामक प्रौद्योगिकीय 2 अनुसूचित की गई तथा 19 प्रौद्योगिकीय (दि अनुमय में जी. एच. 30424, जी. एच. 30425, जी. एच. 30240, जी. एच. 30144, जी. एच. 30139, जी. एच. 30138, जी. एच. 30137, जी. एच. 30136) के उच्चतम स्तरों के लिए अनुसूचित की गई थी। उपस्थित थे विभिन्न प्रौद्योगिकीय 36, जिनकी सभी मंत्र 43, मंत्र 93, मंत्र 514, मंत्र 515, मंत्र 516, मंत्र 47, मंत्र 2, मंत्र योग 1, मंत्र योग 1, मंत्र 2, तथा मंत्र 415 तथा सभी मंत्र 266 एवं मंत्र 402) के राज्य प्रशस्त व राजस्थान पर्यावरण संस्थानों के लिए विभिन्नता की अलग-अलग अवधारणाओं में हैं।

जैसक मे एवं अन्य प्रतिष्ठापन दोनों अंशों के लिए उपयुक्त होगा सख्ती मंत्र की विभिन्नता मंत्र 11 के संस्करण के पर्यावरण क्षेत्रों के लिए अनुसूचित एवं विभिन्नता की गई। साथ ही इसकी बृहत परिवर्तनीय प्रौद्योगिकी, जिसके नाम के साथ-साथ प्रौद्योगिकी 375, जिसके दोनों में अटक नहीं किया गया। इसके अतिरिक्त 18,000 नए तथा भविष्य के इलाकों की गई।

वर्ष 2010–11 के दौरान 46 विभिन्नता विभागों/ अन्य प्रति प्रौद्योगिकी का कुल 265.88 दंपत स्थानक का उपयोग किया गया था। जिसमें शाखाओं की 17 प्राधिकृत एवं 5 अन्य जानकारी, दोनों की 7, प्रौद्योगिकी की 5, उपभोक्ता एवं उपभोक्ताओं के एक-एक एवं संस्करण 7 प्रौद्योगिकी संस्थान है। 256.13 दंपत मंत्री जी की आपूर्ति विभिन्नता योजना करने वाली पृष्ठभूमियों को थी। 39 विभिन्नता विभागों का लाभ 20.83 दंपत जीवनकाल बीच का प्रयोग किया गया, जिसके अन्य संस्करण प्रौद्योगिकी के दो संकेत जी का उपयोग करने वाली आपूर्ति की गई। विभिन्नता विभागों का संयोग दि नंड 9 दंपत से अन्य बीच का प्रयोग कर विभिन्नता संस्करण एवं विभिन्न जीवनकाल निर्देशित किया गया। इसके अतिरिक्त संस्करण के प्रयोग का विकास जी का उपयोग करने वाली आपूर्ति की गई। विभिन्नता विभागों का लाभ 64.67 दंपत जी का आपूर्ति भी की गई।
अनुरंगत विषयं स्थानमा यो धारा का 135 कुंलत, गोद्री,
का 20.0 कुंलत एवं भृगु का 0.11 कुंलत भोज बांस के से के से में उपलब्ध किया गया। इसकी अनुशासना 1.95 कुंलत जीवक माण का शुल्क 66 किा किया गया।

अनुशासन निर्माण के 18 गांवों के 10.12 हेक्टेयर क्षेत्र में धारा की प्रभावीति में वि. धारा 85 एवं वि. धारा 65 के लिए अधिक परिक्षण प्राप्ति सामान्यता किया गया। ये प्रभावीति उन गांवों के 102 कुंलत के लिए किया गया तथा इन प्रभावीतियों के निर्माणक दिनों की दुनिया में उल्लेखनीय रूप से उत्कृष्ट प्रकाश किया। इसके अतिरिक्त विनिमय परिवर्तन के (की एल पूर्व 125 एवं वि की पूर्व 587 में 20, वि की पूर्व 42 में 20, वि की पूर्व 15 में 77 एवं वि की पूर्व 1 में 90) 207 अधिक परिवर्तन भी किए गए। सभी प्रभावीतियों में उत्तर दिशा देने वाली प्रभावीति स्थानीय किताबों की दुनिया में उल्लेखनीय रूप से उत्कृष्ट प्रकाश किया।

प्रस्तुत उत्तरदाता

मोदी की खाद्य का 89.9 फिक्रा/है, फास्कोमर की दर से प्रयोग करके पति जगत की चौथी उपलब्धि रूप से अधिक उपस्थ (8,880 फिक्रा/है) प्राप्त हुआ। जबकि प्रायोगिक में अनुशासन नामक, फास्कोमर एवं फालोमर-10 दोनों प्रति हेक्टेयर क्षेत्र में धारा का प्रयोग करके पहचान की उपलब्धि रूप से अधिक उपस्थ (15,750 फिक्रा/है) प्राप्त हुई। गोद्री-सीतारी के प्रस्तुत प्रदर्शनी के अन्तर्गत में, एक बार जैसी गोद्री (4,210 फिक्रा/है) एवं सोमनाथ में गोद्री-सीतारी के प्रस्तुत प्रदर्शनी की रूप से अधिक उपकारी दी।

नेघेरों एवं बाजार में सूची तैयार करके पहली उपस्थ (4.230 एवं 2,510 फिक्रा/है) प्राप्त हुई। गोद्री-सीतारी के प्रस्तुत प्रदर्शनी के अन्तर्गत में, एक बार जैसी गोद्री (3,780 एवं 2,390 फिक्रा/है) में अधिक प्राप्त हुई। गोद्री-सीतारी के प्रस्तुत प्रदर्शनी के अन्तर्गत में, एक बार जैसी गोद्री (3,780 एवं 2,390 फिक्रा/है) में अधिक प्राप्त हुई। गोद्री-सीतारी के प्रस्तुत प्रदर्शनी के अन्तर्गत में, एक बार जैसी गोद्री (3,780 एवं 2,390 फिक्रा/है) में अधिक प्राप्त हुई।

प्रस्तुत दूरस्थ

उपज के दौरान धारा की प्रधान, सूचीबद्ध दोनों के इंस्टेंस, जिनकी में लंबी, लंबी स्थानीय दृष्टि, जिनकी में लंबी, लंबी
परिवहित एवं किट्टा रोग का सामान्य से तीस तक प्रकोपों का उपचार। मनुष्यों का परिवर्तन के लिए सयाबेटोन की उपयोग में 244 से 298.4 प्रतिशत तक की विकास आती गई। दूसरे 17, 74, 35 और 8, 7 एवं 125 हजरतों रोग के लिए प्रतिशतों के लिए प्रतिशतों की एवं प्रथम 2 रोग के लिए सटीकता प्राप्त होने गयी। वीडेथ के प्रकोष की वैश्विक पहचान में अनावरण की गई तथा लिपि.अनु.ए. अनुमान के प्रयोगकार प्रथम उताराम में लिखता है कि वीडेथ वेश्य निष्कर्षी (अभिन्न) लाना योग्य है। नवीनए ने अपूर्वत में धर्मिक प्रकार का आत्मनिर्देश करने के लिए प्रश्नत कितेसी (अल्टर्नेट) लाना योग्य है। नवीनए ने अपूर्वत में धर्मिक प्रकार का आत्मनिर्देश करने के लिए जिन्हें लिखता है कि वीडेथ वेश्य निष्कर्षी (अभिन्न) लाना योग्य है। नवीनए ने अपूर्वत में धर्मिक प्रकार का आत्मनिर्देश करने के लिए जिन्हें लिखता है कि वीडेथ वेश्य निष्कर्षी (अभिन्न) लाना योग्य है। नवीनए ने अपूर्वत में धर्मिक प्रकार का आत्मनिर्देश करने के लिए जिन्हें लिखता है कि वीडेथ वेश्य निष्कर्षी (अभिन्न) लाना योग्य है। नवीनए ने अपूर्वत में धर्मिक प्रकार का आत्मनिर्देश करने के लिए जिन्हें लिखता है कि वीडेथ वेश्य निष्कर्षी (अभिन्न) लाना योग्य है।
परिक्षित किया गया। एक ई-पुस्तक का भी सूचना किया गया। श्लोकों एवं नींवें चित्रांकों के लिए अदालत में विवरण किया गया। उठाए स्वर्ण और उठाए दुर्गा सुंदरी की श्लोकों के लिए कृतित गान अदालत में विवरण किया गया। सुंदरी के रचन के लिए साहित्य की वस्त्रहार एक महाकाव्य स्वरूप है जिसे निर्देशित कर में से अन्वेषण किया जाता है। संस्कृत द्वीप का व्यक्तित्व "दिवसियाँ जन्मतीने आसमान की चुंबकी को लेकर उन्मत उन्मताओं" नामक अनुभव कथाओं का द्वीप संस्कृत की वृद्धि की जानकारी देने हेतु एक बहुत अच्छा व्यक्तित्व है तथा मान के अध्याय पर संस्कृत द्वीप की सुधारी की जाती है।

वर्ष 2010-11 के दौरान विद्यालयों एवं उपभोक्ताओं द्वारा विविध प्रकार की परिक्षाओं में की जाने वाली महत्वपूर्ण कक्षा की स्वतन्त्र पहचान को विविधता किया गया।

परिक्षाओं में महत्त्व दी गई थी कि ज्ञान वाले लोगों के उपर निर्भरता से मानने के नियमों को अनुसरण कर दी गई थी। विविध प्रकार की परीक्षाओं का द्वीप संस्कृत की रचनाओं को दर्शाता है। वारा किताब का शेष शब्द "विस्तार के लिए समय अधिक है" यह व्यक्ति संस्कृत पढ़ाई का व्यक्तित्व इतना होता है।

अन्य श्रेणी परिवर्तनों

वर्ष 1999 तथा 1998 में निर्धारित क्षेत्रों के लिए हासिलपूर्व नगरी पर्यावरण-यी भीमन-1

इन परिवर्तनों के अंतर्गत विभिन्न पर्यावरणों में कुछ मुद्दों का व्याख्या दी गई है—1) अनेक साधनों का 1200 किसे, जिसे अदालत द्वारा पाठकों को ध्यान देना की चुंबकी शी ची की एक पत्र की चुंबकी और पत्र 3 की 19,000 पृष्ठ का उत्पादन विविध कृतियों के केन्द्र मुख्य के के लिए किया गया; 2) 26 पृष्ठों के एवं
समस्त प्रतिष्ठानों से प्राप्त संबंध एवं 16 एवं आदि जीवन पर आयातित 13 में के आदि पर तीन जीवन पुण्यता को प्रभावित किया गया।

इस परियोजना का उपयोग करते हुए इस तरह के कर्मचारी की रोजगार एवं आदि जीवन पुण्यता की प्रभावित किया गया है। इसके प्राथमिक तीनों निकलते है तथा इसकी सहायता से दूसरी छाया उच्चतम स्तर पर विशेष उद्देश्य ओर जीवन पुण्यता का निर्माण किया गया।

इस परियोजना का उपयोग करते हुए इनके लिए निकलते है तथा इसकी सहायता से दूसरी छाया उच्चतम स्तर पर विशेष उद्देश्य ओर जीवन पुण्यता का निर्माण किया गया।

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EXECUTIVE SUMMARY

Enhancement in the productivity of Major Hill Crops

During the year 2010-11, a total of three varieties were notified and another 19 entries are at different stages of release by the central and state systems. The varieties notified for different crops include Vivek Matar 11 (garden pea), VL Tamatar 4 (tomato) and VL Shimla Mirch 2 (capsicum). The crops for which the entries are at different stages of release (Identified/ Released by the SVRC/ under Notification) include rice (VL 30424, VL 30425, VL 30240), barley (VLB 94), maize (Vivek Maize Hybrid 39, Vivek Maize Hybrid 43), lentil (VL Masoor 133, VL Masoor 514, VL Masoor 515, VL Masoor 516), field pea (VL Matar 47), tomato (VL Tamatar Hybrid 2, VTG 85, VTG 86, VTG 95), capsicum (VL Capsicum Hybrid 1), French bean (VLFB 415) and garden pea (VP 266, VP 402).

Vivek Matar 11 is a garden pea variety released and notified for Uttarakhand hills and also identified for Agro-ecological Zone I (Uttarakhand, Himachal Pradesh and Jammu & Kashmir). It is a medium maturity cultivar having attractive long green curved pods with high number of sweet and bold seeds per pod and highly resistant to powdery mildew. The average green pod yield is 10,000-11,000 kg/ha. It is suitable for cultivation under both organic and inorganic conditions. Similarly, VL Tamatar 4 is an open pollinated tomato variety released and notified for Uttarakhand state. It is suitable for cultivation under both organic and inorganic conditions and also suitable for protected cultivation. Plants are indeterminate in growth, fruits medium, round, attractive red (T.S.S -5° Brix) with thick pericarp having longer storage life and suitable for distant market. This variety is moderately resistant to seedling rot, fruit rot and blight diseases. In hills, it yields 20,000-30,000 kg/ha under open-field conditions and 55,000-65,000 kg/ha under polyhouse conditions. VL Shimla Mirch 2 is an open pollinated capsicum variety released and notified for Uttarakhand state. It is suitable for cultivation under both organic and inorganic conditions. Plants are straight, vigorous having bright dark green, medium, bell-shaped fruits which turn red on ripening. In hills, it yields 15,000-25,000 kg/ha under off-season cultivation. One genetic stock of maize inbred line, V. 373 with light orange flint, flat and bold grain was registered with the NBPG, New Delhi (INGR 10002).

A total of 265.88 quintals of breeder seed of 46 released varieties/inbreds were produced during the period. This includes 17 varieties and 5 inbreds of cereals, 3 of finger millet, 1 of barnyard millet, 7 of pulses, 5 of oilseeds, 1 of buckwheat, amaranth and 7 of vegetables. A total of 235.13 q breeder seed was supplied to different seed producing agencies. Around 20.83 q nucleus seed of 39 released varieties were also produced. Hybrid seeds of many maize hybrids were produced and supplied. Notably, more than 10.0 q of Vivek QPM 9 seeds were produced and supplied to different government and non-government agencies. In addition to this around 64.87 q truthfully labeled seed of 12 cereals, 3 pulses, 2 oil seeds, 14 of vegetables, 3 of finger millet, 1 each of barnyard millet, buckwheat and amaranth varieties were also produced to meet the demand of institute extension activities. A total of 75.72 q TL seed were supplied during the period. Under farmers’ participatory seed production
programme 1.35 q of rice, 26.0 q of wheat and 0.11 q of lentil seeds were produced at farmers’ fields at different places. Besides this, 1.95 q of organic seed was also produced.

Front Line Demonstrations (FLDs) were conducted for rice varieties (VL Dhan 85 and VL Dhan 65) among 102 farmers covering an area of 10.12 ha in 18 villages of Almora district and were found significantly superior to the local cultivars. Besides, 207 FLDs (20 for VL Masoor 125 and VL Masoor 507; 20 for VL Matar 42; 77 for VL Gahat 15 and 90 for VL Arhar 1) were also conducted. In all the cases, the HYVs were found significantly superior to the local cultivars.

**Crop Production**

Application of FYM @69.9 kg P/ha recorded significantly higher pod yield in garden pea (6,880 kg/ha), whereas in French bean application of recommended NPK + FYM 10 t/ha recorded significantly higher pod yield (15,760 kg/ha). Inoculation of *Pseudomonas fragii* in wheat (4,210 kg/ha) and *Pseudomonas fragii* + PGERS 17 in soybean (3,080 kg/ha) with 75% recommended P provided highest grain yield in respective crops of wheat-soybean cropping system. The variety VL 892 of wheat produced (5,830 kg/ha) significantly higher grain yield than rest varieties in organic and integrated crop management modules of wheat-horse gram cropping system.

The higher wheat and rice yield (4,230 and 2,510 kg/ha) was recorded in zero tillage in comparison to conventional tillage (3,760 and 2,350 kg/ha). The higher rice and wheat yield was recorded with four irrigations. The higher wheat yield 202.6% and 211.0% WEE was recorded with the application of NPK + FYM in comparison to control (1,580 kg/ha yield, 3.3 kg/ha-mm WEE). Spring discharge was higher after roof water harvesting in infiltrating trenches in all the months. The annual discharge of spring was 18.9, 68.8, 72.8, 64.6 and 141.9 per cent higher during 2006, 2007, 2008, 2009 and 2010, respectively in comparison to annual discharge of 2000 i.e. before inception of the treatments.

Various small tools were investigated for possible replacement of some metal parts by plastics. Poor grip, poor life, and low capacity were the main problems. Iron handles of kutila, khrupi, hand fork and sickle were coated with plastic grip at one point, while handles of line maker, hand hoe and garden rake were coated at two points.

In Fescue grass, Hima-14 produced the highest green forage (15,209 kg/ha). Out of six entries of *Setaria* grass, entry S-20 produced significantly higher (68,742 kg/ha) green biomass than PSS-1 and S-25. In cowpea, entry AVTC-II gave significantly higher green (36,453 kg/ha) and dry (5,718 kg/ha) forage. VL.B-118 gave the highest green forage (2,311 kg/ha) along with 1,465 kg/ha grain in dual purpose barley. In silvi-horti system the highest rhizome yield of turmeric was obtained under *Quercus leucotrichophora* (11,738 kg/ha) followed by *Bauhinia variegata*. Yield of grasses increased with the intercropping with leguminous hedge and the highest green forage (61,428 kg/ha) was obtained from intercropping of Hybrid napier with desmodium.

**Crop Protection**

Rice blast, tika disease of groundnut, frogeye leaf spot of soybean, angular leaf spot and rust of French bean occurred in moderate to severe intensities during the year. Yield losses in soybean due to frogeye leaf spot varied between 2.44% to 29.48%. VLS 74, VLS75 and MACS 1259 were resistant whereas VLS 2 was tolerant to the disease. Monitoring of insect pest incidence was done in fortnight intervals and pest calendar was made for VPKAS experimental farm.
Hawalbagh. Severe infestation of Helicoverpa armigera in chickpea and wheat, Spodoptera litura in capsicum, sucking bug in soybean, whiteflies in tomato and brown plant hopper in rice were observed. Severe incidence of BPH in rice was observed in a few rice growing areas of Uttarakhand.

Rice varieties developed at the institute were screened against BPH in which Vivek Dhan 62 and VL Dhan 87 were found promising. Resistant/promising genotypes against major diseases were identified in various station and coordinated nurseries in different crops. Monitoring of virulence pattern of rice blast pathogen revealed that BL 245, Reminad Str. 3, Taducan and Teep were highly resistant to the prevalent pathogen population at Hawalbagh.

Rice IPM trials conducted at farmers’ fields showed increased yield (between 500 to 700 kg/ha) of different varieties and decreased incidence and severity of diseases and pests as compared to non-IPM practice was observed.

Azoxyostrobin @ 0.1% and Difenconazole 0.025% were found most effective against rust and angular leaf spot of French bean. Soil incorporation of Peritrichum hysterephorum and Lautania showed effectiveness in reducing the root rot in French bean. Foliar sprays of bio-products such as cow dung extract, cow urine resulted in reduced severity of rust whereas Panchgavaya and cow dung extract were effective against angular leaf spot. Trichoderma harzianum isolates T-11, T-28, T-18 and T-45 were found effective in reducing the root rot in French bean. Similarly, Pseudomonas fluorescence isolates showed effectiveness against bacterial wilt of tomato. Mustard straw residue, mustard cake and neem cake also gave significant reduction in bacterial wilt.

Btain seed kernel extract sprays gave a significant reduction in the population of sucking bug on French bean and aphid on cauliflower. Insecticide Spinosad was found most effective against soybean beetle whereas cartap hydrochloride and indoxacarb were effective against sucking bug in soybean. In a study related to age specific susceptibility of Spodoptera litura and Spilosoma obliqua to different insecticides, Indoxacarb was found effective even on later instar larvae of both the pests.

Entomopathogen bacterium Brevibacterium frigoritolerans isolate HSB-15 can grow over a wide temperature 4-28°C and pH 6-10 range. The 16S rRNA gene sequence showed 99% identity with the type strain of B. frigoritolerans. The bacterium also produces appreciable amount of IAA.

Six native Bacillus thuringiensis (Bt) isolates showed larval mortality of more than 85% against the third instar larvae of Bihar hairy caterpillar. One hundred six native Bt isolates from Uttarakhend were screened for the presence of vegetative insecticidal proteins (VIPs) out of which 24 isolates showed the presence of around 85 KDa band.

The impact study of Bacillus cereus on other native soil microbes revealed that the double dose of B. cereus did not affect the other soil microbes. Insect trap was found effective in trapping white grub adults.

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

For the use of farmers a technical bulletin "कृषियों की उपज खेती", was converted into CD ROM format; one e-book was also created. Data base for the use of researchers and policy makers is also developed *i.e.* agricultural database for major crops for North West and North East Himalayan states was updated. Institute's website is an important resource for obtaining information which is updated regularly. Institute's publication **Technological**
Options, viz., “सरल पतझड़तक हरियाली अभ्यासों में कृषि उत्पादकता की वृद्धि के लिए उपयोग उन्नतियाँ” is a very useful source of information about VPKAS technologies for farmers as well as the extension professionals, as per the demand the institute supplies the copies of this book.

The information system for participation by scientists/officers in different events was developed during the period.

Various field operations were evaluated for analysis of drudgery prone activities in case of hill women farmers. Data regarding rate of perceived exertion was recorded. The fodder cutting activity was found to be causing very strong exertion followed by harvesting and weeding to the hill farm women. Pains in different body parts due to faulty work practices were measured with the help of a suitable body map. During fodder cutting activity moderate pain was perceived by women in shoulder, upper back, lower back and knee region and mild pain in neck and ankle region. During harvesting activity severe pain was reported by women in shoulder and lower back.

Other Research Projects

Horticulture Mission for North East and Himalayan states Mini Mission-I Project

Under different projects in this scheme, the salient points are- (1) >1250 kg seeds of different vegetables and 1,90,000 seedlings of late cauliflower var. PSBK-1 and onion var. VL Piaza 3 were produced for different groups of users, (2) 26 Polytanks and 21 Polyhouses were constructed, (3) 69 Trainings/Field days/Field schools were conducted benefitting more than 1600 participants, (4) 416 demonstrations were laid on vegetable production, MIS and Mushroom production technologies, (5) vegetable production in 97 polyhouses at Bhagartola and other adopted villages, gave a gross return of Rs. > 7.00 Lakh, (6) 80.77% reduction in white grub population was recorded by using light traps along with entomopathogen, Bacillus cereus strain WGPB-2 in 7 villages, (7) 437 kg of talc based formulation was prepared, (8) significant increase in yields of fruits and seeds of vegetable crops was obtained by planned honey bee pollination and (9) the necessity of development of basic marketing infrastructure was revealed by an analysis of marketing costs incurred by the farmers.

AMAAS Project

Rhizobium leguminosarum-PR1 inoculation enhanced lentil varieties nodulation in the range of 22.7 to 119.6% over uninoculated control. It also enhanced lentil varieties yield in the range of 6.40 to 10.8% as compared to uninoculated control. Single bacterial strain inoculation enhanced P uptake of lentil plants in the range of 34.2 to 76.7%. Rock phosphate application combined with bacterial inoculation improved the number of seed of lentil/plant by 11.4% and 7.5% in Pseudomonas fragi strain CS11RH1 and P. poae strain NS12RH2(1), respectively over the application of rock phosphate alone. Single inoculation of cold tolerant bacterial strains NARs9, PBRs5, PPERs23 and PGERs17 significantly enhanced grain yield by 19.2, 17.1, 16.0 and 13.5%, respectively, over uninoculated control. Twelve bacterial isolates showed a shift in pH (neutral to acidic) after growth in the broth and correspondingly increased the available zinc, ranging from 189.0 to 581.9 mg/l after 7 days of incubation at 28°C. Three bacterial cultures were identified based on the sequence of their 16S rRNA gene and GenBank accession numbers obtained for all the deposited isolates.

Network Project on Transgenics

Approximately 50 putative transgenic plants were regenerated and DNA was extracted from them when the seedlings were of 21 days old and were amplified with bar specific primers.
DBT Project

Seeds of Vivek QPM 9 were distributed to NSC, Tarai Seeds, Sikkim government, Maharashtra Seed Corporation and many other organizations. Licences are also given to three private companies for production and marketing of hybrid seeds of Vivek QPM 9.

Evaluation of maize genotypes over three locations for three years resulted in identification of many stable genotypes that possess relatively high level of kernel iron and zinc. Four lines viz. V 336, V 348, CM 129 and BAJIM 06-3 were found promising for both the micronutrients. In order to understand the variability and stability of total carotenoid and β-carotene, a common set of 100 inbred lines were evaluated at three locations during kharif 2010.

Yellow rust resistance genes Yr5 and Yr10 are being utilized for transferring resistance in the wheat variety VL 738 using MAS. A set of 150 markers were evaluated for availability of polymorphism between the recipient and donor parents for background selection. Six backcross populations were generated and are in BC3F1 generation. Approximately, 500 plants from each cross were grown for foreground and background selection. The linked markers for Yr5 and Yr10 were validated and two populations were retained.

NAIP Project

Among many interventions, polyhouses, water harvesting structures, solar dryers and contour trenches were constructed covering all the clusters spread over the NW Himalayan states. Besides, goats/sheep, poultry units and animal clothing were also provided. The area under food crops was 309.5 ha whereas it was 305.3 ha for seed production, 73.1 ha potato, 11.6 ha spices and 53.64 ha pulses. In the Champawat district, a total of 66.75 ha was under food crops whereas the area under high value crops was 14.2 ha. A total of 358 group meetings and 18 farmers’ trainings were conducted on various aspects within the Champawat clusters.

DUS Project

A total of 42 varieties including 12 hybrids, 21 inbreds and 9 composites of early and medium durations were characterized for thirty characters. Ninety released and notified varieties of soybean from different state Agricultural Universities/Institutes were maintained by growing in the Field. For maintaining the purity of these varieties, single true to the plant type, selected from last year harvest was sown in plot size of 3.0 x 1.35 m² (3 rows).

Technology Assessed and Transferred

More than 200 training programmes were conducted by institute and its KVKs, which benefited more than 4,000 farmers and state officials. During the reported period FLDs on different crop were laid on more than 89 ha area by the institute and its KVKs benefiting more than 1700 farmers.
Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora, is a premier institution working in the North-Western Himalaya for research in hill agriculture. 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.

Presently, the Institute is engaged in agricultural research for N-W Himalayan region, including Jammu and Kashmir, Himachal Pradesh and Uttarakhand states of India. Being a multi-crop and multi-disciplinary research institute, the research work is being carried out under four divisions/sections viz., Crop Improvement, Crop Production, Crop Protection and Social Sciences.

The Institute Headquarters is located at Almora in Uttarakhand State, at an altitude of 1,600 m above msl. The Research Farm is located at Hawalbagh, 13 km away from Almora on Kausani/Ranikhet Road at an altitude of 1,250 m above msl. The latitude and longitude are 29°56' N and 79°40' E, respectively.

The VPKAS, in the last 87 years of service to the nation, has several pioneering achievements to its credit. The most notable ones are:

i. Development of first hybrid of maize (VL Makka 54).
ii. Development of first hybrid onion (VL Piaz 67).
iii. Development of first hybrid extra early grain and baby corn (VL Makka 42).
iv. Development of dual purpose wheat varieties (VL Gchun 616 & VL Ghun 892) for grain and fodder.
v. Introduced new plants like kudzu vine, giant star grass, love grass, lemon grass, pecan nut and avocado in the region.
vi. Converted normal maize inbreds into Quality Protein Maize inbreds through Molecular Marker Assisted Selection and developed and released QPM 9.
vii. Developed Vivek Thresher-cum-Pearler for finger millet and barnyard millet, which helped in reducing drudgery of the hill women.
viii. Developed a two pronged strategy of managing the adult beetles and subterranean larvae of 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 Gehun 804, 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, VL Madira 172 and VL Ugai 7 of small millets; VL Soya 2, VL Soya 47 of soybean; VL Masoor 4, VL Masoor 103 of lentil and VL Ageti Math 7, Vivek Matar 6, Vivek Matar 8 of garden pea, VL Rajma 63 of rajmash.

The Institute has won the Sardar Patel Outstanding ICAR Institution Award twice for the year 2000 & 2007 in recognition of its valuable research contributions in development of hill agriculture.

During last five years, 32 improved varieties of wheat (VL Gehun 892, VL Gehun 907), maize (Vivek Maize Hybrid 21, Vivek Maize Hybrid 23, Vivek Maize Hybrid 25, Vivek Maize Hybrid 27, Vivek QPM 9, Vivek Maize Hybrid 33, Vivek Sankul Makka 35, Vivek Sankul Makka 37), barley (VL Barley 85), rice (VL Dhan 86, VL Dhan 65, VL Dhan 209), millets (VL Madira 207), Pulses (VL Gabat 10, VL Gabat 15, VL Gabat 19, VL Arhar 1, VL Matar 42, VL Masoor 126, VL Masoor 129), oilseeds (VL Toria 3, VL Soya 59, VL Soya 63, VL Moongphali 1, VL Bhat 65) and vegetable (Vivek Matar 10, Vivek Matar 11, VL Tamatar 4, VL Shimla Mirch 2, VL Bean 2) were released for cultivation. During these five years, around 1,365.99 quintals of breeder, 98.23 quintals of nucleus and 415.06 quintals of truthfully labeled seeds were produced for various agencies and farmers. More than 9,000 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 like, spring rice–wheat–finger millet–toria with 200 per cent cropping intensity instead of spring rice–wheat–finger millet–fallow sequence with 150 per cent cropping intensity in two years; and soybean–lentil, maize–pea, maize–wheat, rajmash–French bean–toria, pigeon pea–wheat, colocasia–coriander–tomato, soybean–pea and soybean–wheat among one year crop sequences were found more remunerative. Intercropping of soybean or groundnut in maize, soybean in finger millet and pea, lentil or toria in wheat were found more profitable than pure crops.

Long term fertility management being studied since 1973 revealed that use of FYM (10 t/ha) along with the recommended dose of inorganic fertilizers was capable of rectifying nutritional problems of crops and the deteriorating soil physical conditions. Institute was awarded by "Kribhco Barani Kheti Award – First Prize" during 1988 for this work.

Under fodder and grassland management; suitable agro-forestry systems, species of grasses (including winter grasses), fodder legumes, and grass composition under pine and deodar trees were identified. Technology for production of grasses on risers, degraded and steeply slopy lands as well as on 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 is, otherwise, 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 systems were 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 leaf spot and false smut in rice; neck and finger blast in finger millet; turmeric leaf blight in maize; powdery mildew, white rot in pea; buck eye rot in tomato, root rot and anthracnose in bean; root rot and wilt in lentil, and frog eye leaf spot and anthracnose in soybean as the major diseases. Fuscous blight of French bean/rajmah and zonate leaf spot of maize have been reported for the first time from this region. Viral diagnosis, based on symptomatology, shows presence of nearly 50 viral diseases affecting different crops grown in hills. Indigenous Trichoderma cultures have also been isolated from the North West Himalayan region and found effective against the soil borne pathogens.

White grub, a polyphagous pest, which devastates a number of rainfed khurif crops, is the most menacing insect of the region. More than 70 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, leafminer 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 and use of locally available plant part extracts and the need-based application of pesticides. The newly developed technology of insect trap and the entomo-pathogenic Bacillus thuringiensis 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.

An empirical formula has been developed for estimation of pan evaporation using only minimum and maximum temperatures, which has satisfactory level of accuracy (R² ranging from 0.76 to 0.86). Studies with empirical and simulated data reveals that nonconformity to the underlying assumptions for a valid data analysis is the cause behind inadmissible value of genetic correlation coefficient, i.e., either r < -1 or r > 1. Major contributing ancillary characters have been identified for pre-harvest forecasting of wheat and soybean yields. In a study of maximum rainfall in a year on a single day for 35 years rainfall data, Gumbel distribution was found to give the best fit. Database creation for North-Western Himalayas is being upgraded regularly. Tables, forms and queries were developed for data entry, editing, storage, searching and retrieval for database consisting of 482 paddy germplasm with 42 characters, 103 pea germplasm with 33 characters, 258 maize germplasm with 52 characters, 350 wheat germplasm with 33 characters and 78 Finger millet germplasm with 18 characters. User-friendly interface was developed for paddy germplasm database management and retrieval. Conversion of institute’s bulletin on technology options, viz., “उत्तर पश्चिमी पर्यावरण की बुद्धि के लिए उपयुक्त सामग्री” to CD ROM compatible format was completed. E-book was created for released soybean varieties.

A survey of the economics of off-season vegetables indicates that producer receives between 13-21% of consumer’s rupee in different vegetable produce and major share is siphoned to the middle-men in the prevailing marketing system. Therefore, keeping farmers and consumers interest in mind, farmers should develop their own marketing system, 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 published a book entitled, “उत्तर पश्चिमी पर्यावरण की बुद्धि के लिए उपयुक्त सामग्री” which is very popular among farmers and extension workers. The publication was awarded prestigious Dr. Rajendra Prasad Puraskar of Indian Council of Agricultural Research in the year 2004. Design and development of Vivek Thresher-I for pearling and threshing of Mandua/Madira won NRDC’s Meritorious Invention Award for the year 2006.
by National Research Development Corporation (NRDC), New Delhi. Institute's scientists won Hari Om Ashram Trust Award 2007 of ICAR for the invention of Vivek Mandua/Madira Thresher. Apart from this, a team of scientists won Outstanding Team Award of ICAR as recognition to the work in area of enhancing productivity and profitability of rice wheat system in N-W Himalayan States. Also, scientists of the institute received World Intellectual Property Organization (WIPO) Gold Medal in 2009, which was identified as the best invention of the year 2008 for development of "Eco-friendly novel technology for managing white grubs in North West Himalayas". This work 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.

User-friendly computer programmes for statistical data analyses were developed and LAN and Internet connectivity were established. Institute’s web site was created and launched at ICAR server. In addition, database for N-W Himalayas and rice germplasm were created. Economic analysis of crop enterprises in TOT villages led to identification of remunerative crops and crop sequences. Potential of vegetable production in Uttarakhand hills was also worked out.

**Infrastructure Facilities**

During the period under report, following construction/renovation works at Almora and Hawalbagh Campus and KVKs were completed:

- Fencing and retaining wall in the organic farming sector at Choti Kosi, Hawalbagh
- Temporary restoration of surrounding of Administrative and Library block at Almora
- Restoration of retaining wall near Lab building at VPKAS, Almora
- Construction of work bench in the Biotech Lab of CID building at Almora
- Construction of Stage for farmers Fair etc. at Hawalbagh

**KVK Chinyalisaur, Uttarkashi**

- Construction of Administrative Building
- Construction of Farmers' Hostel
- Construction of Demonstration Unit
- Construction of Residential building (Type III-4, Type I -2).

**KVK Sinduri Baskhola, Bageshwar**

- Construction of Administrative Building
- Construction of Farmers' Hostel
- Construction of Demonstration Unit
- Construction of Residential building (Type III-4, Type I -2).

**Laboratories and Research Farm**

Institute has well-equipped Bio-technology and Molecular Plant Pathology, Plant Physiology, Soil Science, Microbiology, Entomology and Plant Pathology laboratories. During the current year a number of scientific equipments namely, Soil DNA Extractor, Electronic Semi-micro Balance, Vertical Autoclave, Fume Hood, DNA Vaccum Concentrator, Monoblock, Centrifugal, Water Pump, Water Purification System, Touch Screen, Spectras Can UV 2600 Double Beam US VIS Spectrophotometer etc. were purchased for enhancing the analytical facilities of the Institute.

Prof. Bosth Sen Field Research Laboratory and Research Farm is located at Hawalbagh about 13 km on Almora-Kausani-Ranikhet Road at an elevation of 1,250 m above msl. The Research Farm of the Institute has about 40 ha of cultivable land.

**Institute Library**

During the period under report, 144 books were acquired and 68 books were also purchased under NAIP. Library subscribed 110 periodicals which includes 37 foreign and 73 Indian periodicals. Library has a collection of Rs. 33,900 (approx.) bound volumes. A sum of Rs. 15,19,270.00 was spent for the procurement of the books/periodicals etc. during the period. Books worth Rs. 3,31,616.00 was also purchased under NAIP. Besides, many annual reports, and other...
miscellaneous publications were also received on gratis from various ICAR institutes and other organizations.


**ARIS Cell**

Institute’s ARIS Cell is presently working with six workstations and two servers. ARIS Cell provides hardware, software, anti-malware, intranet and internet support to the institute. ARIS Cell also maintains institute’s website, which can be assessed at the [http://vplas.nic.in](http://vplas.nic.in).

**Staff**

The staff position of the Institute as on 31.3.2010 is given below:

<table>
<thead>
<tr>
<th>Type</th>
<th>Sanctioned</th>
<th>Filled</th>
<th>Vacant</th>
</tr>
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<tbody>
<tr>
<td>RMP</td>
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<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Scientific</td>
<td>60</td>
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<td>23</td>
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<tr>
<td>Technical</td>
<td>48</td>
<td>46</td>
<td>02</td>
</tr>
<tr>
<td>Administrative</td>
<td>24</td>
<td>18</td>
<td>06</td>
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<tr>
<td>Supporting</td>
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<td>44</td>
<td>07</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>184</strong></td>
<td><strong>146</strong></td>
<td><strong>38</strong></td>
</tr>
</tbody>
</table>

**Finance**

The budget outlay for 2010-11 (Rs. in lakhs) is given hereunder:

<table>
<thead>
<tr>
<th>Item</th>
<th>Allocation</th>
<th>Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Plan</td>
<td>911.46</td>
<td>911.33</td>
</tr>
<tr>
<td>Plan</td>
<td>223.00</td>
<td>223.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,134.46</strong></td>
<td><strong>1,134.33</strong></td>
</tr>
</tbody>
</table>

**Weather and Crop Season**

Almora district, which falls under mid hills of N-W Himalaya, has sub-temporate and sub-humid climate. The mean maximum daily temperature during kharif season (May to October) ranged from 26.1°C (September) to 30.6°C (June) and minimum monthly temperature varied from 12.8°C (October) to 19.9°C (July), respectively. During this season, about 1,295 mm rainfall was received. The maximum rainfall was received in the month of September (507.6 mm) followed by July (350.4 mm). The mean maximum daily temperature during rabi season (November to April) ranged from 14.6°C (January) to 30.7°C (April) and the mean minimum daily temperature ranged from 2.9°C (January) to 17.2°C (April). During rabi, about 136.1 mm rainfall was received with nil rainfall in December. The annual rainfall for Almora (1,600 m amsl) for 2010-2011 was 1,431.1 mm.

The Institute’s Research Farm is located at an elevation of 1,200 m above msl at Hawalbagh. The mean maximum daily temperature during kharif season (May to October) ranged from 28°C (October) to 32.1°C (May) and mean minimum daily temperature varied from 10.3°C (October) to 20.9°C (August). During this season, about 1,230.5 mm of rainfall was received. The maximum rainfall was received in the month of September (463.5 mm) followed by July (368 mm). The mean maximum daily temperature during rabi season (November to April) ranged from 18.2°C (January) to 32.1°C (April) and the mean minimum daily temperature from -0.3°C (December) to 10.3°C (April), respectively. During rabi, about 130 mm of rainfall was received. The annual rainfall for 2010-11 at Research Farm, Hawalbagh was 1,360.5 mm.
RESEARCH

ACHIEVEMENTS

Vivek Maize Hybrid 39  VL Masoor 514  Vivek Maize Hybrid 43
Vivek Matar 11  VL Matar 47  VL Shimla Mirch 2
Enhancement in the Productivity of Major Hill Crops

- Genetic Enhancement for Productivity and Quality in Maize [Drs. P.K. Agrawal, S.K. Jha, D. Mahanta & Chandrashekara C.]
- Genetic Enhancement for Productivity and Quality in Wheat and Barley (Drs. L. Kant, D. Mahanta, S.K. Jain, Mr. U.B. Khetinini & Dr. J.K. Bisht)
- Genetic Enhancement for Productivity and Nutritional Quality in Millets and Underutilized Crops (Drs. A. Gupta, B.M. Pandey, Chandrashekara C., S. Sood & 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. Subhanna, Mr. R.S. Pul (w.e.f. September 19), Drs. R. Arun Kumar & M.L. Roy)
- Enhancing Quality and Resistance to Biotic Stress through Molecular Breeding (Drs. P.K. Agrawal, J.C. Bhatt, L. Kant & N.K. Hedau)
- Seed Production (Dr. L. Kant & Mr. U.B. Khetinini – Field crops)
2.1. Enhancement in the Productivity of Major Hill Crops

2.1.1. Maize

Maize is an important cereal of North-Western hills and occupies an area of 0.65 million ha with an average productivity of 2.092 kg/ha as against 2.414 kg/ha at National level in 2008-09. 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 85-95 days in hills with high yield potential and resistance to prevailing diseases in general and *tungro* leaf blight in particular.

2.1.1.1 Varietal Improvement

**Varieties Released**

**Vivek Maize Hybrid 39 (FH 3350):** An extra-early maturing single cross hybrid (85-90 days) with yellow, semi-dent grain was released by CVRC for commercial cultivation in Zone-I (Uttarakhand, Himachal Pradesh, Jammu & Kashmir and NEH region) in 2010. 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 (FH 3358):** An extra-early maturing (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) in 2010. Vivek Maize Hybrid 43 recorded average yield of 4,491 kg/ha and 5,868 kg/ha in Zone-III and V, respectively, in the all India trials. The hybrid exhibited consistent yield superiority of 24.04 to 32.92% in Zone-III and 31.85 to 52.28% in Zone-V over Vivek Maize Hybrid 17.

**Evaluation of Normal and Speciality Maize in Coordinated and Station Trials**

One hundred sixty-seven genotypes including 66 hybrids and five composites developed at VPKAS were evaluated in eight trials and 85 genotypes of speciality corn including 36 hybrids of VPKAS in four trials, in order to identify superior genotypes in medium, early and extra-early maturity groups. Seven extra-early maturity (85-90 days) trials viz. AET-I (8), IET (12), Zonal 103 (32), SVT (13), 27 new hybrids in VL Station trials I, 14 normal inbreds and 3 QPM inbreds were evaluated in VL Station trial 3. In AET-I, FH 3483 (9,236 kg/ha) was superior to Vivek Maize Hybrid 9 (8,518 kg/ha) and Vivek QPM 9 (7,972 kg/ha). The hybrid established substantial yield superiority over Vivek Maize Hybrid 9 in Zone-I, II, III & IV. In AET-I (early) single cross hybrid PH 3506 (8,731 kg/ha) out-yielded the hybrid check Parkash (6,803 kg/ha) and JH 3459 (6,288 kg/ha). On the basis of zonal mean, the hybrid established 23.5% superiority over JH 3459, the best check. In Zonal Trial, VL Hybrid FH 3549
(11,416 kg/ha), FH 3548 (11,387 kg/ha), FH 3550 (11,283 kg/ha), FH 3555 (10,614 kg/ha), FH 3554 (1,008 kg/ha) were superior to the best check Vivek Maize Hybrid 9 (9,139 kg/ha). These hybrids performed well across the locations in Zone-I and registered yield superiority ranging between 9.3 and 28.3% over Vivek Maize Hybrid 9. In IET (extra-early), single cross hybrid FH 3510 (10,349 kg/ha) and FH 3225 (10,076 kg/ha) out-yielded the best hybrid check Vivek Maize Hybrid 9 (8,553 kg/ha). Similarly, in IET (early) FH 3513 (7,829 kg/ha) was found superior to Pankash (7,136 kg/ha) and JH 3459 (6,409 kg/ha). In the station trials, promising hybrids found were FH 3534 (8,532 kg/ha) and FH 3559 (8,256 kg/ha) whereas the best productive inbreds were V373 (5,622 kg/ha), V400 (5,153 kg/ha) and V341 (4,676 kg/ha) and the best QPM inbred was VQL 17 (4,730 kg/ha). Among the 20 entries evaluated for green cob, Vivek QPM 9 (12,897 kg/ha) was the best followed by Vivek Maize Hybrid 9 (12,569 kg/ha), FH 3358 (12,113 kg/ha), FH 3356 (12,102 kg/ha), Vivek Maize Hybrid 25 (11,986 kg/ha), Vivek Maize Hybrid 21 (11,847 kg/ha), FQH 55 (11,380 kg/ha) and Vivek Maize Hybrid 23 (11,141 kg/ha).

**Development of Early and Extra-early Duration Yellow Composites**

- Mild selection for uniformity, better yield and tolerance to biotic stresses was practiced in sweet corn synthetic VL 15, improved through ear-to-row selection.
- Selection for better yield, uniformity and tolerance to prevailing diseases was practiced in experimental composite VL. Pop corn 1, synthesized involving seven elite materials through half-sib method during 2004.

**Development of Early and Extra-early Yellow Hybrids**

In order to extract early, yellow, vigorous disease-resistant inbreds from EYHP-I and II, nine S_5, ten S_6, seven S_7 and four S_8 onwards lines were evaluated and thirty lines among these (five S_5, seven S_6 and four S_7) were retained for further selection, inbreeding and use in hybridization programme. In order to develop short duration productive inbred lines inbreeding was initiated in 20 promising materials. Out of these, 28 lines possessing early maturity, shorter plant height and resistance to prevailing diseases were retained for further inbreeding and selection. Two hundred twenty two lines of different homozygosity levels (44 S_5, 47 S_6, 36 S_7, 18 S_8, 19 S_9, 34 S_10 and 24 advance generation) were evaluated. Of these, 142 lines (21 S_5, 22 S_6, 47 S_7, 14 S_8, 9 S_9 and 29 advance stage) possessing earliness, shorter plant and ear height, good vigour, shorter ASI and tolerance to biotic stresses mainly E. turcicum were retained for further selection and inbreeding. Five elite lines possessing desirable traits were established (V411 to V417) and used in the hybridization programme. Selection and inbreeding was continued in 26 different inbred lines of sweet corn (3 S_5, 6 S_6, 15 S_7 and 2 S_8) and 17 desirable lines (1 S_5, 1 S_6, 13 S_7, 1 S_8 and 2 advance stage) with shorter plant height, earliness and tolerance to E. Turcicum and other prevailing diseases were retained for further inbreeding and selection.

**Development of Single Cross Hybrids**

Fifty seven new single cross combinations were developed through hybridization of 28 short duration promising inbreds, including released ones. Besides, 18 hybrids of Sweet Corn were generated through seven newly developed lines.

**Germplasm Resource – Evaluation and Maintenance**

One hundred and sixty four indigenous/exotic inbred lines received from DMR, CIMMYT, S.M. Sahgal Foundation and 52 accessions from NBPGR were evaluated. Of these, 78 early-medium materials and six populations possessing desirable agromorphic traits and resistance to **E. turcicum** leaf blight were maintained for their potential use in hybridization program. Besides, 113 early-medium duration exotic and indigenous germplasm deposited with mid-term storage module of the institute were evaluated, rejuvenated and maintained (Table 2.1.1).
Table 2.1.1. Germplasm evaluation and maintenance during Khareif 2010

<table>
<thead>
<tr>
<th>Germplasm</th>
<th>Lines Evaluated</th>
<th>Lines Maintained</th>
<th>Days to 50% Silking (Range)</th>
<th>E. turcicum (Scores: 1-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIMMYT India Normal lines</td>
<td>57</td>
<td>29</td>
<td>55</td>
<td>1.00-2.25</td>
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<tr>
<td>SM Sahgal Foundation</td>
<td>10</td>
<td>2</td>
<td>57-63</td>
<td>1.3-2.25</td>
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<tr>
<td>DMR Introductions</td>
<td>87</td>
<td>37</td>
<td>53-62</td>
<td>1.5-2.75</td>
</tr>
<tr>
<td>CIMMYT QPM Donor Lines</td>
<td>8</td>
<td>8</td>
<td>57-68</td>
<td>1.75-2.25</td>
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<td>CIMMYT Low Phytate lines</td>
<td>2</td>
<td>2</td>
<td>56-62</td>
<td>2.75-4.25</td>
</tr>
<tr>
<td>NBPI/C Accessions</td>
<td>52</td>
<td>6</td>
<td>53-61</td>
<td>2.0-2.75</td>
</tr>
<tr>
<td>CM212 (Check)</td>
<td>-</td>
<td>-</td>
<td>53-54</td>
<td>2.75-3.75</td>
</tr>
<tr>
<td>Y341 (Check)</td>
<td>-</td>
<td>-</td>
<td>55-57</td>
<td>1.5-1.75</td>
</tr>
<tr>
<td>Vivek Sankul Makka 11 (Check)</td>
<td>-</td>
<td>-</td>
<td>52-53</td>
<td>1.5-2.75</td>
</tr>
</tbody>
</table>

Production and Maintenance of Nucleus Seeds, Truthfully Labeled Seeds, Hybrid Seeds and Parental Lines

- Purification, maintenance and seed increase of 30 parental lines (0.5-1.0 kg) of experimental hybrids of normal corn, two of QPM test hybrid and two new advance stage lines was done.
- Nucleus seed (1.0-12.0 kg) of parental lines of VL Makka 42, Him 129, Vivek Maize Hybrid 4, Vivek Maize Hybrid 5, Vivek Maize Hybrid 9, Vivek Maize Hybrid 15, Vivek Maize Hybrid 17, Vivek Maize Hybrid 21, Vivek Maize Hybrid 23, Vivek Maize Hybrid 25, Vivek Maize Hybrid 27, Vivek Maize Hybrid 33, Vivek Maize Hybrid 39 and Vivek Maize Hybrid 43 was produced.
- F₁, seed (2.5-48.0 kg) of 38 test hybrids for All India Coordinated and standard varietal trials and on farm demonstrations was produced by controlled pollination.
- F₁, seed of Vivek QPM 9 (610 kg), Vivek Maize Hybrid 9 (175 kg) was produced in isolation. Besides, 5.0-35.0 kg F₁, seed of 10 released hybrids was also multiplied by controlled pollination.
- Nucleus seed (15.0-32.0 Kg) of released composites, Vivek Sankul Makka 11, Vivek Sankul Makka 31, Vivek Sankul Makka 35, Vivek Sankul Makka 37, VL Amber Popcorn and VL Baby corn 1 was produced.

Sharing of Maize Germplasm and Inbred Lines with Coordinated Centers

A total of 68 inbred lines of normal corn and QPM lines were supplied to four centers of AICMIP including two centers in zone I so as to strengthen their extra-early maize breeding program (Fig. 2.1).

Fig. 2.1. Inbreds supplied to different centres of India

2.1.1.2. Crop Protection Investigations

Evaluation for Disease Resistance

On the basis of evaluation of maize entries under high disease pressure conditions in coordinated nurseries consisting of various maturity groups, FH 3513 (IET Early maturity) was resistant to turcicum blight, FH 3520, FH 3521 (IET Extra Early Maturity) and FH-3488 (Extra early maturity) were resistant to both turcicum and maydis blights, whereas FH-3506 (Early maturity) was resistant to maydis blight.
2.1.1.3. Agronomic Investigations

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

The genotype Vivek QPM 9 was evaluated for different plant geometry (Equal row at 67 cm and paired row of 84 cm: 50 cm) and density (plant to plant spacing of 35, 30 and 25 cm). The plant to plant spacing of 25 cm provided the significantly higher grain yield (8,130 kg/ha) than rest of the density. There was no significant difference between equal row (7,320 kg/ha) and paired row (7,640 kg/ha) in grain yield. There was no interaction between plant geometry and density.

Developing Agro-techniques for Seed Production of Inbred Maize Parent

The genotype VQL 1, one of the parent of Vivek QPM 9 was evaluated for different plant population and fertilizer levels. The plant population 74,627 (60 x 20 cm) provided significantly higher grain yield (3,860 kg/ha), than 59,701 (60 x 25 cm) plant population (3,510 kg/ha). Among the fertilizer levels, application of 300:105:105 kg N:P:O₃K₂O/ha along with FYM 15 t/ha recorded significantly higher grain yield (4,090 kg/ha), which was at par with 250:90:90 kg N:P:O₃K₂O/ha along with FYM 15 t/ha. There was no interaction between population and fertilizer 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 1.5-2.0 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 2,001 kg/ha in 2008-09 whereas the average national productivity was 2,178 kg/ha. Rigorous efforts have been made in the institute in last few years to develop and identify the superior genotypes of rice in terms of grain yield, resistance/tolerance to prevailing biotic/abiotic stresses, quality traits and development of production technologies for their suitability under rainfed upland (spring and summer sowing) and irrigated transplanted conditions.

2.1.2.1. Varietal Improvement

Varieties Identified / Recommended for Release / Under Notification

**VL 30424:** VL 30424 based on three years performance in the State Varietal Trial was identified by Varietal Identification Committee (VIC) of the Uttarakhand state for irrigated early condition of Uttarakhand hills. It out-yielded the check varieties Pant Dhan 11 by 28.02 per cent, Vivek Dhan 82 by 25.42 per cent and VL Dhan 85 by 22.08 per cent. It is a semi-dwarf line which matures in about 120 days. It has long slender grains and is also highly resistant to leaf and neck blast. It matures in about 120 days and has plant height of 79 cm.

**VL 30240:** It has been identified by Variety Identification Committee (VIC) of SVT, Uttarakhand for the June-sown rainfed upland condition of Uttarakhand hills. It is derived from Thapachini x VL 1695. On the average of three years of testing, VL 30240 has shown yield potential of 2,326 kg/ha. It out-yielded the check varieties VL Dhan 221 by 31.14 per cent and Vivek Dhan 154 by 18.14 per cent. It matures in about 115-120 days and has plant height of 100 cm. This entry was also recommended by the AICRP (Rice) for the state of Uttarakhand.
Multi-locational Evaluation Trials

Altogether 11 trials were conducted as a part of multilocational trials. These include four trials under organic conditions in 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). Three entries viz., VL 31290, VL 31284, VL 31449 of irrigated early, three entries viz., VL 31450, VL 31452, VL 31451 of irrigated medium and two entries viz., VL 7954, VL 7852 of rainfed upland have been promoted for the third year of testing under AICRP (Rice) trials (Table 2.1.2).

Table 2.1.2. Promising breeding lines under different trials

<table>
<thead>
<tr>
<th>AICRP (Rice)</th>
<th>AVT I &amp; AVT II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated (Early)</td>
<td>VL 31449, VL 31284, VL 31290, VL 31334, VL 31339</td>
</tr>
<tr>
<td>Irrigated (Medium)</td>
<td>VL 31452, VL 31451, VL 31450</td>
</tr>
<tr>
<td>Upland (June sown)</td>
<td>VL 7954, VL 7742, VL 7820, VL 7702, VL 30569</td>
</tr>
<tr>
<td>SVT, Third Year (Uttarakhand)</td>
<td></td>
</tr>
<tr>
<td>June Sown</td>
<td>VL 7620, VL 30560</td>
</tr>
<tr>
<td>Irrigated (Medium)</td>
<td>VL 31329</td>
</tr>
</tbody>
</table>

Segregating Breeding Materials

Based on the good phenotypic characters, drought tolerance, disease and insect resistance, genotypes of desired maturity and plant height, a total of 2642 progenies derived from 342 crosses were selected in F₃ to F₅ generations under different ecosystems viz., rainfed upland (Spring and June sown) and irrigated transplanted conditions (Early & Medium maturity). Under rainfed upland spring sown conditions, 12 crosses of F₃ generation and 10 crosses of F₅ generation were bulked. 410 plant progenies from 40 crosses in F₅ generation, 261 plant progenies from 34 crosses in F₅ generation, 378 plant progenies from 19 crosses in F₅ generation and 45 plant progenies from 15 crosses in F₅ generations were selected for drought tolerance, resistance against blast & brown spot with higher grain yield. Under June sown rainfed upland conditions, 13 crosses of F₅ generation were bulked. A total of 129 plant progenies derived from 30 crosses in F₅ generation, 195 plant progenies from 22 crosses in F₅ generation and 370 plant progenies from 23 crosses in F₅ generation were selected for drought tolerance, short duration, blast resistance and better grain yield.

For the irrigated ecosystem, 38 crosses of F₅ generation were bulked. 648 plant progenies from 43 crosses in F₅ generation and 206 plant progenies from 37 crosses in F₅ generation were selected. In this ecosystem more emphasis was given to select short duration plants with resistance against blast

Station Trials

The Institute Station Trial was conducted in three categories, viz., spring sown rainfed upland, June sown rainfed upland and Irrigated conditions. Promising lines were selected for further evaluation and multilocational testing. Promising lines selected from advance station trials includes VL 31396 (2,658 kg/ha) and VL 8066 (2,409 kg/ha) in rainfed upland spring sown; VL 8204 (2,714 kg/ha) and VL 8302 (2,333 kg/ha) in rainfed upland June sown; VL 31616 (5,611 kg/ha), VL 31618 (5,571 kg/ha) in irrigated early and, VL 31724 (5,284 kg/ha) and VL 31726 (5,690 kg/ha) in irrigated medium conditions. All these lines selected are resistant to blast and have acceptable agronomic traits like plant height, days to maturity and grain quality.
disease. Emphasis has also been given to develop quality rice for the hill farmers. In the breeding programme for the quality (aromatic/slimmer), 17 crosses of F, generation were bulked and 53 plant progenies from 6 crosses in F, generation were selected in 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 resistance to blast with a score of 3.0 in a scale of 0 to 9 were VL 31611, VL 31724, VL 31726, VL 31598, VL 31615, VL 31616, VL 31619, VL 8185, VL 8169, VL 31430, VL 31429 and VL 31396. Among these, VL 7853, VL 30919 and VL 31290 have shown resistance to blast for the last three years. Besides VL 7853, VL 7876, VL 8158, VL 8167, VL 30919, VL 31228, VL 31296, VL 31341, VL PR.8 were found promising against brown spot.

**Seed Production**

TL seed of VL Dhan 65 and VL Dhan 85 was produced in the farmers field at Basulsera. A total of 385 kg seed was produced, which was utilized for institute's outreach programmes. Besides, seeds of more than 15 entries at different stages of AICRP and SVT trials were multiplied and submitted for multilocalational evaluations.

**Physiological Studies in Rainfed Upland Rice**

An experiment was conducted with eighteen rice genotypes viz. VL 8201, VL 8204, VL 8214, VL 8257, VL 8292, VL 8302, VL 8188, VL 8185, VL 8369, VL 31364, VL 31402, VL 31430, VL 31590, VL 31567, VL 31440, VL 31419, Vivek Dhan 154 and VL Dhan 221 to study the physiological traits contributing to yield at the Malhaat Farm of VPKAS, Haralwall during kharif, 2010 in randomized block design. The results revealed that during the post flowering stage, genotype VL 8302 recorded maximum chlorophyll a content of 5.617 mg g⁻¹ f.wt. whereas VL 31440 exhibited 3.159 mg g⁻¹ f.wt. Similarly, VL 8302 recorded maximum chlorophyll-b total chlorophyll and total carotenoid contents of 4.821, 10.424 and 2.022 mg g⁻¹ f.wt. respectively, while VL 31440 possessed lower chlorophyll-b, total chlorophyll, and total carotenoid contents. Significant differences were also observed between genotypes for relative water content (RWC) and photosynthetic efficiency (Fv/Fm). VL 31402, VL 8302 and VL 8185 recorded significantly higher RWC and Fv/Fm (Fig. 2.2). Significant differences were also recorded for photosystem II efficiency, days to 50% flowering, days to physiological maturity and grain yield. Genotypes VL 8204, VL 8302, VL 31402 and VL 8185 exhibited significantly higher grain yield compared to other rice genotypes. This could be due to better leaf pigment content along with efficient photosynthesis. RWC and Fv/Fm were observed to have significant positive correlation with grain yield. These physiological traits can be used in rice breeding programme.

![Fig. 2.2. Genotypic variations for relative water content and photosynthetic efficiency in eighteen rice genotypes grown under rainfed upland condition (Vertical bars show S.E. of mean. Data for genotypes (G) were significant (P=0.05).](image)

**2.1.2.2 Crop Protection Investigations**

**Evaluation for Disease Resistance**

In VL rice nurseries, VL31429 and VL31396 in spring sown, VL8185, VL8188, VL8204, VL8369, VL31430 in June sown and in irrigated transplanted rice VL31611, VL31724, VL31726 were found promising against blast diseases.

One hundred and six rice entries were evaluated under Donor Screening Nursery (DSN) against blast and brown spot. VL7853, VL30919, VL31290, VL31296, VL31320, VL31429, VL31430, VL31431, VL31438, VLRP7 and...
VLPR8 showed high resistance against leaf and neck blast whereas VL7853, VL7876, VL8158, VL8167, VL30919, VL31228, VL31296, VL31341, VLPR-8 were promising against brown spot. Among these, VL7853, VL30919 and VL31290 have shown resistance to blast for the last three years.

In NSN-Hills rice nursery 79 entries were screened for leaf and neck blast, and brown spot diseases. IET 21751, IET 21752, IET 21756, IET 21757, IET 20959, IET 21318, IET 21319, IET 20955, IET 21390 and IET 21393 were resistant against leaf and neck blast with the score of 3-4. Entries IET 21749, IET 21750, IET 21759 were promising against brown spot with the score of 3.

**Evaluation of Rice Genotypes under Shuttle Breeding Programme**

Fifty-six entries of Advanced Yield Trial (AYT) and 84 of Observational Yield Trial (OYT) from CRURRS, Hazaribagh (Jharkhand) were evaluated for blast and brown spot resistance under the Upland Rice Shuttle Breeding Network (URSBN-2010). Thirteen entries of AYT viz. CRR 498-4-1-1-1-B, IR 82635-B-B-25-4, IR 82635-B-B-47-2, IR 82635-B-B-88-2, IR 82635-B-B-93-2, IR 82639-B-B-140-1, IR 82639-B-B-3-3, NDR 1131, RR 429-1, RR 646-B-B-93-6-B-3, RR 517-34-1-1, RR 646-IR 79971-B-12-B, IR 81025-B-311-B were resistant to leaf blast with a score of 3.0. Similarly, CRR 427-199-3-2-1, CRR 417-B-68-1-1-2-B-B, IR 83928-B-B-28-3, IR 82635-B-B-75-2, IR 82635-B-B-88-2, IR 82635-B-B-25-4, IR 82635-B-B-143-1, IR 82639-B-B-118-3, 428-237-1-3-1 were resistant to leaf blast in OYT.

In a separately sown nursery under upland condition, AYT and OYT entries were evaluated against brown spot. No entry showed less than 4 brown spot score. AYT entries IR 84881-B-132-CRA-1-1, IR 82635-B-B-143-1, IR 82635-B-B-145-1, IR 82635-B-B-23-1, IR 82635-B-B-88-2, IR 82635-B-B-93-2, RR 617-B-B-3-3 and OYT entries BAU 411-05, BAU 415-05, CRR 427-199-3-2-1, IR 82589-B-B-44-2, IR 82635-B-B-47-2, IR 82635-B-B-88-2, IR 82590-B-B-121-3, IR 83928-B-B-9-1, IR 82638-B-B-147-1, IR 82635-B-B-47-1, Rewa 710-42-22 were found promising for brown spot with a score of 4.

**2.1.2.3 Agronomic Investigations**

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

Five AYT-III entries (IET 20818, IET 20819, IET 20820, IET 20822 and IET 20826) of short duration group and three AYT-III entries (IET 20803, IET 20806 and IET 20812) of medium duration group were tested at three levels of nitrogen (50 per cent, 100 per cent and 150 per cent N/ha of recommended dose). No significant differences were found among various nitrogen levels. The highest grain yield were recorded by IET 20819 (5,386 kg/ha) and IET 20803 (4,790 kg/ha) under short and medium duration groups, respectively.

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

Two AYT-III entries viz., IET 20957 and IET 20961 with 2 checks (Vivek Dhan 154 and VL Dhan 221) were evaluated for their growth and yield parameters at three levels of nitrogen. Application of 60 kg N/ha (100 per cent dose) produced the highest grain yield, however, an increase of 30 kg N/ha affected the yield adversely. IET 20957 (3,699 kg/ha) and IET 20961 (3,568 kg/ha) recorded significantly higher yield over checks (2,632 and 2,509 kg/ha).
2.1.3. Wheat

Wheat is the most important cereal crop of summer season in the North Western Himalaya with the average productivity of 1,770 kg/ha, which is much below the national productivity of 2,907 kg/ha in 2008-09. It is grown over an area of 1.0 million ha in N-W Himalayas with the average productivity of 1,520, 1,735 and 2,003 kg/ha in the state of Himachal Pradesh, Jammu & Kashmir and Uttarakhand, respectively. The present status of production and productivity can be raised by the adoption of high yielding varieties having resistance/ tolerance to biotic (yellow and brown rust and, loose smut) and abiotic (drought and cold) stresses along with suitable production and protection technologies.

2.1.3.1. Varietal Improvement

Genetic Stock Identified through All India Coordinated Testing

A genetic stock VW 0648 (DONG XI E3/ HD30//HD2743) has been identified for number of tillers/metre through the All India testing from 2007-08 to 2009-10. On the basis of three years of testing at 50 locations the tillers/metre in VW 0648 was 101.66 as compared to 91 in HD 2009, the best check (Table 2.1.3).

Strains Completed Three Years of Testing in Coordinated Trials

VL 925 a high yielding disease resistant strain suitable for late sown restricted irrigation condition has completed three years of testing in All India.

Table 2.1.3. Three years testing detail of genetic stock VW 0648

<table>
<thead>
<tr>
<th>Year</th>
<th>Name of Entry</th>
<th>Range</th>
<th>Mean</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007-08</td>
<td>VW 0648</td>
<td>13-136</td>
<td>89</td>
<td>6/14</td>
</tr>
<tr>
<td></td>
<td>HD 2009</td>
<td>52-153</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>2008-09</td>
<td>VW 0648</td>
<td>56-197</td>
<td>100</td>
<td>5/15</td>
</tr>
<tr>
<td></td>
<td>HD 2009</td>
<td>42-153</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>2009-10</td>
<td>VW 0648</td>
<td>58-185</td>
<td>116</td>
<td>15/21</td>
</tr>
<tr>
<td></td>
<td>HD 2009</td>
<td>56-133</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>Mean</td>
<td></td>
<td>101.66</td>
<td></td>
</tr>
<tr>
<td>Check</td>
<td>mean</td>
<td></td>
<td>91</td>
<td></td>
</tr>
</tbody>
</table>

VW 0648 – a genetic stock of wheat identified

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Coordinated trials. VL 925 (2,657 kg/ha) has shown an overall yield superiority of 8.00, 9.21, 9.31, 18.49 and 2.19% over checks HS 295, Sonalika, HS 490, HS 420 and VL Gehun 892, respectively, during all the three years of testing in the Northern Hill Zone. VL 925 was found to have a higher degree of resistance against yellow and brown rust under natural as well as artificial epiphytic conditions. In addition, it possesses Lr 23+10+ and Sr 9h+11+ gene combinations, different from prevailing checks. VL 925 has pseudo black chaff, therefore, may have Sr2 complex known to have Ug99 resistance world over.

Adaptability Evaluation of Newly Developed Strains

Twelve yield evaluation trials were conducted to assess the adaptability of new wheat strains with respect to grain yield, disease resistance and other desirable attributes under the rainfall early sown, rainfall timely sown, irrigated timely sown and restricted irrigation late sown conditions of Northern Hill Zone (NHZ). Under the recorded situations, the early sown trials included twenty nine entries i.e., AVT (14) and Station trial (15). None of the test entries under AVT could surpass the best check VL Gehun 829 (1,730 kg/ha). In the Station Trial VW 0910 (2,650 kg/ha) yielded at par to the best check VL Gehun 829 (2,605 kg/ha). Eighty-eight entries in four timely sown trials, viz., AVT (11), IVT (23), SVT organic (10) and Station trial (42), were evaluated. HS 514 (1,800 kg/ha) in AVT, VL 930 (3,400 kg/ha), HS 524 (3,220 kg/ha), HPW 349 (3,090 kg/ha), VL 940 (3,070 kg/ha) and VL 941 (3,070 kg/ha) in IVT, VL 938 (3,174 kg/ha) in SVT were found to be superior in grain yield. Under the late sown restricted irrigation (pre-sown irrigation only) trials, 30 entries (AVT 13, Station trial 17) were evaluated. The entry VL 925 (1,770 kg/ha) yielded at par with the best check VL Gehun 892 (1,840 kg/ha). Under the irrigated conditions 88 entries were evaluated under four timely sown trials, viz., AVT (11), IVT (23), SVT organic (10) and Station Trial (42). VL 930 (4,640 kg/ha) yielded at par with the latest identified check VL Gehun 907 (4,650 kg/ha) in AVT trial, VL 938 (5,260 kg/ha), HS 528 (5,200 kg/ha), HS 525 (5,160 kg/ha), VL 940 (5,150 kg/ha) and HPW 341 (5,130 kg/ha) in IVT trial and UP 2770 (3,899 kg/ha) in SVT were found superior in grain yield. Out of 69 new bulks generated under the institute breeding programme and evaluated in different station trials under the rainfall as well as irrigated conditions, eleven promising strains were entered in different All India Coordinated Trials of NHZ.

Development of New Strains

The major objective of the programme is to develop high yielding disease resistant (yellow and brown rust and, loose smut) genotypes suitable for rainfall early sown, rainfall timely sown, irrigated timely sown and restricted irrigation late sown conditions of NHZ. Diverse donors of Winter and spring wheats were used and 336 fresh crosses (111 Spring x Spring (SxS) and 225 Winter x Spring (WxS) wheat) including two and three way crosses were made. Two hundred and ninety eight F1 hybrids were evaluated and 89 better performing F1 hybrids, consisting of 15 SxS and 74 WxS were identified for the F2 generation.

The breeding materials were handled following pedigree method. F1 and F2 generations were exposed to low fertility and the rainfall conditions. A total of 90 F2s (i.e., 14 SxS and 76 WxS), and 1666 single plant progenies (653 SxS and 1013 WxS) of 270 crosses in F2 and subsequent generations were subjected to rigorous selection. The inoculum of rust received from the Regional Station of Directorate of Wheat Research (DWR), Flowerdale, Shimla (Himachal Pradesh), was multiplied under the glass house conditions. The infector rows planted in and around the breeding materials were inoculated following syringe inoculation method. Subsequently rust spores were collected from the infector rows and sprayed at regular intervals on the breeding materials. 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. Since the Bulk-pedigree method being followed at
CIMMYT, Mexico, the breeding method at VPKAS was changed from pedigree method to Bulk-pedigree method. Finally, 266 bulk and 630 individual plant progenies from $F_1$ generations onward and $79$ bulks in $F_2$ and onward generations were selected for further evaluation during the ensuing season. In addition, one experiment on combining ability was conducted to study combining ability and heterosis.

**Breeding for Quality Wheat**

Efforts have been made to incorporate the desirable quality traits viz., high protein content, high micro-nutrients, good chapati and biscuit making quality etc. through hybridization with proven donors. The donors like KYZ 9712, QLD 11, UP 2672 (for protein >14%), QLD 31, QLD 33, QLD 36, and QLD 39 (for protein yield), QLD 35, QLD 37, QLD 38 (for hectoliter weight), HUW 609, VL 852, VL 858 (for chapati quality), QLD 18, HS 490 (for biscuit quality), QLD 27, QLD 31 (for sedimentation value) have been crossed with well adapted genotypes. During **rabi** 2009-10, sixty two fresh crosses were attempted. In addition $27$ $F_1$ and $7$ $F_2$ were also evaluated and $6$ $F_3$ were retained for growing $F_3$ generation. Besides, $81$ single plant progenies of $21$ crosses were selected in $F_3$, 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 $66$ lines, $6$ lines were having >12.0% protein content and >40 ml sedimentation value and have been included in the All India Trials (Table 2.1.4).

**New Initiatives**

**Pre-breeding Activities**

This new initiative was taken with the major objective of tapping the newly available variability in the form of bulk, synthetic lines and other proven component lines. A total of 424 single plant progenies arising out of 85 crosses in $F_1$, $F_2$, generations were evaluated under artificial epiphytic condition out of which 383 single plant progenies from 68 crosses were selected for their further evaluation. Some promising stocks like VW 0648 (tillers/m=116), VL 913 (early maturity=116 days), VL 912 (spike length=14 cm), VW 0770 (tiller/m=95, grain weight=56), VL 71 and VL 697 (for bolder grain>40 g/1000 grains, number of spikelets 20 and number of grains >60/spike and seed weight/spike >2.5 g) have been identified through multi-location test by the Directorate of Wheat Research, Karnal from this programme.

**New Avenues for Yield Advancement: Winter x Spring Wheat Hybridization**

During 2009-10, thirty one winter and facultative wheat, selected for their high grain yield, tillering, ear length, grain number per ear and disease resistance were planted in a crossing block at the experimental farm, VPKAS (ICAR), Hauz Khas and crossed to spring wheats like PBW 582, PBW 485, VL 900, VL 895, VL 912, VL Gehun 892, HS 490, HS 492, UP 2742, UP 2711, HD 2937, MP 3223, DBW 28, Raj 4125, Raj 4124 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

**Table 2.1.4. Quality traits of different wheat genotypes**

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Protein (%)</th>
<th>Moisture (%)</th>
<th>Starch (%)</th>
<th>Wet gluten (%)</th>
<th>Sedimentation value (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VW 0908</td>
<td>13.4</td>
<td>9.8</td>
<td>63.0</td>
<td>30.9</td>
<td>42.9</td>
</tr>
<tr>
<td>VW 0939</td>
<td>15.1</td>
<td>9.8</td>
<td>63.1</td>
<td>37.9</td>
<td>53.9</td>
</tr>
<tr>
<td>VW 0943</td>
<td>14.7</td>
<td>10.0</td>
<td>63.9</td>
<td>37.0</td>
<td>52.2</td>
</tr>
<tr>
<td>VW 0924</td>
<td>14.4</td>
<td>9.7</td>
<td>63.1</td>
<td>35.4</td>
<td>50.1</td>
</tr>
<tr>
<td>VW 0930</td>
<td>12.6</td>
<td>10.4</td>
<td>64.9</td>
<td>38.8</td>
<td>44.9</td>
</tr>
<tr>
<td>VW 0937</td>
<td>13.9</td>
<td>9.8</td>
<td>65.1</td>
<td>34.3</td>
<td>53.7</td>
</tr>
</tbody>
</table>

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attempting crosses. In addition, three way cross were also attempted with the F₁ of the previous year by crossing them with selected spring wheat. A total of 60 crosses were successfully attempted during nabi 2009-10. In addition, 55 F₁’s made during last season were planted and 50 F₁’s retained for growing their F₂ generation during the coming season. A total of 55 F₁’s retained last year, were raised during nabi 2009-10. The high incidence of yellow and brown rust facilitated the selection. Only negative selection was practiced in these materials. Finally 43 F₂’s were bulked. These will be supplied for further distribution in the coming crop season to DWR Karnal. Twenty-five F₂ bulk were supplied during nabi 2009-10 to DWR, Karnal. These were further distributed to different coordinating and cooperating centers. During the last ten years a total of 430 bulks have been supplied. Some promising lines generated at DWR, Karnal, under this project are mentioned in the following Table 2.1.5.

The seed of F₁ bulks was shared with 6 cooperators through DWR, Karnal. The

Table 2.1.5. Salient features of promising materials in F₂ and F₁ generations

<table>
<thead>
<tr>
<th>Parentage (pedigree)</th>
<th>Salient features</th>
</tr>
</thead>
<tbody>
<tr>
<td>90Zhong65/UP2572</td>
<td>Late to medium-late maturity, high tillering and long spikes</td>
</tr>
<tr>
<td>HUW 548/MV 231-98</td>
<td>Medium late maturity, high tillering and long spikes</td>
</tr>
<tr>
<td>UP2572/Wiangang89025</td>
<td>Medium late maturity, high tillering and long spike</td>
</tr>
<tr>
<td>UP 2556/MV 231-98</td>
<td>Medium late to late in maturity, high tillering and good spike</td>
</tr>
</tbody>
</table>

utilization report from cooperating centers is given in Table 2.1.6.

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. Some crosses viz., three of F₁, five of F₂, six of F₃, seven of F₄ and three of F₅ generations were attempted including both winter as well as spring wheat parents for resistance against black rust Ug 99.

Genetic Resources - Evaluation and Maintenance

A total of 418 entries comprising of six national nurseries were evaluated. The entries having desirable attributes have been identified for use in the breeding programme. In National Genetic Stock nursery (NGSN), the entries were selected for rust resistance (4), high grains/spike (5), high tillers (8) and high grain weight (7). Thirty entries were selected from the Elite International Germplasm Nursery-1 (EIGN-1), which had long ears, high test weight, high tiller number, rust resistance and good agronomic base. From the Yield Component Screening Nursery (YCSN), 18, 8 and 4 entries were selected for 1000 grain weight, number of tillers/m and number of grains/ear, respectively. Twelve genotypes were selected from the Short Duration and Late Heat Tolerance Screening Nursery. Similarly, twenty entries having high protein, high protein yield, good

Table 2.1.6. Detail of utilization of crosses

<table>
<thead>
<tr>
<th>Name of centre</th>
<th>Crosses utilized</th>
<th>Utilization %</th>
<th>Characteristics for which utilized</th>
</tr>
</thead>
<tbody>
<tr>
<td>IARI, New Delhi</td>
<td>25</td>
<td>56</td>
<td>Yield components, morphological traits and disease resistance</td>
</tr>
<tr>
<td>NDUAT, Faizabad</td>
<td>44</td>
<td>98</td>
<td>Yield components, morphological traits, disease resistance &amp; seed characteristics</td>
</tr>
<tr>
<td>GARP/GAT, Pantnagar</td>
<td>12</td>
<td>27</td>
<td>Yield components, disease resistance &amp; seed characteristics</td>
</tr>
<tr>
<td>RAU, Jabalpur</td>
<td>24</td>
<td>53</td>
<td>Yield components, disease resistance &amp; seed characteristics</td>
</tr>
<tr>
<td>SDAU, Vijapur</td>
<td>21</td>
<td>47</td>
<td>Yield components, morphological traits and disease resistance</td>
</tr>
<tr>
<td>JNKV, ZARC Powarkheda</td>
<td>34</td>
<td>76</td>
<td>Yield components, morphological traits, disease resistance &amp; seed characteristics</td>
</tr>
</tbody>
</table>
chapati and biscuit quality were selected from Quality Component Screening Nursery (QCSN). Besides this, 19 local wheat germplasm (collected from Nainital district of Uttarakhand) were evaluated and deposited for long term storage.

**Off-season Nursery**

During kharif 2010, 20 F₁ generation of the breeding populations were grown at the off-season facility at Dalang Maidan, Lahaul Spiti, H.P. Three crosses were highly susceptible so rejected. Selections were made in rest of the generations. In addition, 203 advance lines were planted at Dalang Maidan, Lahaul Spiti, H.P. as well as IARI RS, Wellington, T.N. for screening against yellow and brown rust, respectively. Out of these, 97 lines having desirable rust reaction were selected and on over all basis 67 lines were selected. Seed multiplication of VL 948 was also done.

**2.1.3.2 Crop Protection Investigations**

**Evaluation for Disease Resistance**

One thousand and fifty eight lines/entries of wheat were evaluated under artificial/natural conditions in various nurseries namely, Elite Plant Pathological Screening Nursery (EPPSN), Hill Bunt Screening Nursery (HBSN), Loose Smut Screening Nursery (LSSN), Leaf Blight Screening Nursery (LBSN), Multiple Disease Screening Nursery, Powdery Mildew Screening Nursery (PMSN) and VL Rust Screening Nursery (VLRSN). Promising lines in each nursery were identified. Twenty wheat entries each of SAARC Wheat Disease Trap Nursery and Trap Plot Nursery (coordinated by DWR Regional Station, Flourdaide, Shimla) were planted to know the disease situation in resistant and susceptible cultivars and for monitoring the pathotypes prevalent in the region.

Wheat genotypes developed at VPKAS, Almora were evaluated at different centers in the country under AICRP through the Directorate of Wheat Research, Karnal. VL 900, VL 926, VL 930, VL 931, VL 934, VL 943, VL 944 and VL 946 had shown 0-10 ACI (average coefficient of infection) to rust diseases at various locations and were found promising. VL 925 was resistant to Karnal bunt whereas VL 914 to loose smut. In multi-location tests VL Gehen 738, VL 900 and VL Gehen 907 were categorized as resistant to leaf blight.

**2.1.3.3 Agronomic Investigations**

**Performance of New Wheat Genotypes at Different Dates of Sowing under Irrigated Conditions**

HS 507 and VL Gehen 907 were evaluated against three checks (viz. HS 240, VL 804 and TL 2942) at normal and late sowing in irrigated condition. VL Gehen 907 (4,860 kg/ha) only recorded significantly more grain yield than all checks. The normal sowing (4,800 kg/ha) recorded significantly higher grain yield than late sown condition (3,820 kg/ha). All genotypes recorded significantly higher grain yield in normal sown condition than late sown condition except HS 240.

**Performance of New Wheat Genotypes at Different Dates of Sowing under Restricted Irrigated Conditions**

Two new genotypes (HS 513 and VL 925) were evaluated against all checks (Sonalika, HS 295, HS 490, VL 804 and VL Gehen 892) in late and very late sown condition. None of the new genotype was able to out yield the best check HS 490 (3,250 kg/ha). Late condition (4,890 kg/ha) recorded significantly higher grain yield than very late condition (3,620 kg/ha). All genotypes recorded significantly higher grain yield in late sown condition than very late sown condition except Sonalika.

**Performance of New Wheat Genotypes at Different Nitrogen Levels under Rainfed Conditions**

HS 507 and VL Gehen 907 were evaluated against three checks (HS 240, VL 804 and TL 2942) with three nitrogen levels (40, 60 and 80 kg N/ha) in rainfed condition. VL Gehen 907 (3,160 kg/ha) only recorded significantly higher grain yield than all checks except VL 804 (3,070 kg/ha). The grain yield increased as the level of N increased from 40 kg (2,560 kg/ha) to 80 kg N/ha (3,210 kg/ha).
2.1.4. Small Millets and Under-utilized Crops

Small millets and other under-utilized crops are the traditional rained 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 219 thousand ha in North-Western Himalayas and their productivity is 775 kg/ha. These crops occupy a relatively larger area (204 thousand ha) in Uttarakhand with relatively higher productivity (1,333 kg/ha) as compared to Himachal Pradesh and Jammu & Kashmir. Development of short duration, high yielding varieties of millets having tolerance to diseases is the main activity.

2.1.4.1. Varietal Improvement

Eleven varietal trials comprised of five in finger millet, three in barnyard millet and one each in amaranth, buckwheat and rice bean were conducted in order to identify improved genotypes for North Western hill zone. In these trials, a total of 227 genotypes were assessed.

Finger millet

Adaptability Evaluation of Brown Grained Finger Millet Strains

One hundred forty one 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 351 (2,533 kg/ha), OEB 526 (2,474 kg/ha) and VL 347 (2,326 kg/ha) in AVT; PRM 9002 (3,570 kg/ha), VL 352 (3,353 kg/ha) and VL 353 (3,146 kg/ha) in IVT; VL 348 (2,247 kg/ha), VL 347 (2,198 kg/ha) and VL 357 (2,069 kg/ha) in SVT under organic cultivation and VR 472 (3,881 kg/ha), VR 465 (3,845 kg/ha), VR 479 (3,772 kg/ha) and VR 476 (3,757 kg/ha) in Station trial were found superior to the checks.

Adaptability Evaluation of White Grained Finger Millet Strains

Out of 36 white grained finger millet genotypes evaluated for yield and yield contributing characters, only 19 genotypes matured under Almora conditions. Coded entry WFM 32 recorded highest yield (3,211 kg/ha) followed by WFM 26 (2,852 kg/ha) and WFM 33 (2,807 kg/ha). Four white grain finger millet bulks were evaluated against check variety VL 324 in which VR 442 and VR 443 were found resistant to blast (finger and neck blast).

Development of New Strains

During kharif 2010, thirty five fresh crosses were attempted in finger millet involving high calcium genotypes GPHCPB 45, GE 86, blast resistant genotypes GPHCPB 52, PRM 701, VL 149, and agronomical superior genotypes HR 374, IE 4502, VL 351 and VL 347 as donors. In finger millet out of 9 crosses attempted during 2009, it is suspected that effective crosses were made in 8 crosses. In F₁ generation, twelve crosses were planted and 175 superior plants were selected, which showed better yield contributing characters and disease resistance. In F₂ generation, 80 progenies of 10 crosses were grown and 127 single plants were selected involving 7 crosses. In the F₃ generation, 24 progenies of 5 crosses were planted and 20 superior single plants were selected and 5 bulks were made. In F₄ generation, 114 progenies of 12 crosses were planted and 73 superior single plants were selected. Twenty six progenies showing uniformity and yield superiority were bulked. In F₅ generation, 5 early maturing progenies of white grained finger millet were bulked.

Utilization of Off-season Facility

To speed up the breeding cycles for the development of improved varieties in finger millet,
34 lines from crosses attempted at Almora along with parents were planted at the VC Farm, Mandya (UAS, Bengaluru) to select the true hybrids and for the advancement of generation.

**Barnyard Millet**

Forty-five genotypes were evaluated for yield and yield contributing characters in Barnyard millet Advance Varietal Trial (BAVT), State Varietal Trial (SVT) and Station Trial. VL 224 (3,778 kg/ha), PRB 901 (3,062 kg/ha) in BAVT whereas PRB 904 (1,570 kg/ha) in SVT, VB 497 (2,468 kg/ha), VB 494 (2,444 kg/ha), VB 499 (2,424 kg/ha) and VB 500 (2,420 kg/ha) in Station trial were found superior to the checks.

**Development of New Strains**

During *kharif* 2010, fifteen fresh crosses were attempted in barnyard millet involving race *stolonifera* *v*., B4, B5, B6, B7 and donor material *v*., GECH 506 (Grain smut resistant), ER 72, VL 137 (agronomically superior). In barnyard millet, only 12 crosses were effective out of 15 crosses attempted during 2009. In F$_2$ generation, 16 crosses were planted and 244 superior single plants were selected. In F$_2$ generation, 38 progenies of 7 crosses were planted and 109 superior single plants were selected. In F$_3$ generation, 44 progenies of 8 crosses were planted and selected those 28 single superior plants, which showed resistance to grain smut and 9 bulks were made. In F$_4$ generation, 7 families of 2 crosses were planted and 5 bulks were made. In the same generation 4 superior single plants were selected in a cross involving parent VL 199 x IEC 76.

**Germplasm Evaluation**

One hundred two accessions of barnyard millet were evaluated for six yield contributing characters. The range of variation was days to flowering (40-64 days); maturity (72-98 days); plant height (57-175 cm), finger length (1.8-6.6 cm), ear length (9-26.6 cm) and yield per plant (0.2-17.6 g). The range of variation in different agro-morphological characters of barnyard millet is depicted through box plots in Fig. 2.3. The box represents the mean ± 1 standard deviation (SD), with error bar of one standard deviation beyond the box. The name of the donors identified for yield per plant is mentioned against star mark.

![Fig. 2.3. Variation in different agro-morphological characters in barnyard millet](image)

**Underutilized Crops**

One trial each of amaranth and rice bean was conducted in which 31 genotypes were evaluated. None of the tested entries was found superior to the best check Durga (IC-35407) (2,006 kg/ha) and RBL 6 (1,356 kg/ha) in grain amaranth and rice bean, respectively.
Development of New Strains

Rice Bean: Eleven crosses were attempted involving determinate parents (PRR-2007-1, PRR-2007-2), bold seeded parent (ICM 104011) and local adaptive material VRB-1. Thirty three single plants were selected involving eight crosses in F_1 generation. Eighty six single plants were selected involving 6 crosses in the F_2 generation and 31 single plants were selected involving 3 crosses in F_3 generation.

Amaranth: Seven superior single plants were selected from a cross involving VL 44 and PLPI in F_1 generation. Four and one single plants were selected in crosses involving parents VL 44 x GA 2 and Annapurna x GA 2, respectively in F_2 generation. Fourteen single plants were selected in a cross involving parents IC 35407x PLP 1 in F_3 generation 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 42340, IC 42337 and IC 42334 recorded grain yield per plant > 18 g, while accessions IC 42991-4, and IC 42994-2 exhibited inflorescence length > 70cm.

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 promising accessions identified for various quantitative traits have been given in Table 2.1.7.

Table 2.1.7. Promising accessions identified in rice bean

<table>
<thead>
<tr>
<th>Traits name</th>
<th>Promising accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>50% flowering ≤ 70 days</td>
<td>LRB 448, LRB 495, LRB 325, LRB 478</td>
</tr>
<tr>
<td>Days to maturity ≤ 150 days</td>
<td>LRB 488, LRB 325</td>
</tr>
<tr>
<td>Plant height &lt; 110 cm</td>
<td>LRB 319, LRB 466</td>
</tr>
<tr>
<td>Pod length &gt; 10 cm</td>
<td>LRB 458, LRB 465, LRB 461, LRB 325, LRB 457, LRB 488, LRB 477</td>
</tr>
<tr>
<td>Seeds per pod ≥ 10</td>
<td>LRB 447, LRB 462, LRB 482, LRB 456, LRB 322, LRB 457, LRB 488, LRB 477, LRB 448</td>
</tr>
<tr>
<td>100 seed weight &gt; 8g</td>
<td>LRB 476, LRB 477, LRB 474, LRB 493</td>
</tr>
<tr>
<td>Yield per plant &gt; 24 g</td>
<td>LRB 490, LRB 449, LRB 496, LRB 457</td>
</tr>
</tbody>
</table>

Table 2.1.8. Promising entries identified under various nurseries

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nursery/Trial</th>
<th>Diseases</th>
<th>Promising lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finger Millet</td>
<td>Initial Varietal Trial</td>
<td>Leaf, neck and finger blast</td>
<td>VL 345, VL 352, VR 959, LRB 4, NRV 3 &amp; GN 5</td>
</tr>
<tr>
<td></td>
<td>Advanced Varietal Trial</td>
<td>Leaf, neck and finger blast</td>
<td>GPU-45, TNAU-1066, OEB-526 &amp; DM 7</td>
</tr>
<tr>
<td>Barnyard Millet</td>
<td>Advanced Varietal Trial</td>
<td>Grain Smut</td>
<td>TNAU-141, VL-223, PRB 904, PRB 903 &amp; RBM 2</td>
</tr>
<tr>
<td></td>
<td>VL Barnyard Millet Disease</td>
<td>Grain Smut</td>
<td>VLB 499</td>
</tr>
<tr>
<td></td>
<td>Screening Nursery</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.1.4.2. Crop Protection Investigations

Evaluation for Disease Resistance

In finger millet, a total of 118 entries were evaluated for resistance against leaf, neck and finger blast in coordinated and station nurseries. In barnyard millet, 35 entries were evaluated against grain smut. The promising lines identified in various nurseries are given in Table 2.1.8.

2.1.4.3. Agronomic Investigations

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

Two pre-released medium duration finger millet varieties (OEB 526 and PRM 6107) and one early maturing variety (VL 347) were evaluated to different levels of nitrogen (0, 20, 40 and 60 kg N/ha) under rainfed condition. Significant differences were found among varieties. OEB 526 (2,122 kg/ha) and VL 347 (1,470 kg/ha) recorded highest yield among medium duration and short duration groups, respectively. The highest yield of finger millet (1,879 & 1,279 kg/ha) in medium short duration was recorded at 40 and 60 kg N/ha, respectively.

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

Two promising pre-released varieties, viz., VL 221 and VL 222 were evaluated to different N levels (0, 20 and 40 kg N/ha). VL 172 (check) performed best (2,152 kg/ha) over all pre-released varieties and no significant differences were found due to various nitrogen levels.
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 64.1 thousand ha with an average productivity of 913 kg/ha (2008-09). Crop improvement work in barley is focused mainly on the development of high yielding and disease resistant varieties suitable for rainfed conditions.

2.1.5.1. Varietal Improvement

Variety Identified

VLB 94, a high yielding disease resistant variety has been identified for release under rainfed timely sown conditions of Uttarakhand state. It has an average yield potential of 1,841 kg/ha as compared to 1,266 kg/ha of the best check VLB 56 and has high degree of resistance to yellow rust and stripe diseases.

Adaptability Evaluation of Newly Developed Strains

To identify high yielding disease resistant genotypes, 70 new barley strains were evaluated in four different trials. In AVT timely sown rainfed trial, VLB 114 (2,837 kg/ha), VLB 118 (2,717 kg/ha), HBL 704 (2,707 kg/ha) and UPB 1011 (2,690 kg/ha) performed significantly better than the best check BHS 169 (2,543 kg/ha). Under the SVT (organic) timely sown rainfed trial, VLB 94 (4,232 kg/ha), VLB 107 (4,109 kg/ha), VLB 112 (3,855 kg/ha), PRB 801 (3,587 kg/ha) and VLB 110 (3,558 kg/ha) performed significantly superior than the best check PRB 502 (3,130 kg/ha). Out of 36 new bulks generated through institute breeding programme and evaluated in station trial under rainfed condition, six promising strains were nominated to the All India Coordinated Trials of Northern Hill Zone.

Development of New Strains

To develop high yielding disease resistant genotypes, 322 introduced materials were evaluated. Thirty high yielding disease resistant genotypes were selected for their further evaluation during the ensuing season.

VLB 94 – a high yielding disease resistant variety
Off-season Nursery

During kharif, 60 advance lines of the breeding populations were grown at the off-season facility at Dalang Mandan, Lahaul Spiti, Himachal Pradesh for screening against yellow rust. Out of these, 36 lines having desirable rust reaction were selected.

2.1.5.2. Crop Protection Investigations
Evaluation for Disease Resistance

One hundred and ninety nine barley entries of National Barley Disease Screening nursery (NBDSN) and Elite Barley Disease Screening nursery (EBDSN) from All India Coordinated Barley Net Work (DWR, Karnal) were evaluated during the year. On the basis of multi-location testing Vl barley entries VLB 114, VLB 120, VLB 121 were highly resistant to leaf and stem rusts whereas VLB 118, VLB 119, VLB 120, VLB 122 were resistant to only leaf rust. VLB 118 showed high resistance to powdery mildew also with a score of 1.0. In EBDSN, VLB 110, VLB 114 and VLB117 were highly resistant to leaf rust. VLB 117, VLB 118, VLB 119, VLB 121 and VLB 122 shown promise against stripe rust with low ACI ranging 0.6 to 2.9.

2.1.5.3. Agronomic Investigations
Performance of New Barley Genotypes to Nitrogen Levels for Higher Grain and Fodder Productivity under Rainfed Conditions in North West Himalayas

UPB 1008 was evaluated against three checks, viz., BHS 169, HBL 113 and BHS 352 with three nitrogen levels (20, 40 and 60 kg N/ha) in rainfed condition. UPB 1008 (2,370 kg/ha) failed to outyield the best check BHS 169 (2,640 kg/ha). The grain yield increased as the N level increased from 20 kg N/ha (1,980 kg/ha) to 60 kg N/ha (2,740 kg/ha).

Performance of Dual Purpose Barley Varieties in Northern Hill Zone

Three genotypes of barley i.e. BHS 169, HBL 276 and BHS 380 were evaluated for dual purpose in different irrigated condition. Irrigated and without cut condition provided the highest grain yield (3,020 kg/ha) followed by rainfed without cut (2,590 kg/ha), irrigated with cut (2,310 kg/ha) and rainfed with cut (1,910 kg/ha). Among the genotypes BHS 169 produced the highest grain yield (2,850 kg/ha) followed by BHS 380 (2,660 kg/ha) and HBL 276 (1,870 kg/ha).
2.1.6. Pulses and Oilseeds

Pulses and oilseeds are important rained crops for marginal lands. The total oilseed production in North-Western Himalaya is 80.6 thousand tones from an area of around 105 thousand hectares with an average productivity of 767 kg/ha as against national productivity of 1066 kg/ha (2008-09). The total pulse production in North-Western Himalaya is 76.7 thousand tones from the area of 125.6 thousand hectares and the average productivity of pulses is 611 kg/ha against the national productivity of 659 kg/ha (2008-09). 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

**Varieties Released**

**VL Masoor 514:** Bold seeded (100 seed weight 3.05 g) brown seed coat with minute spots and globose flat seeded variety developed from VL 501 x VL 103, was released by SVRC for timely sown rained conditions of hills of Uttarakhand, with an average yield of 1,000-1,200 kg/ha. It showed yield superiority of 16.04 and 11.19 per cent over the best checks VL Masoor 507 and PL 05 over three years of testing in Uttarakhand hills under the organic conditions. It has 21.13% protein content, and was found moderately resistant to wilt and rust diseases.

**VL Masoor 133:** A small seeded lentil variety release over VL Masoor 125 and 27.12% over PL 05 over three years of testing in Uttarakhand hills under organic conditions. 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 field pea variety with partly aphillous

**VL Masoor 133:** It is a high-yielding small seeded variety of lentil developed from the cross VL 103 x DPL 58, was released by SVRC for timely sown rained conditions of Uttarakhand hills. Its average yield potential is 1,200-1,600 kg/ha, i.e. 22.28%
leaves, developed from the cross JVP 14 x HFP 4 and has been released by SVRC for timely sown, rained areas of Uttarakhand hills. It showed yield superiority of 10.62, 13.36 and 24.85% per cent over the checks VL Matar 42, Pant 4 and IFPD 1-10, respectively over three years of testing in Uttarakhand hills under organic conditions. Its yield potential ranged from 1,100-2,000 kg/ha and it matures in 142-155 days. It has 21.04% protein content and was found resistant to powdery mildew and moderately resistant to rust diseases.

Varieties Identified

VL 516: VL 516 is a bold seeded with brown seed coat genotype developed from the cross ‘VL 501 x DPL 61’ is suitable for timely sown rained conditions of Uttarakhand hills. It has shown yield superiority of 20.98% over the best bold seeded check VL Masoor 507 and 21.87% over the PL 05 over three years (2007-08 to 2009-10) of testing under organic mode in the Uttarakhand hills. Its yield potential ranged from 1,200-1,400 kg/ha and it matures in about 154-160 days. VL 516 showed resistance to wilt and root rot.

VL 515: VL 515 is a bold seeded genotype, which was developed from the cross VL 501 x Schore 74-3, is suitable for timely sown rained conditions of Uttarakhand hills. VL 515 (1,260 kg/ha) has shown significant yield superiority of 31.52% over best check VL 507 and 32.49% over the PL 05 over three years (2007-08 to 2009-10) of period of testing under organic mode in Uttarakhand hills. Its yield potential ranged from 1,000-1,500 kg/ha and it matures in about 154-170 days. It was found moderately resistant to root rot and wilt diseases.

Evaluation for Varietal Adaptability

Six hundred and thirty-seven entries of eight crops, viz., lentil (244), field pea (90), toria (6), flax (7), soybean (163), horsegram (87), rajmash (20) groundnut (20) and pigeon pea (10) were evaluated for yield and other traits during rabi and kharif seasons. Efforts for development of new strains were made in lentil, field pea, soybean and horsegram.

Field Pea

Varietal Adaptability Evaluation

Eighty entries of field pea were tested in five trials along with suitable checks. The genotype VL 47 has shown significant yield superiority of 10.62% over VL Matar 42, 13.36% over Pant 4
and 24.85% over IPFD 1-10. VL 52 was promoted from IVT to AVT I (Dwarf) in Northern Hills. A total of 10 entries were short listed in advance and initial station trials. VP 2006-21 (1,533 kg/ha) and VP 2003-19 (1,415 kg/ha) were found superior in the advance station trial whereas VP 2009-4 (1,711 kg/ha) and VP 2009-18 (1,126 kg/ha) were found superior in the initial station trial.

**Development of New Strains**

Efforts were continued to develop more productive and disease resistant genotypes. Sixty-four fresh crosses were made involving eighteen selected parents. The parents were selected on the basis of yield and yield components and resistance to biotic and abiotic stresses. Seventy-two F₁ and sixty-seven F₂ crosses were advanced to next generation. 929 progenies were selected from F₁ to F₂ generations. Thirty-three bulk progenies selected for further testing in term of yield and other traits.

**Soybean**

**Varietal Adaptability Evaluation**

One hundred sixty-three entries of soybean were tested in seven trials along with suitable checks. Four entries viz., VLS 74, VLS 75, VLS 76 and VLS 77 are in different stages in coordinated trials. In AVT-I, VLS 74 (3,166 kg/ha) has shown significant yield superiority of 19.56% over best check VLS 63, 23.72% over VLS 59 and 35.29% over Bragg at Almora location. Amongst the various entries tested in the station trial (early), VS 2007-2 (2,983 kg/ha) and VS 2007-29 (2,874 kg/ha) were found to be the earliest in maturity (100 days). A total of 18 entries were short listed in the advance and initial station trials. VS 2008-1 (3,185 kg/ha) and VS 2005-37 (3,067 kg/ha) were found superior in the advance station trial whereas VS 2009-54 (3,630 kg/ha) and VS 2009-29 (3,333 kg/ha) were superior in the initial station trial. A total of 4 entries were selected in the advance station trial (bhat). VSB 2007-207 (2,047 kg/ha) and VRPH 1961 (2,026 kg/ha) were found superior over the check VL Bhat 65 (1,638 kg/ha).

**Development of New Strains**

Eighty-three fresh crosses were made involving twenty purposely selected parents. The parents were selected on the basis of yield and yield components like higher pod length, higher number of pods/plant, earliness, good market quality and resistance to **Cercospora** leaf spot. Seventy-seven F₁ and eighty-six F₂ crosses were advanced to the next generation. 1658 individual plants were selected from F₂ to F₃ generations. Seventy-four bulk progenies were selected for further testing in term of yield and other traits. Black soybean, popularly known as 'Bhat' was used in the crossing programme. Fifteen cross combinations were made involving 14 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**

Eighty-seven entries of horse gram were tested in five trials along with suitable checks. Two entries, viz., VLG 29 and VLG 30 are in co-ordinated programme. A total of 27 entries were short listed in the advance and initial station trials. Six entries were tested in state varietal trial under organic mode where none of the entries performed better than the best check VL Gahat 15 due to heavy rain.

**Development of New Strains**

Twenty-seven fresh crosses were made involving 10 purposely selected parents. The parents were selected on the basis of yield and yield components like higher pod length, higher number of pods/plant, earliness, good market quality and resistance against prevailing diseases. Sixty F₁ and 30 F₂ crosses were advanced to the next generation. Five hundred fifty individual plants were selected from F₂ to F₃ generations. Fifteen bulk progenies were selected for further testing.

**Evaluation of Germplasm**

A total of 91 horsegram germplasm were grown during kharif 2010 and data was recorded.
on 12 characters. Twenty promising accessions were selected which exhibited variation in seed size, plant height (45-80 cm), days to 50% flowering (40-75 days), days to maturity (110-130 days), number of pods per plant (14-55), pod length (4.5-5.2 cm), number of grains per pod (5-6) and 100-seed weight (2.5-3.5 g).

**Rajmash**

*Varietal Adaptability Evaluation*

Twenty entries of rajmash were tested in two trials along with suitable checks. Eight entries were tested in the state varietal trial under organic mode where no entry performed better than the best check VL Rajma 125. A total of two entries were short listed in initial station trial. One genotype, VRJ 125 (1,176 kg/ha) was proposed for AVT 1 for the CZ.

**Groundnut**

*Varietal Adaptability Evaluation*

Twenty entries of groundnut were tested in two trials along with suitable checks. Eight entries were tested in the state varietal trial under organic mode. Maximum yield was expressed by VLGN 9 (1,595 kg/ha) followed by VLGN 13 (1,580 kg/ha) as compared to the check VL Moongfali 1 (1,067 kg/ha). In advance station trial, 12 entries were evaluated. VGN 2007-4 (1,625 kg/ha) and VGN 2007-5 (1,457 kg/ha) were found to be superior over the check VL Moongfali 1 (948 kg/ha).

**Toria**

*Varietal Adaptability Evaluation*

Six entries were tested in the state varietal trial under organic mode. The entry VLT 8 (667 kg/ha) was considered for re-testing.

**Pigeon pea**

*Varietal Adaptability Evaluation*

Ten entries were evaluated in state varietal trial under organic mode. The entries VLA 10 (2,512 kg/ha) and VLA 11 (2,465 kg/ha) performed well.

**Flax**

*Varietal Adaptability Evaluation*

Seven entries of flax were evaluated. JRF 3 (335 kg/ha), JRF 2 (511 kg/ha) and JRF 1 (504 kg/ha) performed well.

**Sharing of Crop Genetic Resources**

During 2009-10, a total of 59 accessions of lentil (25), horsegram (12) and soybean/bhat (22) were shared with different scientists for utilization in different breeding programs.

**Evaluation and Maintenance of Genetic Resources**

Two thousand one hundred and ten accessions of different pulse and oilseed crops were maintained in the gene bank of the institute (Fig. 2.4).

![Fig. 2.4. Details of maintained germplasm of pulses and oilseed at the institute](image)

**Physiological Observations in Soybean and Bhat Genotypes**

An experiment was conducted during kharif 2010 with soybean and bhat genotypes to study the physiological traits contributing to the grain yield. Five soybean genotypes VLS 21, VLS 47, VLS 59, VLS 63, VRB-PS 1444 (brown soybean) and one bhat genotype V. Bhat 65 were sown in randomized block design. During the pod stage VLS 47 and VLS 63 possessed significantly higher total chlorophyll and carotenoid content while VRPH 1444 showed
the least chlorophyll and carotenoid contents (Fig. 2.5). VL Bhat 65 closely followed by VLS 47 showed significantly higher leaf relative water content while VRB-PS 1444 showed the least RWC (Fig. 2.6). Even though the bhat genotype possessed better green leaf area per plant, due to poor dry matter partitioning, they recorded less grain yield compared to the soybean genotypes. Improving the dry matter partitioning in bhat genotypes is expected to contribute towards increase in the grain yield.

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

The variations in physiological traits under normal and late sown (one month late) conditions was studied during 2009-10 with five lentil genotypes viz VL 125, VL 126, VL 133, VL 507 and VL 514. The experiment was laid out in factorial randomized block design. Late sown condition resulted in significant reduction in seed yield (23%) compared to that of normal sown condition (Fig. 2.7). Among the varieties VL 507 and VL 514 possessed better yield potential. Significant reduction of 10% in leaf relative water content (RWC), leaf area 45% (60 DAS) and flowers 45% (120 DAS) were obtained under late sown condition. Under the late sown condition, there was significant increase in the anthocyanin content, total chlorophyll content and total carotenoid content in all the varieties in general and VL 507 and VL 514 showed the highest values in all the observed physiological parameters which was reflected in better grain yield. Significant reduction of 6% in grain protein content was observed under late sown condition compared to normal sown and the low yielding VL 133 was found to possess higher protein content under late sown condition (Fig. 2.8).
2.1.6.2. Crop Protection Investigations

Evaluation for Disease Resistance

**Soybean**

In trap nursery trial for disease monitoring, mainly frogeye leaf spot, bacterial pustules and pod blight diseases were observed. Most of the entries were resistant or moderately resistant to frogeye leaf spot (*Cercospora sojina*). Severity of bacterial pustule and pod blight was low in all the entries. Twenty-four entries previously resistant to frogeye leaf spot, maintained resistance to this disease including VLS 47 and VLS 73. Amongst 42 entries of IVT evaluated, most of the entries were resistant to frogeye leaf spot. VLS 76 was highly resistant whereas VLS 77 resistant with the score of 3. In advance varietal trial, yield loss due to frogeye leaf spot varied between 2.44 to 29.48% in 13 entries tested. VLS74, VLS75 and MACS 1259 showed low yield losses and were grouped under resistant and high yielding category. VLS 2 though found susceptible, gave good yield and categorized as tolerant in Maximin-minimax analysis.

**Groundnut**

In groundnut, entries VLGN 9, VLGN 10, VLGN 13, VLGN 14, VLGN 15 and VLGN 2008-5 were found promising against tikka disease.

**Chickpea**

Thirty entries of International Chickpea Ascochyta Blight Nursery from ICRISAT, Hyderabad were screened under artificial inoculation conditions. Nineteen entries were found resistant (<3 rating) and moderately resistant (<5.0) to Ascochyta blight.

2.1.6.3. Agronomic Investigations

**Response of Lentil Varieties to Seed Rate**

Four lentil varieties, 2 each bold seeded (VL 507 and VL 516) and small seeded (VL 135 and VL 126) were evaluated with three different seed rates (30, 40 and 50 kg/ha) under field condition at Hawalbagh farm. Between bold seeded varieties VL 516 resulted significantly higher yield (1,330 kg/ha) than VL 507 (1,220 kg/ha) at 50 kg/ha. Similarly, between small seeded varieties VL 126 resulted higher yield (1,220 kg/ha) than VL 135 (960 kg/ha) at 40 kg/ha.

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

Four lentil varieties, 2 each bold seeded (VL 507 and VL 516) and small seeded (VL 135 and VL 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. The experiment revealed that between bold seeded varieties VL 507 resulted higher seed yield (1,780 kg/ha) than VL 516 (1,420 kg/ha) at 20:40:20 of N:P:K kg/ha. Similarly, between small seeded VL 126 resulted higher yield (1,340 kg/ha) than VL 135 (1,120 kg/ha) at 20:40:20 of N:P:K kg/ha.
2.1.7. Vegetables

Vegetable cultivation, particularly off-season and temperate ones are recognized as highly viable and money-spinning venture as compared to cereals, due to niche potentials of hills. The total area under vegetable production in N-W Hills is around 217 thousand ha with an average productivity of 15,493 kg/ha, which is below the national productivity of 16,200 kg/ha (NHB 2009). Development of high yielding varieties and hybrids specific to quality and market demands along with package of practices is an important area of research activity for the improvement of vegetable scenario of the North-Western Himalayas.

2.1.7.1. Varietal Improvement

Varietal adaptability evaluation was undertaken in six vegetable crops, viz., garden pea, onion, garlic, french bean, tomato and capsicum. A total of 210 genotypes were evaluated in 20 trials for yield performance against suitable checks to identify the high yielding and disease resistant genotypes/strains. Development of new strains with high marketable yield and nutritional quality including disease resistance was undertaken in garden pea, tomato, capsicum and French bean.

Varieties Released

**Vivek Matar 11 (VP 233):** Vivek Matar 11 is a garden pea cultivar released and notified for Uttarakhand hills and also identified for Agro-ecological Zone-1 (Uttarakhand, Himachal Pradesh and Jammu & Kashmir). The cultivar was developed by hybridization between Azad Pea 1 x PRS-18-6-4-5-1 through pedigree method. It is a medium maturity cultivar having attractive long green curved pods with high number of sweet and bold seeds per pod and highly resistant to powdery mildew. The average green pod yield is 10,000-11,000 kg/ha. It is suitable for cultivation under both organic and inorganic conditions.

**VL Tamatar 4:** VL Tamatar 4 is an open pollinated tomato cultivar released and notified for Uttarakhand. It is suitable for cultivation under both organic and inorganic conditions and also suitable for protected cultivation. Plants are indeterminate in growth, fruits medium, round, attractive red (T.S.S. - 5° Brix) with thick pericarp having longer storage life and suitable for distant market. Further this variety is moderately resistant to seeding rot, fruit rot and blight diseases. In hills, it yields 20,000-30,000 kg/ha (400-600 kg/200 m²) under open-field conditions and 55,000-65,000 kg/ha (1,100-1,300 kg/200 m²) under polyhouse conditions.

**VL Shimla Mirch 2:** This variety is an open pollinated capsicum cultivar released and notified for Uttarakhand. It is suitable for cultivation under both organic and inorganic conditions. Plants are...
Fruits of YL Shimla Mirch 2

straight, vigorous having bright dark green, medium, bell-shaped fruits which turn red on ripening. In hills, it yields 15,000-25,000 kg/ha (300-500 kg/200m²) under off-season cultivation.

**Garden Pea**

**Varietal Adaptability Evaluation**

Seven field trials were conducted to evaluate 64 strains against suitable checks to identify early and medium maturing, high yielding and disease resistant genotype. 08/ PMVAR/5 (10,556 kg/ha), VP 266 (8,730 kg/ha), VP 434 (11,667 kg/ha), SVTE 6 (12,200 kg/ha) and VP 434 (11,853 kg/ha) recorded maximum green pod yield in AVT-I (medium), AVT-II (early), AVT-II (PM), SVT, organic mode (early) and (medium) trials, respectively. In the garden pea station trial, genotypes VP 526 (12,100 kg/ha), VP 525 (11,800 kg/ha) and VP 625 (10,550 kg/ha) in medium maturing, whereas in pre varietal trial VP 907 (14,626 kg/ha) in early and VP 925 (14,440 kg/ha) in medium maturing were found promising.

**Development of New Strains**

Emphasis was given to develop early and medium duration genotypes with high green pod yield potential and resistance to powdery mildew. In this endeavour, 54 new F₁’s were made among selected parents to combine different agronomic traits like earliness, high green pod yield, high shelling percent, attractive pod color & shape and disease resistance etc. Better performing 49 F₁’s were advanced for the F₂ generation. Besides, selection was practiced in the segregating materials derived from 47 F₁’s, 61 F₂’s, 46 F₃’s, 20 F₄’s and 03 F₅’s crosses. Based on desirable traits, 1,116 progenies derived from 136 crosses advanced in F₁ to F₅ generations (40 F₁’s, 46 F₂’s & 20 F₃’s) were retained for further selection. Fourteen new bulbs were also made based on phenotypic uniformity.

**Onion**

**Varietal Adaptability Evaluation**

One AINRP trial on long day onion (IET) was conducted with 25 genotypes to evaluate their yield performance against two checks viz., VL Plaz 3 & Brown Spanish. AOLDREB0921 (60,280 kg/ha) recorded maximum bulb yield.

**Purification of Maintainer (B line) of VL Plaz 67 (F₁ Hybrid)**

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

**Garlic**

**Varietal Adaptability Evaluation**

Two AINRP trials on long day garlic (AVT-I & AVT-II) were conducted with 18 genotypes to evaluate their yield performance against three checks viz., VL Garlic 1, G 41 and G 282. BGLDRB 907 (16,666 kg/ha) in AVT-I and CGLDRB 909 (17,035 kg/ha) in AVT-II recorded maximum bulb yield with big cloves and flavor.

**French Bean**

**Varietal Adaptability Evaluation**

Coordinated, State varietal and Station trials were conducted with 26 genotypes to evaluate their
green pod yield performance against checks viz., Arka Anoop, Arka Komal, and Local in Coordinated trial; Contender and VL Bean 2 in State Varietal Trial and Arka Anoop, Contender and VL Bean 2 in Station Trial. 09FBBVAR-4 (6,100 kg/ha), VLFB 510 (9,903 kg/ha) and VLFB 512 (11,472 kg/ha) recorded maximum green pod yield in AVT-I (bush), SVT (organic mode) and Station Trials, respectively. In pre-varietal trial, none of the entries were found superior over checks viz., Arka Anoop (12,098 kg/ha) and VL Bean 2 (11,975 kg/ha).

Development of New Strains

With a view to develop high yielding bush genotype having stringless pod and resistance to angular leaf spot, root rot, anthracnose and rust, 7 new F1’s were developed using diverse parents. Selection was practiced in the segregating materials derived from 13 F1’s and 1 F2’s progenies. Based on desirable traits, 154 progenies derived from 19 crosses advanced in F1 to F1 generations (7 F1’s and 12 F2’s) were retained for further selection. Six new bulks were also made based on phenotypic uniformity for the ensuing season.

Tomato

Varietal Adaptability Evaluation

Eighteen genotypes were assessed in two trials (Coordinated and Station Trials) against checks to identify high yielding genotypes/hybrids. 09/ ToDHYB-7 (8,600 kg/ha) and VTG 28 x PAU 2371 (21,389 kg/ha), recorded highest fruit yield in AVT-I Det. Hybrid and station trials, respectively.

Development of New Strains

Emphasis was given to develop high yielding early F1 hybrids having market acceptability with regard to size and shape. Seventeen F1’s were made involving diverse parents with regard to yield and other desirable traits like earliness. Twenty seven progenies derived from 14 crosses were advanced to F2 to F4 generations and 7 F2, 5 F3 & 2 F4, were retained for further selection. Three new bulk were also made based on phenotypic uniformity for the ensuing crop season.

Capsicum

Development of New Strains

In capsicum, 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. Thirty F1 were developed involving diverse parents with regard to yield and other desirable traits to assess their yield potential in the next season for identification of productive hybrids.

Genetic Resources – Evaluation & Maintenance

Five hundred twenty four accessions of different vegetable crops are maintained in the ‘Gene Bank’ of the institute. The detail of these accessions has been given in Fig. 2.9.

2.1.7.2. Crop Protection Investigations

Evaluation for Disease Resistance

Garden pea

Out of 36 garden pea entries screened, Vivek Matar 11, VL 688, VL689 were found resistant against powdery mildew.

French Bean

Bacterial blight: Out of 50 French bean entries evaluated VLFB-4, 8, 12, 15, 38, 44, 48, 53, 71, 74, 80, 88, 89 and 91 were found promising against bacterial blight.
Angular leaf spot: Out of 50 French bean entries, VLFB-4, 6, 7, 8, 14, 12, 48, 53, 80 and 83 were found promising.

Rust: Out of 11 French bean entries evaluated for rust disease, VLFB-412, 512, 514 & 629 were found promising.

Root rot: Out of 61 entries screened, VLFB-16, 27, 32, 47, 48, 50, 53, 79, 80, 88, 415, 513 and 629 were found promising.

**Tomato**

Out of 6 tomato genotypes screened against bacterial wilt, VTG-28 showed high resistance under sick plot and pot culture studies.

2.1.7.3. Agronomic Investigations

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

Three garden pea varieties (VP 215, VP 434 and Vivek Matar 6) were evaluated with four different fertility levels (20:40:40, 20:60:40, 20:80:40 of N:P:K kg/ha and 20 t FYM/ha) under field condition. It was observed that VP 215 resulted in higher pod yield (14,000 kg/ha) than VP 434 (12,110 kg/ha) and Vivek Matar 6 (11,100 kg/ha) at 20:60:40 of N:P:K kg/ha.
2.1.8. Seed Production Programme

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

Production of breeder seed of hill crop varieties is the mandate of the institute. In addition, the institute also produces small quantities of truthfully labeled seed to meet out the demand of its own outreach programme and local farmers.

265.88 q of breeder seed of 46 released varieties/inbreds were produced during the period. This includes 17 varieties and 5 inbreds of cereals, 3 of finger millet, 1 of barnyard millet, 7 of pulses, 5 of oil seed crops, 1 of buck wheat, amaranth and

Table 2.1.9. Seed Production Rabi 2009-10 & supply during Rabi 2010-11

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Breeder Seed Production (q)</th>
<th>Supply (q)</th>
<th>TL Seed Production (q)</th>
<th>Supply (q)</th>
<th>Nucleus Seed Production (q)</th>
<th>Supply (q)</th>
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<td>178.40</td>
<td>36.35</td>
<td>36.98</td>
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7 of vegetables. A total of 235.13 q breeder seed was supplied during this period to different seed producing agencies to take up further multiplication. Around 20.83 q nucleus seed of 39 released varieties were also produced following standard methods to maintain the genetic purity.

In addition to this, around 64.87 q truthfully labeled seed of 12 cereals, 3 pulses, 2 oil seeds, 14 of vegetables, 3 of finger millet, 1 of barnyard millet, 1 of buckwheat and amaranth varieties were also produced to meet the demand of the institute extension activities. A total of 75.72 q TL seed has been supplied during the period (Table 2.1.9 and Table 2.1.10). Other than this quantity of seed production, seeds were also produced under different breeding programme and projects including HTMM 1.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Breeder Seed</th>
<th></th>
<th>TL Seed</th>
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<th>Nucleus Seed</th>
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<td>Production (q)</td>
<td>Supply (q)</td>
<td>Production (q)</td>
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Table 2.1.10: Seed Production kharif 2009 & supply during kharif 2010

Annual Report 2010 - 2011

41
### Crop Variety

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<th>Crop</th>
<th>Variety</th>
<th>Breeder Seed</th>
<th>TL Seed</th>
<th>Nucleus Seed</th>
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<tr>
<td>Tomato</td>
<td>VL. Tamatar 4</td>
<td>0</td>
<td>0</td>
<td>0.008</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>72.31</td>
<td>56.735</td>
<td>28.529</td>
</tr>
</tbody>
</table>

### Farmers’ Participatory Seed Production

A total of 26.0 q TL seed of wheat variety VL. Gehun 829 and VL. Gehun 892 was produced in farmers’ field. Besides, 11.0 kg TL seed of VL Masoor 4 was also produced (Table 2.1.11).

#### Table 2.1.11. Seed Production at farmers’ field

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Quantity (q)</th>
<th>Village</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>VL. Gehun 829</td>
<td>17.60</td>
<td>Kamola</td>
</tr>
<tr>
<td></td>
<td>VL. Gehun 892</td>
<td>8.40</td>
<td>Nag. Someshwar</td>
</tr>
<tr>
<td>Lentil</td>
<td>VL. Masoor 4</td>
<td>0.11</td>
<td>Kamola</td>
</tr>
</tbody>
</table>

### Organic Seed Production

During the period, the institute and its KVKs produced 1.95 q of organic seed of various hill crops. The detail of which is given in Table 2.1.12.

#### Table 2.1.12. Organic Seed Production

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Quantity (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kharif</td>
<td>Okra</td>
<td>6.35</td>
</tr>
<tr>
<td></td>
<td>Bean</td>
<td>13.00</td>
</tr>
<tr>
<td></td>
<td>Ugal</td>
<td>15.00</td>
</tr>
<tr>
<td></td>
<td>Ragi</td>
<td>9.75</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>44.10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Quantity (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rabi</td>
<td>Radish</td>
<td>4.50</td>
</tr>
<tr>
<td></td>
<td>Lentil</td>
<td>72.00</td>
</tr>
<tr>
<td></td>
<td>Wheat</td>
<td>60.00</td>
</tr>
<tr>
<td></td>
<td>Methi</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td>Dhaniya</td>
<td>3.70</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>151.20</td>
</tr>
<tr>
<td>Total Kharif &amp; Rabi</td>
<td></td>
<td>195.30</td>
</tr>
</tbody>
</table>
2.1.9. Molecular Approaches to Enhance Productivity and Quality in Hill Crops

Plant biotechnology research at VPKAS has all the components involving basic, strategic and applied research. We have contributed in all these areas in last few years. We released the first MAS product for QPM maize. Our other MAS products in maize (QPM) and rice (resistance against blast) are under multilocation evaluation. Besides, we are also working on transformation of maize and rice, allel mining in rice and maize, mapping of agronomically useful genes in rice, maize and wheat, MAS in wheat (yellow rust) and garden pea (powdery mildew).

2.1.9.1. QTL Mapping for the 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 (a-a-modifiers) play a very important role in determining the level of amino acid in the maize endosperm. Twenty five SSRs were found to be informative polymorphic markers among the 850 SSRs. This low polymorphism may be due to the fact that the two parental inbred lines are sister lines i.e., derived from same parent CM 145. Twenty three polymorphic markers were used for genotyping of individual plants of the F1,3 population (230 plants) raised at the Hawalbagh farm in kharif 2008. Phenotyping (estimation of tryptophan content) of F2:3 populations (50 individuals) were done using HPLC while the genotyping of the population is done using 100 polymorphic SSR markers. The fine mapping and analysis is under way.

2.1.9.2. 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 Pi 2 and Pi 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. Pi 2 and Pi 9 are the two proven resistance genes which have been mapped and site specific markers are available for both the genes. The donor used for Pi 2 was C101A51 and the donor for the Pi 9 was O. minuta derivative. Primers linked to both the genes were found to be polymorphic to the recipient parent VL Dhan 206. 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. The lines are available for mulitlocation evaluation.

Under another experiment, two rice cultivars were taken to induce blast resistance in them from different sources. The target genes for deployment were Pi 9, Pi 1 and Pi K0. Parental polymorphism between the recipient and donor parents was completed for all the three genes. The marker for Pi 9 is available right within the gene where as the marker for Pi 1 and Pi K0 are highly linked. A set of 300 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 of recipient-donor will be selected for the background selection. The PCR conditions for all the polymorphic markers have been standardized. The background selection will be conducted in the BC,F, generation.
Natural Resource Management for Sustainable Productivity

- Development of Integrated Farming System Modules for Different Farm Holdings [Drs. D. Mahanta, A.K. Srivastva (upto December 31), J.K. Bishit, B.M. Pandey, B.L. Mina & K.P. Singh (upto January 12)]

- Enhancing Productivity and Profitability of Major Hill Crops through Diversification and Reduction in Cost of Cultivation (Drs. M.D. Tuti, B.L. Mina, D. Mahanta, R. Bhattacharyya & B.M. Pandey)


- Design and Development of Small Tools and Farm Machineries for Hill Agriculture [Dr. K.P. Singh (upto Jan. 12), Dr. B.M. Pandey (w.e.f. Jan. 13) & Dr. Pratibha Joshi (w.e.f. August 28)]

- Wasteland Management with Special Reference to Production of Fodder and Fuel-wood [(Drs. J.K. Bishit, S.C. Pandey, P.K. Mishra, B.M. Pandey, R. Bhattacharyya & Mr. R.P. Yadav (w.e.f. September 18)]

- Management of Water Resources for Higher Use-Efficiencies in Crop Production (Drs. S.C. Pandey, B.L. Mina, R. Bhattacharyya & M.D. Tuti)
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 were carried out. These included tillage, water harvesting, intensive cropping, long term fertility management, IPNS, weed management, forage and grassland management, farm machinery and post harvest technology, application of plastics for sustainable production in hilly region.

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

**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 P/ha, poultry manure @ 17.5 kg P/ha (+ biofertilizers) and 34.9 kg P/ha, Vermicompost @ 17.5 kg P/ha (+ biofertilizers) and 34.9 kg 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 equivalent P/ha recorded significantly higher pod yield (6,880 kg/ha) compared to other treatments in the 7th year. In French bean, application of recommended NPK + FYM 10 t/ha produced more pod yield (15,760 kg/ha), which was at par with FYM @ 52.4 kg P/ha (14,880 kg/ha) and FYM @ 69.9 kg P/ha (14,840 kg/ha).

**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 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 namely, Khakal, Athadhar 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 Athadhar site was found most suitable.

**Table 2.2.1. Performance of different crops under different growing conditions**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield (kg/ha)</th>
<th>Kannigere</th>
<th>Athadhar</th>
<th>Khakal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>1,360</td>
<td>1,070</td>
<td>780</td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>1,370</td>
<td>1,270</td>
<td>1,380</td>
<td></td>
</tr>
<tr>
<td>Finger millet</td>
<td>650</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Lentil</td>
<td>340</td>
<td>940</td>
<td>340</td>
<td></td>
</tr>
<tr>
<td>Horse gram</td>
<td>31</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Toria</td>
<td>585</td>
<td>587</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Garden pea</td>
<td>-</td>
<td>1,380</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Okra</td>
<td>188</td>
<td>557</td>
<td>1,058</td>
<td></td>
</tr>
<tr>
<td>Capsicum</td>
<td>5,840</td>
<td>4,000</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Squash</td>
<td>-</td>
<td>4,060</td>
<td>1,790</td>
<td></td>
</tr>
<tr>
<td>Turmeric</td>
<td>-</td>
<td>2,200</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

**Performance of Silvi-pastoral System:** The performance of Hybrid Napier was higher in Khakal than other sites. The green forage yield of winter grasses and *Morus alba* were higher in Athadhar sites than others (Fig. 2.11).

![Fig. 2.11. Green forage yield of grasses under different sites](image-url)
Effect of Selected Management Practices and Land Use Systems on Soil Organic C Sequestration and Selected Soil Physical Properties

Mean (of eight terraces) plant available water capacity (PAWC) and mean weight diameter (MWD; determined by wet-sieving techniques) values of the plots under Khural Site were 11 and 13% higher compared with mean initial PAWC (2.75 cm/15 cm layer) and MWD (0.67 mm), respectively, after seven years of cultivation with improved management practices. Plots under long-term pecan nut based agri-horti system (wheat-soybean cropping under pecan nut trees) had about 48% higher total Soil Organic Carbon (SOC) stock than the plots under wheat-soybean system (26.13 Mg C ha⁻¹) in the 0-30 cm soil layer. Plots under long-term rainfed soybean-wheat (annually fertilized) and agro-forestry systems had about 28 and 29%, higher total SOC stock, respectively, than native grassland (that was continuously grazed and cut plots (42.85 Mg C ha⁻¹) in the 0-60 cm soil layer. Plots under irrigated colocasia based cropping system had about 12% larger total SOC stock than the plots under rice-wheat system (15.1 Mg C ha⁻¹) in the 0-15 cm soil layer.

Evaluation of New Pseudomonas Strains in Wheat-Soybean Cropping System

Pseudomonas fragii and PGERS 17 were evaluated individually and in combination with 75 and 50 per-cent of the recommended P against recommended P and control in wheat followed by soybean. Application of 75 per cent recommended P + P. fragii (4.210 kg/ha) produced 4.5 per-cent more grain yield of wheat than 100 per cent recommended P treated plot (4.030 kg/ha). However, in soybean inoculation of both P fragii and PGERS 17 with 75 per cent recommended P produced (3.080 kg/ha) 6.2 per-cent more grain yield than recommended P (2.900 kg/ha).

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

Three biofertilizers, viz. azotobacter, pseudomonas (PGERS 17), VAM (Glomus fasciculatum) inoculated individually and in combination with FYM 7.5 t/ha were evaluated against FYM 10 t/ha and 7.5 t/ha and control in fingermillet-lentil cropping system. Combination of three biofertilizers with FYM 7.5 t/ha produced (2.630 and 1.480 kg/ha in finger millet and lentil, respectively) more grain than FYM 10 t/ha (2.610 and 1.440 kg/ha in finger millet and lentil, respectively).

Performance of Wheat and Horse gram Variety in Organic and ICM (Integrated Crop Management) Modules

Two nutrient sources viz. organic (FYM 15 t/ha + biofertilizers and FYM 5 t/ha + biofertilizers for wheat and horse gram, respectively) and ICM (recommended NPK + FYM 5 t/ha and FYM 2.5 t/ha + recommended fertigation) treatments were evaluated in wheat and horse gram varieties. The data are given in Table 2.2.2.

Table 2.2.2. Effect of organic and ICM treatments on wheat and horse gram

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Grain Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wheat</td>
</tr>
<tr>
<td>Module</td>
<td></td>
</tr>
<tr>
<td>Organic</td>
<td>4,550</td>
</tr>
<tr>
<td>ICM</td>
<td>5,130</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>310</td>
</tr>
<tr>
<td>Variety</td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
</tr>
<tr>
<td>VL 802</td>
<td></td>
</tr>
<tr>
<td>VL 804</td>
<td></td>
</tr>
<tr>
<td>VL 829</td>
<td></td>
</tr>
<tr>
<td>VL 832</td>
<td></td>
</tr>
<tr>
<td>VL 892</td>
<td></td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td></td>
</tr>
<tr>
<td>Horse gram</td>
<td></td>
</tr>
<tr>
<td>VLG 8</td>
<td>4,190</td>
</tr>
<tr>
<td>VLG 10</td>
<td>4,520</td>
</tr>
<tr>
<td>VLG 15</td>
<td>5,200</td>
</tr>
<tr>
<td>VLG 19</td>
<td>4,450</td>
</tr>
<tr>
<td>VLG 21</td>
<td>5,830</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>310</td>
</tr>
</tbody>
</table>
NP for wheat and horse gram, respectively) in main plot and five different varieties in sub plot were taken for evaluation in split plot design. In wheat, ICM (5,130 kg/ha) produced significantly higher grain yield than organic (4,550 kg/ha). The variety VL 892 produced (5,830 kg/ha) significantly higher grain yield than rest varieties (Table 2.2.2). The interaction for nutrient source and variety was significant and VL 892 and VL 829 performed better in organic. But rest varieties performed in reverse trend. In horse gram, there was no significant difference between nutrient sources for grain yield. VLG 10 (140 kg/ha) produced significantly higher grain yield than rest varieties. The low yield of horse gram was due to heavy rainfall during flowering and early grain filling stage. VLG 15 and VLG 21 performed significantly better in organic (127 and 120 kg/ha in organic and ICM, respectively) than ICM (101 and 87 kg/ha in organic and ICM, respectively).

Evaluation of Barley Varieties in Organic Condition

Four entries (VLB 94, VLB 107, VLB 56 and VLB 85) of barley were evaluated with different levels of FYM (15, 20 and 25 t/ha). The grain yield increased as the FYM level increased from 15 t/ha (2,390 kg/ha) to 25 t/ha (3,230 kg/ha). Among the varieties, VLB 85 (3,530 kg/ha) produced significantly higher grain yield than other varieties followed by VLB 56 (2,900 kg/ha).

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 beneficial effect of integrated use of NPK and FYM was more pronounced and effective in enhancing the productivity of soybean and wheat. FYM incorporated in the soil before soybean crop had residual effect on the succeeding wheat crop, as evident from the grain yield. The mean yield of soybean and wheat under unfertilized control treatment suggest that the soil of our experimental field was capable of supporting yield of soybean and wheat to the tune of 0.31 and 0.57 t/ha, respectively, without any external application of nutrient inputs (Fig. 2.12). Imbalanced fertilization caused drastic reduction in yield. The grain yield reduced by 64.8, 48.8, 45.1, 38.3 and 6.2% in wheat and 90.4, 75.5, 83.2, 71.6 and 16.5% in soybean under control, N_{0}+P_{80}, N_{16}+K_{80}, N_{25}+P_{80}K_{80} and N_{35}+FYM, respectively, as compared to N_{40}+P_{80}K_{80}+FYM (wheat 1.62 t/ha and soybean 3.26 t/ha).

Fig. 2.12. Effect of long term fertility management on yield and weed density of soybean-wheat cropping system

Further, the weed distribution revealed that in control (without nutrient application) and without FYM treatments (N+P, N+K and N+P+K) the population of Cyperus rotundus was higher compared to Ageratina conyzoides and Oxalis latifolia (Fig. 2.12). However, in FYM applied plots (N+FYM and N+P+K+FYM), A. conyzoides population was more than O. latifolia and C. rotundus. It revealed that FYM application favoured the growth of A. conyzoides.
Short-term Conservation Tillage Effects on Soil Organic Carbon Pools in A Sandy Clay Loam Soil of the Indian Himalayas

Soil conservation and carbon sequestration are critical issues in rainfed farming of the Indian Himalayas. This study, conducted from 2003 to 2009 on a sandy clay loam soil (Typic Hapludult) near Almora evaluated the effect of seasonal tillage alterations [year-round conventional tillage (CT-CT), year-round no tillage (NT-NT), CT in the kharif season and NT in the rabi (CT-NT) and the reverse (NT-CT) of the latter treatment] on soil aggregation and soil organic carbon (SOC) pools. Results indicate that the plots under NT-NT, NT-CT and CT-NT had nearly 16, 12 and 10% higher total SOC concentration compared with CT-CT (12 g kg⁻¹) in the 0-5 cm soil layer. However, tillage had no impact on total SOC of the sub-surface (5-15 cm) soil layer. Although the labile pools of SOC were positively affected by conservation tillage practices (CT-NT; NT-NT and NT-CT), the recalcitrant pool was only influenced by the continuous NT in the 0-5 cm depth. Plots under NT-NT and one seasonal tillage (NT-CT and CT-NT) also had higher macroaggregates and macroaggregate-associated SOC after six years of study. Greater proportion of microaggregates within macroaggregates in the plots under NT-NT compared with CT-CT was observed. Thus, the adoption of continuous no tillage (NT-NT) is the best management option for improvement of soil C under a rainfed lentil-finger millet cropping system of the Indian Himalayas, as the management practice has the potential to improve soil aggregation and greater SOC stabilization.

Studies on Spring Sown Rajmash-Based Cropping System

In this study, seven rajmash-based crop rotations (rajmash-maize-toria, rajmash-soybean-toria, rajmash-finger millet-toria, rajmash-barnyard millet-toria, rajmash-June rice-toria, rajmash-french bean-toria, rajmash-amaranth-toria and rice-wheat) were undertaken to test the hypothesis that crop diversification with colocasia based crop combinations is more productive as well as remunerative than rice-wheat cropping system in hills of Uttarakhand. The result showed that rajmash equivalent yield (3,800 kg/ha) was highest in rajmash-frenchbean-toria cropping system followed by rajmash-maize-toria (2,940 kg/ha). Similarly, B:C ratio was the highest in rajmash-frenchbean-toria (0.77) cropping system followed by rajmash-maize-toria (0.70) cropping system (Fig. 2.13).

Evaluation of Multistory Colocasia (Taro or Gaderi) Based Cropping System

In this study, seven colocasia based crop rotations were undertaken to test the hypothesis that crop diversification with colocasia based crop combinations is more productive as well as remunerative than rice-wheat cropping system in mid-hills of North-West Himalaya (Table 2.2.3).
Table 2.2.3. System productivity (kg/ha) and economics of colocasia based cropping system in 2009-10

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Colocasia equivalent yield (kg/ha)</th>
<th>Cost of cultivation (Rs/ha)</th>
<th>Net returns (Rs/ha)</th>
<th>Net B:C ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>T&lt;sub&gt;1&lt;/sub&gt;</td>
<td>51,360</td>
<td>1,55,296</td>
<td>3,58,289</td>
<td>2.31</td>
</tr>
<tr>
<td>T&lt;sub&gt;2&lt;/sub&gt;</td>
<td>39,760</td>
<td>1,43,646</td>
<td>2,13,934</td>
<td>1.49</td>
</tr>
<tr>
<td>T&lt;sub&gt;3&lt;/sub&gt;</td>
<td>29,960</td>
<td>1,13,850</td>
<td>1,85,750</td>
<td>1.63</td>
</tr>
<tr>
<td>T&lt;sub&gt;4&lt;/sub&gt;</td>
<td>15,200</td>
<td>1,27,450</td>
<td>34,555</td>
<td>0.27</td>
</tr>
<tr>
<td>T&lt;sub&gt;5&lt;/sub&gt;</td>
<td>36,320</td>
<td>1,47,576</td>
<td>2,15,654</td>
<td>1.46</td>
</tr>
<tr>
<td>T&lt;sub&gt;6&lt;/sub&gt;</td>
<td>25,570</td>
<td>1,70,826</td>
<td>84,904</td>
<td>0.50</td>
</tr>
<tr>
<td>T&lt;sub&gt;7&lt;/sub&gt;</td>
<td>37,080</td>
<td>1,51,098</td>
<td>2,19,682</td>
<td>1.45</td>
</tr>
<tr>
<td>T&lt;sub&gt;8&lt;/sub&gt;</td>
<td>12,160</td>
<td>59,059</td>
<td>62,559</td>
<td>1.06</td>
</tr>
</tbody>
</table>


The highest colocasia equivalent yield (51,360 kg/ha), net returns (Rs. 3,58,289/ha) and net B:C ratio (2.31) was recorded in colocasia-onion-French bean cropping sequence. The next best result was recorded in colocasia-wheat-okra cropping sequence with net returns of Rs. 1,85,750/ha and net B:C ratio of 1.63.

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

Significantly higher grain yield was observed in all the treatments compared to that of conventional practice. Highest grain yield was obtained under seed priming + deep sowing + FYM packing (3,200 kg/ha) followed by deep sowing + FYM packing (2,930 kg/ha). The lowest yield was recorded in conventional practice (2,030 kg/ha). Similarly, the plant stand was also the highest in seed priming + deep sowing + FYM packing at 15 and 90 DAS with 32 and 24/m row, respectively (Fig. 2.14).

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

A four year average of rice-wheat crop rotation indicated that the grain yield (Fig. 2.15) of zero-till rice (3,480 kg/ha) and wheat (4,060 kg/ha) was higher than that of conventionally tilled rice.

*Fig. 2.14. Effect of seed priming, deep sowing and FYM packing on wheat under moisture stress condition*

*Fig. 2.15. Effect of different tillage, crop residue and sowing methods on yield of wheat and rice in rice-wheat cropping system*
(3,380 kg/ha) and wheat (4,000 kg/ha). Rice yield (3,480 kg/ha) was higher under 10 cm contrast to wheat (4,110 kg/ha) under 15 cm crop residue of previous crop. Similarly, higher rice yield (3,440 kg/ha) was recorded under bed sowing method than in normal sowing method (3,420 kg/ha). However, wheat performed better under normal sowing (4,110 kg/ha) than in bed sowing (3,960 kg/ha) (Fig. 2.15).

Screening of Suitable Finger Millet Variety for Contingent Crop Planning

Five finger millet varieties, viz., VL 146, VL 149, VL 315, VL 324 and PRM-2 were evaluated for 4 dates of sowing (5 July, 15 July, 25 July and 5 August) under rainfed condition for contingent crop planning incase of late onset of monsoon. Sowing on July 5 (3,382 kg/ha) gave the highest grain yield followed by July 25 (1,983 kg/ha), July 15 (1,932 kg/ha) and August 5 (926 kg/ha). VL 315, VL 146, VL 324 and VL 146 were found most suitable varieties for sowing on 5 July, 15 July, 25 July and 5 August, respectively.

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 Substitution for Single Super Phosphate to Supplement Phosphorus Requirement of Soybean-Wheat Cropping System

In soybean-wheat cropping system application of phosphorus through SSP resulted highest grain yield of wheat (5,473 kg/ha), which was comparable to treatment P enriched compost (5,256 kg/ha). However, significantly lower yield was observed under direct application of rock phosphate (4,686 kg/ha) and P enriched compost + SSP (4,986 kg/ha) as compared to SSP. Similarly, in soybean crop application of phosphorus through SSP resulted highest grain yield (3,028 kg/ha), which is comparable (Fig. 2.16) to treatments P enriched compost (2,925 kg/ha) and P enriched compost + SSP (3,006 kg/ha). However, significantly lower yield was observed under direct application of rock phosphate (2,659 kg/ha) as compared to SSP, P enriched compost and P enriched compost + SSP (Fig. 2.16).

Phosphorus Management in Soybean-Wheat Cropping System for Yield Maximization

An experiment on use of rock phosphate along with biofertilizers under soybean-wheat cropping system was conducted. Application of rock phosphate (150%) along with PSB and VAM resulted significantly higher grain yield of wheat (4,140 kg/ha) and soybean (3,080 kg/ha) as compared to 100 per cent P applied through rock phosphate alone (3,610 and 2,520 kg/ha, respectively) and which was comparable with recommended dose of P applied through SSP (4,050 and 3,060 kg/ha, respectively) and RP 125% along with PSB and VAM (4,000 and 2,930 kg/ha, respectively) treated plot. Inoculations of both phosphate solubilizing and mobilizing microorganism with different levels of rock phosphate resulted significantly higher grain yield than their corresponding level of rock phosphate in soybean-wheat cropping system.

Management of Magnesite Waste Deposited Soil through Integrated Nutrient Management

Three crops in rabi season (lentil, garden pea and wheat), four crops in kharif season (finger millet, rice, soybean and maize) were evaluated with four nutrient management (viz. control, FYM, NPK + lime and NPK+ FYM + lime) under magnesite waste deposited field.
Application of fertilizers and manure along with lime significantly increased wheat equivalent yield in _rabi_ and rice equivalent yield in _kharif_ season as compared to control plots (Fig. 2.17). Among the crops garden pea (5.260 kg/ha) and maize (3.480 kg/ha) contributed significantly higher wheat and rice equivalent yield in respective season.

**Utilization of Magnesite Waste in Hill Farming**

Magnesium is an important essential element in crop production. At the same time, India and Uttarakhand has considerable magnesite deposits (249 and 21 million tonnes, respectively). A magnesite processing factory is located in district Almora and there is a need to explore the economic utilization of magnesite waste, which contains 48% magnesium. Wheat, tobia 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 ha⁻¹) along with recommended dose of NPK. Application of magnesite waste along with recommended dose of NPK significantly increased yield of wheat, tobia and lentil upto 100 kg Mg ha⁻¹, which was at par with 75 kg Mg ha⁻¹ under pot culture study in _rabi_ season (Fig. 2.18). Among the crops, highest response to magnesite application was recorded in wheat (70% increase in grain yield) followed by tobia (54%) and lentil (31%). However, in _kharif_ season, application of magnesite waste along with recommended dose of NPK responded up to 75 kg Mg ha⁻¹ for rice and 100 kg Mg ha⁻¹ for soybean and finger millet. The response to magnesite application were 119, 70 and 41 per cent for rice, finger millet and soybean, respectively. Among the different crops cereals responded more to magnesite application than legumes.

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

**Response of Lentil Varieties to Rhizobium leguminosarum-PRI Inoculation**

Four lentil varieties (VL Masoor 103, VL Masoor 125, VL Masoor 126 and VL Masoor 507) were tested under field condition for the
Effect of Cold Tolerant Pseudomonads on Plant Growth of Wheat

Carrier based formulation of eight plant growth promoting Pseudomonads were tested under field condition on growth, nutrient uptake and yield of wheat variety VL 804. Single inoculation enhanced root dry matter (5.1-44.3%) while no significant difference was observed in shoot dry matter. Bacterization with cold tolerant strains significantly (P < 0.05) enhanced uptake of N (11.2 to 34.1% except PGRs4), P (5.5 to 87.7%), K (8.7 to 129.0%), Fe (1.3 to 2.9 fold except PGERs17), Na (10.4-55.2% except PGRs4), Zn (7.7 to 53.9% except PGRs4 & NPRs3) and significantly decrease Na / K ratio at 60 DAS as compared to nonbacterized control. Single inoculation of cold tolerant bacterial strains NARs9, PB Rs5, PP Rs23 and PGERs17 significantly enhanced grain yield by 19.2, 17.1, 16.0 and 13.5%, respectively, over un inoculated control (2.810 kg/ha) except PPRs4 (Fig.2.19) as well as enhanced grain nutrient content.

Effect of Phosphate Solubilizing Bacterial Strains on P Uptake of Lentil

Seven P solubilizing bacterial strains were evaluated for P uptake in lentil (VL Masoor 507) under pot condition. *Pseudomonas* sp. PB2RP, *Pseudomonas fragi* strain CS11RH1 and *P. fragi* strain CS11RH4 improved the number of seeds/plant by 10.5 and 8.6%, respectively over un inoculated control. *P. fragi* strain CS11RH1 and *P. ppa* strain NS12RH2(1) with rock phosphate inoculation improved the number of seeds/plant by 11.4 and 7.5%, respectively, over the application of rock phosphate alone. Bacterial inoculation alone enhanced P uptake of lentil plants in the range of 34.2 to 76.7%. Maximum P uptake was recorded by *Pseudomonas* sp. CS11RP1 (76.7%), *P. fragi* strain CS11RH1 (74.4%) and *P. torulassei* strain PC7RP(2) (51.1%), respectively, over un inoculated control. Rock phosphate application combined with bacterial inoculation improved P uptake of lentil plants by 26.5 to 55.1%. Maximum P uptake was recorded with the inoculation of *P. ppa*-NS12RH2(1) (55.1%) followed by *P. torulassei*-PC7RP(2) (47.8%) and *Pseudomonas* sp. CS11RP1 (46.5%) over the application of rock phosphate alone.

Evaluation of cold tolerant bacterial strains under field condition

Vishwananda, Pratapada, Krishna Amanvel, Santhu.
Isolation of Zinc (Zn) Solubilizing Bacteria and
Quantitative Zn Solubilization under in-vitro
Condition

Soils are naturally rich in zinc but availability of
zinc to plant is very less, therefore,
microorganisms that solubilize appreciable
amounts of zinc oxide can be effectively used as a
bioinoculant to supplement zinc for the crop
plants. Thirty bacterial isolates were screened for
their ability to solubilize insoluble zinc under in-
vitro condition. Twelve isolates were able to
solubilize zinc on a plate assay amended with zinc
oxide with different concentrations (viz., 0.25, 0.5,
0.75 and 1.00%) (Fig. 2.20). The Bunt and Rovira
medium was modified by addition of 1% methyl
red so that qualitative determination becomes easy
as the zone turns yellow to red (around the
colony). A broth assay was conducted by
inoculating bacterial isolates into the basal
medium supplemented with 0.1% zinc oxide at
three different temperatures (4, 15 and 28°C) under
shaking condition (120 rpm) for a week to confirm
the Zn solubilization. All the cultures showed a
shift in pH (neutral to acidic) after growth and
correspondingly increased the availability of zinc,
ranging from 189.0 to 581.9 mg/l after 7 days of
incubation.

2.2.5. Design and Development of Small
Tools and Farm Machineries for Hill
Agriculture

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

Self propelled seed-cum-ferti drill (weight =
65 kg) was developed with an engine of 5.5 HP
capacity. It is also suitable for organic farming as
well as zero tillage condition.

Development of Vermi-compost Strainer

A machine named, "Jaivik Khad Chhanna
Drum" was developed for sieving of prepared
vermi-compost for application. It consists of a
sieve drum, frame and handle. This machine
effectively separates the earthworms from vermi-
compost without any harm to them. The hand-
operated machine can easily strain 6 quintals
vermi-compost in 1 hour.

Study and Evaluation of Traditional vs
Improved Yoke on the Basis of Ergonomic
Parameters

In the Ploughing operation, load is born by
the draft animals on their shoulders and neck. This
causes galls on the neck of the bullock which
affects not only the efficiency of animal but also
causes inflammation of the skin and sub-cuts on
the neck due to constant friction caused by the
yoke. To increase the efficiency of bullock, 'Pant
Hill Yoke' evaluated on the ergonomic parameters,
to overcome the short comings of the traditional
yoke by having modified shape and reduction in
weight. Clinical examination revealed significant
decrease in physiological demand of bullocks after conducting two hours experiments. Significant decrease in Temperature (°F), Respiration rate (per minute), Pulse rate (per minute) and Heart rate (b/min) was observed.

*Comparative Study on Paddy Threshing Activity*

Traditionally, threshing is done manually. Paddy threshing not only demand considerable time and energy but also is sources of drudgery for rural women. Improvement and modifications in the existing tools, equipments, machinery and method of work has significant effect in minimizing in human strain and fatigue and increase farm productivity. In this respect, paddy threshing activity was evaluated on the basis of ergonomic parameters. We found significant difference in Heart rate, Blood pressure and Blood lactate concentration with paddy thresher over traditional method.

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

*Adaptability and Evaluation*

*Winter Season*

In winter Fescue grass, Hima-14 produced the highest green forage (15,209 kg/ha) followed by Hima-15.

*Rainy Season*

Under wasteland condition six entries of *Setaria* grass were evaluated. Out of these, entry S-20 produced significantly higher (68,742 kg/ha) green biomass than S-21 and S-92 and numerically higher dry biomass than the rest.

Different Hybrid Napier entries were tested and they produced green forage up to December. Six cuts were taken for green forage production. Entry NBO-8-7 gave significantly higher green forage (74,470 kg/ha) and dry fodder (15,050 kg/ha) yield than others.

*Evaluation of Cultivated Fodder*

*Oat*

Kent produced the significantly highest green fodder (2,974 kg/ha) than the rest except UFO-6-2.

*Cowpea*

In cowpea, entry AVTC-5 gave significantly higher green (36,453 kg/ha) and dry forage (5,718 kg/ha) than AVTC-5 (27,426 and 4,300 kg/ha, respectively) only.
Maize

In dual purpose maize (babycorn+fodder) entries/varieties from VPKAS were evaluated. Joanshar local (45,032 kg/ha) has produced the highest green forage followed by Vivek-27 (38,836 kg/ha). However, Vivek-27 produced significantly higher baby corn (1,885 kg/ha) than the rest.

Dual Purpose Wheat and Barley

Effect of Bacterial and Chemical Fertilization on the Dual Purpose Wheat

In hills during winter season availability of green forage is very less. Dual purpose wheat which gives grain and green forage during winter period can be a suitable option for this. To have maximum grain yield 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. Keeping this in mind wheat entries VL 829 and VL 934 were grown under different N fertilization with bacteria and its consortium i.e. C1=Un cut Normal N (120 kg N/ha), C2=Cut with additional 20 Kg N/ha after cut, C3=Cut+B1 (Azotobacter), C4=Cut+B2 (Pseudomonas PGERS-17) and C5=Cut+B1+B2. VL 829 and VL 934 produced same amount of green forage (6,770 kg/ha). However, VL 829 produced significantly higher grain yield (4,300 kg/ha) than VL 934. Green forage yield did not affect significantly with different fertilization (Fig.2.21). Though, application of consortia of two bacteria gave the highest green forage (7,200 kg/ha). Grain yield was significantly higher in no cut with normal N (4,430 kg/ha) than individual application of bacteria i.e. C2 and C3. Grain yield were non significant between cut and uncut with additional 20 kg N (C2) after cut.

Evaluation of Dual Purpose Barley Entries under Rainfed Mid Hill Condition

To find out the suitable dual purpose barley variety under rainfed situation, seventeen barley strains were evaluated for green fodder production along with grain production. Green fodder and grain yield of these strains affect significantly due to different cultivars. UPB-1011 gave the highest green forage (2,120 kg/ha) along with 1,465 kg/ha grain followed by BHS-392 (1,823 and 1,977 kg/ha, respectively). Due to dry season in this year during rabi grain yield was very less.

Fodder Production Potential of Grasses

Grassland Management

Fodder trees i.e. Quercus ilex, Grewia optiva, Morus alba, Bauhinia retusa and Melia azedarach along with four grasses viz., Setaria kazungula, Setaria noddi, Congo signal grass and Broad leaf Paspalum were tested under silvopastoral system. Green forage was obtained from forage trees during winter and from grasses during summer. Morus alba yielded (14,350 kg/ha) significantly higher green biomass than others. The lowest green biomass was harvested from Grewia optiva. During rainy season Setaria noddi produced the highest green forage (6,234 kg/ha) out of three cuts.

Intercropping of Grasses with Legume

In hill, framers do not apply inorganic fertilizer in grasses under waste land situation. To increase the yield of grasses, intercropping of grasses with legume can be a beneficial option. Keeping this in mind three grasses were grown with desmodium (legume) under 1:1 combination. Yield of grasses increased with the intercropping and the highest green forage (61,428 kg/ha) was obtained from intercropping of hy. napier with desmodium.
Establishment and Cutting Management in Fodder Trees

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

There is an acute shortage of green nutritious fodder during winter months affecting the productivity of the livestock especially in hilly areas. In hills only 10% area is irrigated which is used for cultivation of other crops. For growing trees we have to utilize the wastelands. This provides an opportunity to exploit such lands for production of forage and fuel to cater the ever-increasing demand. The establishment and survival of fodder trees on sloping and degraded lands is very poor due to poor land support. In this experiment two planting methods *i.e.* improved and traditional pit with different fertilization treatments *i.e.* Control (T1), Soil + FYM mix (T2), Soil + FYM lower part (T3), T2 + 25 Kg N/ha I year + 12.5 Kg N/ha II year + 12.5 Kg N/ha III (T4), T2 + Stone mulching (T5), T2 + grass mulching (T6) and T2 + Lower half part of pit is covered with black polythene (T7) were studied for the proper development of *Bauhinia retusa*. During initial year only growth observations were taken, now green forage was also recorded. During fifth year after planting, improved pit showed significantly higher plant height (136.64 cm) than traditional pit. Similarly, improved pit produced the significantly higher green biomass (5.41 kg/tree) than the traditional planting (Fig. 2.22).

*Cutting Management of Trees*

For the proper tree canopy management of eleven year old oak plantation, four lopping techniques were applied. The four lopping treatments were coppicing (whole tree is cut off close to the ground level), local (removal of leaves and tender twigs at random just above the bifurcation of 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 *Grevia opita* during initial years. Pollarding 2 m yielded the highest forage (13.467 kg/ha) followed by coppicing. Similar trend was recorded in case of fuel yield (Fig. 2.23).

*Agroforestry*

**Agri-horti System**

Presence of pecan nut tree in the field could not bring any significant reduction in the grain yield of soybean, maize, 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 crops, 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 5,900 to 4,600 kg/ha in different treatments.
**Silv-horti system**

Two varieties of turmeric (Pand Pitabh & Swarna) were grown under *Grewia optiva, Quercus leucotrichophora, Bauhinia variegata* and * Celtis australis*. The highest rhizome yield was obtained under *Q. leucotrichophora* (11.738 kg/ha) followed by *B. variegata* (Fig. 2.24). Pand Pitabh gave significantly higher yield (10.860 kg/ha) than Swarna.

![Fig. 2.24. Performance of turmeric varieties under different trees and open condition](image)

**Nutrient Management in Forage Based Cropping System**

Treatment combinations with total seven treatments consisted of 100% NPK through inorganic fertilizer and curtailed doses of cent per cent NPK doses substituted fully or partially through FYM or bio-fertilizer along with control were studied in Setaria – clover based cropping system in hills. The highest green (59,893 kg/ha) and dry (7,703 kg/ha) forage was recorded in bio fertilizer + 75% NPK. The same treatment had the highest resource use efficiency (52.25%) and net return of Rs. 42,526 kg/ha.

**Chemical Analysis**

Nutrient management was also studied in forage based cropping sequences. Total NPK uptake of the cropping sequence was also calculated. Nitrogen, phosphorus and potassium uptake (Fig. 2.25) varied significantly in different treatments. The highest NPK uptake was obtained from T6 (Bio fertilizer + 75% of NPK through inorganic fertilizer). However, the lowest NPK uptake was in control treatment. Crude protein yield (1,161 kg/ha) and crude fiber yield (2,466 kg/ha) of the sequence was highest from treatment T6.

![Fig. 2.25. Nutrient uptake of different treatments](image)

**2.2.7. Water Harvesting and Water Management for Higher Water Use Efficiencies in Crop Production**

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

The direct sown rice-wheat rotation was evaluated with limited irrigation under zero and conventional tillage. During the *rahi* crop season, 109 mm rainfall was received. The significant increase in yield was recorded with increasing level of irrigation. However, grain yields were at par in two irrigation applications (pre sowing + CR1) and one irrigation applied at pre sowing. Grain yield of wheat was higher (4,230 kg/ha) in zero tillage in comparison to conventional tillage (3,760 kg/ha), however, differences were at par with each other. The net returns and net returns per mm applied water were higher in zero tillage in comparison to conventional tillage. More profile moisture depletion was recorded in conventional tillage in comparison to zero tillage. Same trend was observed with regard to water expense efficiency (WEE) (Table 2.2.5).

In case of rice, higher yield (2,510 kg/ha) was recorded in zero tillage in comparison to conventional tillage (2,350 kg/ha), but differences were non-significant. The significantly higher yield (2,850 kg/ha) was obtained with four irrigations in comparison to lower level of irrigations (Table 2.2.6).
Table 2.2.5. Grain yield and water use of wheat under tillage and irrigation levels

<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>Net returns (00) Rs./ha</th>
<th>Net returns per mm applied water (Rs./ha)</th>
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<tbody>
<tr>
<td>Tillage</td>
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<tr>
<td>Zero</td>
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<td>NS</td>
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<td></td>
</tr>
<tr>
<td>Irrigation</td>
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<td></td>
</tr>
<tr>
<td>Pre</td>
<td>3,500</td>
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<td>50</td>
<td>238.7</td>
<td>14.7</td>
<td>15.6</td>
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<td>Pre+CRI</td>
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<td>287.8</td>
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<tr>
<td>Pre+CRI+Flowering+GF</td>
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<td>11.1</td>
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<td>NS</td>
<td>1.56</td>
<td>1.66</td>
<td>5.20</td>
<td>78.0</td>
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</table>

Total Rainfall = 109.0 mm, Effective rainfall = 94.0 mm

Table 2.2.6. Grain yield and water use of rice under tillage and irrigation levels

<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>Net returns (00) Rs./ha</th>
<th>Net returns per mm applied water (Rs./ha)</th>
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<td>Tillage</td>
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<td>Conventional</td>
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<td>NS</td>
<td>0.27</td>
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<td>0.39</td>
<td>3.23</td>
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</table>

Total Rainfall = 1161.5 mm, Effective rainfall = 643.3 mm

Soil Moisture and Nutrients Dynamics in Wheat-Soybean Rotation under Irrigated Conditions

Wheat was grown under fertilized condition and soybean was grown on residual fertility, barring one treatment wherein it was grown with recommended NPK. Application of recommended NPK+10 t FYM recorded highest wheat grain yield (4,790 kg/ha) followed by N+FYM (4,350 kg/ha). The lowest grain yield was obtained in control (1,580 kg/ha). The average profile moisture was higher in FYM consisting treatments in comparison to control and alone application of fertilizer. The WEE, gross returns and gross returns per mm applied water followed the trend of grain yield.
The grain yield of soybean was affected significantly due to the residual effect of fertilization. The highest grain yield (2,710 kg/ha) was recorded in NPK+FYM whereas lowest in control (1,760 kg/ha). The highest residual effect on soybean grain yield was recorded with NPK+FYM (2,710 kg/ha). The residual effect was in the order of NPK+FYM (950 kg/ha), N+FYM (730 kg/ha), NPK (610 kg/ha), FYM (580 kg/ha) and only N effect was negative (-230 kg/ha) over the control.

The residual effect of NPK+FYM was higher than direct effect of NPK+FYM (670 kg/ha). The values of WEE ranged from 1.7 to 2.6 kg/ha/mm. The gross returns and gross returns per mm-applied water followed the same trend. The values of WEE ranged from 1.4 to 2.6 kg/ha/mm. This year extremely low water use efficiency was recorded due to heavy rainfall in kharif. The gross returns, gross returns per mm water use and water use efficiency followed the trend of grain yield.

*Artificial Recharging Techniques for Hill Springs*

The main purpose of artificial spring recharge technology is to store excess surface runoff for later uses, make sure water availability during winter and post monsoon season. One of the springs located at VPKAS Hawalbagh farm was selected to revive because its discharge is greatly reduced due to heavy construction on its catchments. Therefore, recharging of ground water became zero. 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 annual discharge of spring was higher by 18.9, 68.8, 72.8, 64.6 and 141.9 per cent during 2006, 2007, 2008, 2009 and 2010, respectively, in comparison to annual discharge recorded during 2000 (before inception of the treatments). Although annual rainfall was below 39, 19.6, 25.8 and 26.7 per cent in 2006, 2007, 2008 and 2009, respectively, in comparison to year 2000, however, it was 14 % higher in 2010 in comparison to 2000 (Fig. 2.26).
Integrated Pest Management

- Development of Integrated Pest Management Modules for French Bean and Cauliflower (Drs. Chandrashekar C., S.K. Jain, J.C. Bhatt & Mr. A.R.N.S. Subbanna)


- 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. Jeevanand & P.K. Agrawal)
2.3. Integrated Pest Management

Crop protection activities have significant importance to reduce the crop yield losses by management of diseases and insect pests. Development of environmentally safe and integrated methods of management assumes importance in hill ecosystem. Thus, major thrusts have been on biological control with specific agents, organic amendments, enhanced varietal resistance and use of safer chemicals besides undertaking survey for identification of important diseases and insect pests of major hill crops.

2.3.1. Disease and Insect-Pest Scenario

Yellow rust of wheat appeared in low to moderate severity in the end of March. Wilt in pea and lentil, powdery mildew of pea and purple blotch in onion appeared in moderate intensities. Rice blast occurred in moderate to severe intensities during 2010 kharif season whereas brown spot was moderately severe. Turmeric leaf blight and maydis blight of maize appeared in moderate intensities. The incidence of zonate leaf spot (Gloeosporium zonale), recorded in 2008 for the first time in Uttarakhand, was increased. Tikka disease of groundnut, frogeye leaf spot of soybean, angular leaf spot and rust of French bean were observed in moderate to severe intensities.

Monitoring of insect pest incidence was done in fortnight intervals and pest calendar was made for VPKAS experimental farm, Hauzibagh (Fig. 2.27). White grubs continue to be the major pest causing significant yield reduction in upland rice, pulses and vegetables. Peak emergence of scarabaeids was observed in June-July, which recorded 95.7% of total beetle catches. Severe infestation of Helicoverpa armigera in chickpea and

![Pest Calendar of VPKAS Experimental Farm, Hauzibagh](image-url)

Fig. 2.27. Pest Calendar of VPKAS Experimental Farm, Hauzibagh

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plants dried up giving a scorched appearance in circular patches.

**Varietal Resistance to Rice Brown Plant Hopper, Nilaparvata lugens**

Severe infestation of brown plant hopper (BPH) was observed in some of the rice growing areas of Uttarakhand. Therefore, rice varieties developed and released by VPKAS were screened for the antixenosis, antibiosis and tolerance mechanism of resistance against the pest.

All the VL varieties were raised and BPH nymphs were introduced to infest the plant and screened through modified seed box screening technique. The varieties were then compared with TN1 (universal susceptible) and PTB 33 (universal resistant) for their reaction against BPH. Vivek Dhan 62 and VL Dhan 87 were found to be resistant in the modified seed box screening. Both the varieties also sustained the damage and took more days to wilt i.e. 28 days, when infested with the pest, which showed their tolerance to BPH damage. In honey dew experiment, Vivek Dhan 62 failed to show its resistance since it allowed a secretion of 8.5 mm² honey dew and it was also preferred by the pest. VL Dhan 87 allowed a secretion of only 2.1 mm² honey dew and also not preferred by the pest. No variety was found to possess antibiosis mechanism of resistance against rice brown plant hopper, Nilaparvata lugens.

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Score</th>
<th>Days to wilt</th>
<th>Honey dew</th>
<th>Nymphaal preference</th>
<th>Nymphaal duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>VL Dhan 61</td>
<td>9 (HS)</td>
<td>12</td>
<td>11.9</td>
<td>12.8</td>
<td>19</td>
</tr>
<tr>
<td>Vivek Dhan 62</td>
<td>3 (R)</td>
<td>28</td>
<td>8.5</td>
<td>13.2</td>
<td>20</td>
</tr>
<tr>
<td>VL Dhan 65</td>
<td>5 (MR)</td>
<td>21</td>
<td>9.6</td>
<td>13.0</td>
<td>20</td>
</tr>
<tr>
<td>VL Dhan 81</td>
<td>5 (MR)</td>
<td>22</td>
<td>9.9</td>
<td>11.2</td>
<td>19</td>
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<tr>
<td>Vivek Dhan 82</td>
<td>7 (S)</td>
<td>18</td>
<td>11.9</td>
<td>11.3</td>
<td>23</td>
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<tr>
<td>VL Dhan 85</td>
<td>5 (MR)</td>
<td>25</td>
<td>9.8</td>
<td>13.3</td>
<td>20</td>
</tr>
<tr>
<td>VL Dhan 86</td>
<td>7 (S)</td>
<td>26</td>
<td>7.7</td>
<td>8.0</td>
<td>20</td>
</tr>
<tr>
<td>VL Dhan 87</td>
<td>3 (R)</td>
<td>28</td>
<td>2.1</td>
<td>4.8</td>
<td>21</td>
</tr>
<tr>
<td>Vivek Dhan 154</td>
<td>7 (S)</td>
<td>22</td>
<td>8.0</td>
<td>6.0</td>
<td>23</td>
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<tr>
<td>VL Dhan 206</td>
<td>9 (HS)</td>
<td>12</td>
<td>16.3</td>
<td>4.8</td>
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<tr>
<td>VL Dhan 207</td>
<td>9 (HS)</td>
<td>8</td>
<td>19.8</td>
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<td>22</td>
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<tr>
<td>VL Dhan 208</td>
<td>9 (HS)</td>
<td>10</td>
<td>10.5</td>
<td>10.2</td>
<td>20</td>
</tr>
<tr>
<td>VL Dhan 209</td>
<td>9 (HS)</td>
<td>16</td>
<td>15.0</td>
<td>4.7</td>
<td>21</td>
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<tr>
<td>VL Dhan 221</td>
<td>9 (HS)</td>
<td>14</td>
<td>8.1</td>
<td>11.3</td>
<td>21</td>
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<tr>
<td>TN 1</td>
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<td>22</td>
<td>7.8</td>
<td>14.2</td>
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</tr>
<tr>
<td>PTB 33</td>
<td>3 (R)</td>
<td>33</td>
<td>0.8</td>
<td>2.3</td>
<td>28</td>
</tr>
</tbody>
</table>
BPH, which is revealed by short time taken for the nymphs to develop into adults (Table 2.3.1).

**Monitoring of Virulence of Rice Blast Pathogen Pyricularia grisea**

Monitoring of virulence pattern of *Pyricularia grisea* was conducted in a nursery comprising of 27 entries in the field at the experimental farm, Hawailbagh, BL 245, Reminad Str. 3, Taducan and Teep were highly resistant. A 57, BL 122, C 101A51, IR 64, *Oryza minuta* and RIL 29 showed moderately resistant reaction (4-5 score).

**Field Evaluation of IPM and Non-IPM Modules for Rice Cultivation**

A trial consisting of IPM components and corresponding non-IPM/farmers practices was undertaken at Raulshen village (Almora) under irrigated transplanted conditions to evaluate the effect of IPM practices in rice production as a collaborative programme with NCIPM, New Delhi. The IPM components were applied on varieties Pant Dhan 12, Taichung, Thapachini and a Local variety. The IPM interventions consisted of balanced fertilizer application, collection and destruction of egg masses/infested plant parts, seedling root dip with chloropyriphos @ 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 borer and leaf folder at early stages itself. Among the varieties tested, the improved variety, Pant Dhan 12 showed less incidence of pest and diseases in comparison to Taichung, Thapachini and local variety grown by the farmers in the area (Table 2.3.2). Data of non-IPM fields showed that these varieties are quite susceptible to diseases and insects. The maximum yield gain of 700 kg/ha was observed in variety Thapachini when IPM treatments were followed. Other cultivars showed yield gain of 500 to 600 kg/ha when IPM technologies were applied.

**Comparison of Helicoverpa armigera Moth Catches in Light and Pheromone Traps**

A comparison was made on the trapping efficiency of light and pheromone traps on *Helicoverpa armigera* moths. Since pheromone trap attracts 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.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Pest status</th>
<th>Leaf blast (%)</th>
<th>Neck blast (%)</th>
<th>Brown spot (%)</th>
<th>Stem borer (no./m²)</th>
<th>Leaf folder (no./m²)</th>
<th>Grain yield (kg/ha)</th>
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</thead>
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<td><strong>IPM</strong></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Taichung</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>1.2</td>
<td>0.5</td>
<td>3,200</td>
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<tr>
<td>Thapachini</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3,500</td>
<td></td>
</tr>
<tr>
<td>Pant Dhan 12</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>3,600</td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>2,500</td>
<td></td>
</tr>
<tr>
<td><strong>Non-IPM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taichung</td>
<td>12</td>
<td>30</td>
<td>25</td>
<td>5</td>
<td>2</td>
<td>2,600</td>
<td></td>
</tr>
<tr>
<td>Thapachini</td>
<td>15</td>
<td>35</td>
<td>30</td>
<td>5</td>
<td>1</td>
<td>2,800</td>
<td></td>
</tr>
<tr>
<td>Pant Dhan 12</td>
<td>10</td>
<td>25</td>
<td>20</td>
<td>4</td>
<td>2</td>
<td>3,000</td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>20</td>
<td>35</td>
<td>30</td>
<td>5</td>
<td>2</td>
<td>2,000</td>
<td></td>
</tr>
</tbody>
</table>
Fig. 2.28. Comparison of light and pheromone trap catches of *H. armigera*

(Fig. 2.28). *H. armigera* catch increased progressively from II week of March and peaked by III week of April and became zero by II week of May onwards in both light and pheromone traps.

**Evaluation of Insecticides against Soybean Leaf Beetle, Platyptyra hystricis and Sucking Bug, Chauliopsis choprai**

A laboratory bioassay was made to find the efficacy of insecticides to leaf beetle (*Platyptyra hystricis*) and sucking bug (*Chauliopsis choprai*) using leaf dip method. Different concentrations were prepared; soybean leaves were dipped in it for 30 sec. and given as feed to the insect. Mortality of insect was recorded at 48 hours after treatment and corrected for its control mortality if any, using Abbott’s correction. Median lethal concentrations (LC$_{50}$) and LC$_{90}$ were obtained for each insecticide. Spinosad was found effective against *Platyptyra hystricis* with a relative efficiency of 107.14 followed by cartap hydrochloride. Deltamethrin and indoxacarb followed by dinofeturon and cartap hydrochloride were effective against *Chauliopsis choprai* (Table 2.3.3).

A comparison of field recommended doses with the LC$_{50}$ of insecticides to soybean pests is given in Fig. 2.29, which revealed spinosad as effective against leaf beetle and indoxacarb against sucking bug of soybean.

**Age Specific Susceptibility of Cut Worm (Spodoptera litura) and Bihar Hairy Caterpillar (Spilosoma obliqua) Larvae to Insecticides**

Studies were undertaken to evaluate the age specific susceptibility of *Spodoptera litura* and *Spilosoma obliqua* to different insecticides to find out an effective insecticide against the pests at its older instars. Median lethal concentrations of insecticides tested *i.e.*, indoxacarb, profenophos, spinosad and chlorpyrifos were determined for every stage of the larva. The susceptibility of the larva is found to decrease at every successive stage of the pests (Fig. 2.30).

The median lethal

<table>
<thead>
<tr>
<th>Insecticides</th>
<th><em>Platyptyra hystricis</em></th>
<th>Relative Efficiency</th>
<th><em>Chauliopsis choprai</em></th>
<th>Relative Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiamethoxam</td>
<td>4.89</td>
<td>10.22</td>
<td>1.95</td>
<td>25.64</td>
</tr>
<tr>
<td>Dinofeturon</td>
<td>22.22</td>
<td>3.60</td>
<td>0.78</td>
<td>102.36</td>
</tr>
<tr>
<td>Cartap hydrochloride</td>
<td>14.31</td>
<td>34.94</td>
<td>5.65</td>
<td>88.49</td>
</tr>
<tr>
<td>Malathion</td>
<td>57.93</td>
<td>12.26</td>
<td>39.26</td>
<td>25.30</td>
</tr>
<tr>
<td>Deltamethrin</td>
<td>2.35</td>
<td>12.88</td>
<td>0.14</td>
<td>214.29</td>
</tr>
<tr>
<td>Spinosad</td>
<td>1.40</td>
<td>187.14</td>
<td>10.79</td>
<td>13.90</td>
</tr>
<tr>
<td>Indoxacarb</td>
<td>31.42</td>
<td>9.77</td>
<td>1.20</td>
<td>151.20</td>
</tr>
</tbody>
</table>

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*Vishwaande Pareek, Kruti, Amansha Sainthia*
concentrations of indoxacarb to first instar larva of *S. littura* was 1.22 mg a.i./l and it was 2.88 mg a.i./l for sixth instar larva, which shows a less/no development of resistance with respect to the larval growth. But sixth instar larva was found resistant to other insecticides tested viz., spinosad chlorpyrifos and profenophos. The resistance ratio of first and sixth instar larva of *S. littura* was found to be only 2.5 whereas it was 10191 for spinosad (Table 2.3.4). Hence, indoxacarb can be used for the management of even later instars of *S. littura* where the other insecticides failed.

The tolerane ratio of sixth instar larva of *S. obliqua* with respect to its first instar was found to be 40.1, 129.5, 317.3 and 457.9 for indoxacarb, profenophos, chlorpyrifos and spinosad, respectively (Table 2.3.4). This shows that the later instar caterpillars develop resistance more to spinosad followed by chlorpyrifos and profenophos and the least to indoxacarb. So indoxacarb can be used for the management of later instar larva of *S. obliqua* and spinosad should not be recommended.

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

**Evaluation of New Fungicides against Foliar Diseases in French Bean**

Six fungicides were tested against foliar diseases of French bean namely, rust and angular leaf spot. All the fungicides significantly reduced both the diseases. Azoxystrobin @ 0.1% and Difenconazole @ 0.025% were found most effective against rust followed by Propiconazole and Tebuconazole whereas these four fungicides were found very effective against angular leaf spot (Table 2.3.5).

**Effect of Bio-products on the Foliar Diseases of French Bean**

Efficacy of 14 bio-products applied as foliar sprays on rust and angular leaf spot of French bean was tested along with fungicidal control and untreated control. Mancozeb (0.3%) recorded lowest severity of rust and angular leaf spot.

### Table 2.3.4. Resistance ratio of instars of *S. littura* and *S. obliqua* to insecticides

<table>
<thead>
<tr>
<th>Insecticides</th>
<th>Resistance ratio of 1st and 5th instar larva</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Spodoptera littura</em></td>
<td><em>Spilota obliqua</em></td>
</tr>
<tr>
<td>Spinosad</td>
<td>10191.0</td>
</tr>
<tr>
<td>Indoxacarb</td>
<td>2.5</td>
</tr>
<tr>
<td>Profenophos</td>
<td>1325.7</td>
</tr>
<tr>
<td>Chlorpyrifos</td>
<td>640.8</td>
</tr>
</tbody>
</table>

### Table 2.3.5. Evaluation of fungicides against foliar diseases of French bean

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Rust (%)</th>
<th>Angular leaf spot (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azoxystrobin (Amistar 25 SC) @ 0.1%</td>
<td>4.3 (11.9)</td>
<td>4.2 (11.8)</td>
</tr>
<tr>
<td>Difenconazole (Score 25 EC) @ 0.025%</td>
<td>6.9 (14.1)</td>
<td>4.1 (11.7)</td>
</tr>
<tr>
<td>Propiconazole (Tilt 25 EC) @ 0.05%</td>
<td>10.7 (20.5)</td>
<td>5.6 (13.6)</td>
</tr>
<tr>
<td>Tebuconazole (Folitric 250 SC) @ 0.05%</td>
<td>15.7 (23.2)</td>
<td>6.4 (14.7)</td>
</tr>
<tr>
<td>Chlorothalonil (Kwach 75 WP) @ 0.2%</td>
<td>24.7 (29.7)</td>
<td>18.2 (25.2)</td>
</tr>
<tr>
<td>Mancozeb (Indoff M45) @ 0.25%</td>
<td>23.3 (28.8)</td>
<td>29.8 (33.1)</td>
</tr>
<tr>
<td>Untreated control</td>
<td>45.0 (42.1)</td>
<td>67.0 (54.7)</td>
</tr>
<tr>
<td>CD (P = 0.05)</td>
<td>3.56</td>
<td>2.39</td>
</tr>
</tbody>
</table>
Among the bioproducts, cow dung extract @ 50% and cow urine @ 50% were found most effective in minimizing the rust disease whereas Panchagavya @ 3%, cow dung extract @ 50% and Azadirachtin 0.03% @ 0.2% were the most effective in reducing the angular leaf spot. The maximum yield increase over control was observed in mancozeb treated plot followed by cow dung extract and cow urine treatments.

**Effect of Organic Amendments on the Incidence of Root Rot of French Bean**

In a field experiment, sixteen organic products incorporated in soil one month before sowing were evaluated against root rot of French bean. A reduction of >78% in root rot incidence was observed in Parthenium hysterophorus @ 20 t/h incorporation followed by Lantana @ 20 t/h and Uricia @ 10 t/h. Application of Parthenium recorded maximum yield of green pods followed by Lantana.

**Evaluation of Local Trichoderma harzianum Isolates for the Management of Root Rot of French Bean**

Seven *Trichoderma harzianum* isolates, applied as seed treatment, soil drenching and in fortified FYM, were evaluated against root rot of French bean. A reduction of >37.3% in root rot incidence was observed in T-11 isolate followed by T-28, T-18 and T-45 isolates (Fig.2.31).

![Fig. 2.31. Effect of *Trichoderma harzianum* isolates on Root Rot of French bean](image)

**Evaluation of Pest Management Options in French Bean and Cauliflower**

In a field trial, botanical (Barain seed kernel extract, BSKE @ 10%) alone, in combination with bio-pesticide (Bt @ 1kg/ha) along with an insecticide (cartap hydrochloride @ 2g/l) were tested against the pest complex of French bean. The experiment revealed that cartap hydrochloride was effective in reducing the population of sucking bug to a tune of 82% followed by BSKE (75%).

Similarly, in a field trial to evaluate different pest management options against insect pest complex of cauliflower, BSKE @ 10% gave significant reduction (89.4%) in the population of aphid, *Brevicoryne brassicae*.

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

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

In a pot culture studies 12 *Pseudomonas* isolates viz., PF-3, PF-30, PF-96, PF-131, PF-149, PF-151, PF-160, PF-163, PF-5, PF-11, PF-17 were evaluated against bacterial wilt of tomato. Among the isolates tested, least wilt incidence (13.3%) was found in PF3, PF11, PF17 and PF151 isolate treatments. All other isolates also gave significant reduction in the bacterial wilt incidence.

Eight organic substrates/composts incorporated in pot soil were tested for their efficacy against bacterial wilt in tomato along with chemical and untreated control. A reduction of >91% in bacterial wilt was observed in copper oxychloride + Streptocycline treatment followed by mustard straw residue (82%), mustard cake (73%) and Neem cake (64%) (Fig. 2.32).

![Fig. 2.32. Effect of organic substrates on bacterial wilt incidence in tomato](image)
Effect of Different Substrates and their Combinations on Yield of Dhingri Mushroom Species

Different substrates and their combinations viz., Wheat straw + Brassica straw, Wheat straw + Lentil straw, Wheat straw alone and Brassica straw alone were used for growing two dhingri mushroom species viz., Pleurotus florida and P. fessulatus. All the substrates and their combinations tested, produced almost equivalent yield of both the mushroom species. Thus, lentil and Brassica straw can also be used in combinations with wheat straw for dhingri mushroom production.

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 17,965 beetles comprising of 18 different species were trapped using eleven light traps (VI. White Grub Beetle Trap-1) installed in VFKAS farm, Havalbhag. The total trap catches comprised of 58.4% of Anomala dimidiata, revealing it as the most predominant species of the region. The other species viz., Aphodius sp., Lepidota sigma, Meladera sp., Xylotrupes gideon and Anomala sp. were 7.1, 4.9, 4.7, 4.7 and 3.2% of the total catches.

Studies on Kairomonal Attraction of Scarabaeid Beetles

Traps loaded with Anisole were tested for monitoring the emergence and intensity of the beetles of Holotrichia seticollis. The emergence of the beetles was started in the second week of May and continued up to 3rd week of August with different peaks. However, peak emergence was noted from 4th week of May to 4th week of June with a trap catch range of 12.4 to 14.5 beetles/trap/day (Fig.2.33).

Effect of Bacillus cereus WGPSB-2 on other Native Soil Micro-Flora

The bio-agent, Bacillus cereus WGPSB-2 has been found effective against white grubs of the region. The impact of Bacillus cereus (Table 2.3.6)

Table 2.3.6. Impact of B. cereus WGPSB2 on native soil micro-flora

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Days after Mixing</th>
<th>90</th>
<th>180</th>
<th>270</th>
<th>360</th>
<th>450</th>
<th>540</th>
<th>630</th>
<th>660</th>
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</tr>
<tr>
<td></td>
<td>Total Bacteria (x10^5cfu/g of oven dry soil)</td>
<td>6.4</td>
<td>37.8</td>
<td>2.11</td>
<td>4.69</td>
<td>23.0</td>
<td>22.5</td>
<td>1.9</td>
<td>17.5</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>6.1</td>
<td>13.3</td>
<td>13.2</td>
<td>3.51</td>
<td>3.97</td>
<td>51.2</td>
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<tr>
<td></td>
<td>Total Fungi (x10^4cfu)</td>
<td>9.0</td>
<td>31.4</td>
<td>2.6</td>
<td>5.75</td>
<td>14.0</td>
<td>8.5</td>
<td>12.5</td>
<td>25.0</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>9.0</td>
<td>10.0</td>
<td>19.7</td>
<td>2.5</td>
<td>7.29</td>
<td>13.5</td>
<td>13.0</td>
<td>11.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Fluorescent Pseudomonads (x10^6cfu)</td>
<td>2.38</td>
<td>188</td>
<td>34.6</td>
<td>51.5</td>
<td>18.7</td>
<td>23.0</td>
<td>27.5</td>
<td>31.2</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>2.33</td>
<td>192</td>
<td>84.0</td>
<td>21.3</td>
<td>71.2</td>
<td>12.0</td>
<td>30.0</td>
<td>23.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Diazotrophic Bacteria (x10^5cfu)</td>
<td>10.4</td>
<td>39.6</td>
<td>16.6</td>
<td>136</td>
<td>42.0</td>
<td>27.7</td>
<td>12.5</td>
<td>23.5</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>10.0</td>
<td>55.0</td>
<td>43.8</td>
<td>21.3</td>
<td>298</td>
<td>40.0</td>
<td>34.2</td>
<td>37.5</td>
</tr>
</tbody>
</table>

Fig.2.33. Anisole trap catches of the white grub, Holotrichia seticollis
on other native soil microbes was assessed in microplots in experimental farm, Hwalkalbagh. Microbial counts in periodical soil samples taken revealed that even 660 days after the addition of B. cereus at 2 x recommended dose did not affect the other soil microbes.

**Polyphasic Characterization of Entomopathogenic Bacterial Isolate HSB-15**

Morphological, biochemical and physiological characterization of the new isolate HSB-15 revealed that the bacterium is rod shaped, Gram +ve, motile and produces creamish, circular colonies on Corenybacterium agar medium with a pH tolerance range of 6-10. This bacterium can grow over a wide temperatures 4 to 28°C, but maximum growth was found to occur at 28°C. The 16S rRNA gene sequence of the isolate had 99% identity with the type strain of *Brevibacterium frigoritolerans* DSM 8801 (AM747813). The plant growth promotion trait of *B. frigoritolerans*-HSB15 was determined at 28°C incubation temperature. The bacterium is able to produce appreciable amount of IAA required for proliferation of plant roots.

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

**Bioassay of Bacillus thuringiensis (Bt) Isolates against Bihar Hairy Caterpillar**

A total of 62 local isolates were tested against the third instar larvae of Bihar hairy caterpillar, *Spilosoma obliqua* under laboratory conditions. Leaf discs of 9 cm diameter were dipped in the purified toxin of different isolates at 10 ppm concentration and fed to the third instar larvae. Thirty larvae were used for each isolate and the data on mortality was recorded after 5 day of treatment. Among the tested isolates, 6 isolates (VLBt 1, VLBt 6, VLBt 21, VLBt 238, VLBt 199, VLBt 201) gave larval mortality between 86 to 92 per cent.

**Studies on Local Bt Isolates for Vegetative Insecticidal Proteins (VIPs)**

The native isolates of *Bacillus thuringiensis* from Uttarakhand were screened for the presence of vegetative insecticidal proteins (VIPs). Crude proteins were extracted from the 36 hours old culture of the each isolate by acetone precipitation. The extracted proteins were analysed through poly acrylamide gel electrophoresis (PAGE) for the existence of VIP toxin bands. Out of 106 Bt isolates tested, 24 isolates showed the presence of around 85 KDa band, which may be of VIP toxin.
Socio-economic Studies and Transfer of Technology

- Information System Technology 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 Kanti)
- Economics of Hill Farming Systems and Its Implication on Efficiency, Employment and Investment Pattern (Mr. H.L. Kharbikar, Dr Renu Jethi & Dr Pratibha Joshi (w.e.f. Aug. 28))
- Development of Need-based Computer Programmes (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 System Technology Management

- Conversion of the technical bulletin "स्वादिष्ट नूतन बसेतियों" which contains information on improved vegetable production technologies, in CD ROM format was accomplished. The e-book has been created in PDF format. The content page of the e-book contains links by which broad topics can be accessed. Besides, bookmarks have been provided to access the e-book to any desired level of information, i.e., topics, sub-topics and sub-sub-topics.
- Agricultural database for major crops for North-West and North East Himalayan states was updated to 2008-09.
- Institute bulletin on technology options, viz., "विभाग परिसंपाक पक्षीय क्षेत्र में कृषि उत्पादन की पुंजी के लिए नूतन नैसर्गिक", was produced as per the requisitions received.
- The institute website was updated regularly.
- About 1,000 photographs were added to the digital photo repository.
- Personnel Management Information System (PERMISnet) database for the institute was updated regularly. Information about the eight personnel, who joined during the reported period, was added to the database. Passport information of all the scientists was regularly updated.
- Detailed information of 35 ongoing projects and 105 completed projects was entered in Project Information Management System for ICAR (PIMSCAR).
- Procured new information kiosks were installed. Two e-books and video film were loaded on both the kiosks.
- ARIS cell provided hardware, software, animal-welfare, intranet and Internet support to the institute.

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

Institute supplied a total of 182.87 q breeder seeds of 11 "kharif" crops during 2008-09 to 33 different places. USS&TDC, Panthnagar and NSC, Rudrapur were found to be major agencies where the institute supplied its "kharif/breeder seeds during 2008-09 (88.29 and 72.40 q, respectively). Crop-wise total breeder seed supply was reported highest in soybean (112.22 q) followed by rice (36.63 q) and maize (18.35 q). Institute supplied a total of 410.45 q of breeder seeds of 7 "rabi" crops during the period of 2007-08 to 2009-10 to 30 different places. USS&TDC, Panthnagar and State department of agriculture were found to be major agencies where the institute supplied its "rabi" breeder seeds during 2007-08 to 2009-10 (179.40 and 39.40 q, respectively). Crop-wise total breeder seed supply was reported highest in wheat (365.00 q) followed by lentil (21.57 q) and barley (10.35 q). As per the reported data of State department of agriculture, Uttarakhand, the state has produced 933.50 q and 6,541 q certified seed of the different varieties of the institute during kharif 2010 and "rabi" 2009-10, respectively. However, the estimated certified seed based on the breeder seed supply during kharif 2008 and `rabi` 2007-08 comes around 24,707 and 23,278 q, respectively. During kharif the certified seed of institute varieties was available for paddy, maize, pigeon millet, soybean whereas, during "rabi" it was available for wheat and field pea only. A survey of farmers and departmental personnel attending Gouchar Kisan Mela at Chamoli district, Uttarakhand revealed that most of them were well aware of VPKAS varieties of wheat, soybean and rice. Wheat
varieties VL 804, VL Gehun 892, VL Gehun 616 and VL Gehun 829 were found most popular among farmers.

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

The data from different institute project sites have been collected to work out the economics of protected cultivation *vis-a-vis* open field cultivation of vegetables. In general, the farmers in the hills have low risk bearing capacity so they adopt risk aversion strategies. One such strategy is mixed cropping which provides an insurance against the adverse meteorological conditions. Average family size of five members owns 0.6 ha of land, of which 0.2 ha is cultivated with irrigated wetland rice followed by a poorly-irrigated wheat crop (both for home consumption) and the remaining 0.3 ha of upland is cultivated with rice/maize/wheat for food and millet.

**Working out the Institutes' Participation Impact in Kisan Mela**

Improved agricultural technology plays a pivotal role in increasing the crop productivity. Technological interventions could be helpful for empowerment of farmers and rural people by increasing accessibility of appropriate technologies and available resources in agriculture and other livelihood activities. The institute disseminates information about the improved technologies through this platform to the scientists, technocrats, policy makers, NGOs, students, farmers and entrepreneurs. Various extension folders, crop calendars and agricultural literature are distributed free of cost to the visitors, farmers and farm women.

A study was conducted during the 2010 in which the data were collected during participation in various Kisan Melas. The results are presented in the Table 2.3.7.

The demand is the highest for kula followed by darati, hand fork, hand hoe, khurpi and garden rake. The improved implements were preferred for its quality of material and design which result in less drudgery. The improved darati was preferred over the traditional one because of it being time efficient and can reach 3-4 cm deeper so the more straw/fodder is collected from the same area.

**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 was collected from twenty two farm women from Bhagartola village of Almora district. It was found that average daily diet of farm women was 1696 Kcal as against the recommended 2200 Kcal. With respect to the BMI it was found that 41% women were underweight.

**Ergonomic assessment of agricultural activities**

Various field operations were evaluated for analysis of drudgery prone activities. A total of 15 farm women were taken for data collection. Data on weeding, fodder cutting and harvesting operations were taken.

Data regarding rate of perceived exertion was recorded on a 10 point Borg Scale (It's a scale of

<table>
<thead>
<tr>
<th>Farm Implement</th>
<th>Selling Price per Unit (Rs.)</th>
<th>No. of implement sold</th>
<th>Amount (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kula</td>
<td>50</td>
<td>315</td>
<td>15,650</td>
</tr>
<tr>
<td>Hand fork</td>
<td>40</td>
<td>41</td>
<td>1,640</td>
</tr>
<tr>
<td>Darat</td>
<td>80</td>
<td>46</td>
<td>3,680</td>
</tr>
<tr>
<td>Hand hoe</td>
<td>120</td>
<td>39</td>
<td>4,680</td>
</tr>
<tr>
<td>Khurpi</td>
<td>55</td>
<td>25</td>
<td>1,375</td>
</tr>
<tr>
<td>Garden rake</td>
<td>150</td>
<td>5</td>
<td>750</td>
</tr>
<tr>
<td><strong>Total Amount</strong></td>
<td><strong>22,775</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
perceived exertion rating from 0 (no exertion) to 10 (maximum exertion). The fodder cutting activity was found to be causing very strong exertion (Table 2.3.8) followed by harvesting (strong exertion) and weeding (somewhat strong exertion).

Biomechanical stresses during performance of activities were also measured by recording the incidence of body pain experienced by hill women in different body parts. This was done by administering body map (developed by Corlette and Bishop in 1976). Pains in different body parts due to faulty work practices were measured with the help of a suitable body map. Body map was divided into four major parts covering the following regions, a) back (the upper and lower back); b) upper extremity: head, neck, eyes, ears, upper and lower arms; c) lower extremity: thigh and legs; d) joints: shoulder, elbow, wrist, waist, knee and ankle.

In order to ascertain the degree of severity of pain, a five point scale given by Verghese et al. (1995) for women was used. Results of experiment show (Fig. 2.34) that weeding activity cause moderate to severe pain in all body parts. However, maximum pain (severe) reported in the ankle region due to adoption of unnatural posture (squatting). During fodder cutting activity moderate pain was perceived by women in shoulder, upper back, lower back and knee region while mild pain in neck and ankle region, and during harvesting activity severe pain was reported by women in shoulder and lower back.

2.4.4 Development of Need-based Computer Programmes

The information system for participation by scientists/officers in different events was developed. The main objective of this system is to provide the information to the Director and PME Cell. This system has two main modules, viz., data entry and report generation. Report generation rights have been assigned to the Director, PME Cell and network administrators. These users can view the information on the following criteria, viz., event, period, and personnel and can export the desired information to MS Excel and/or MS Word formats, view and print the report. This system has been made available on LAN for data entry.

<table>
<thead>
<tr>
<th>Activities</th>
<th>Mean RPE</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weeding</td>
<td>4.1</td>
<td>Some what strong</td>
</tr>
<tr>
<td>Fodder Cutting</td>
<td>5.73</td>
<td>Very Strong</td>
</tr>
<tr>
<td>Harvesting</td>
<td>4.92</td>
<td>Strong</td>
</tr>
</tbody>
</table>

Fig. 2.34. Work Related Biomechanical Problems perceived by respondents
Other Research Projects

Horticulture Mission for North East & Himalayan States Projects
- Production of Quality Seed and Planting Material (Vegetables) (Dr. N.K. Hinduja)
- On Farm Sustainable Production and Demonstration of Fruits and Vegetables Farming Systems (Dr. P. Beete)
- Training and Demonstration on Micro-irrigation System for Enhancing Irrigation in Terrace Level for Vegetable Cultivation [(Dr. K.P. Singh, upto January 12), Dr. B.M. Pandey, w.e.f. January 13]
- Training and Demonstration of Growing Off-Season Vegetables under Protected Environment (Mr. K.K.S. Bishai)
- Demonstration of Existing Mushroom Production Technologies (Dr. Chandrashekhar C.)
- 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 Jethi)
- Training in Mechanization of Horticulture [(Dr. K.P. Singh, upto January 12), Dr. B.M. Pandey, w.e.f. January 13]

DBT Project
- Rapid Conversion of Normal Maize Inbreds to Quality Protein Maize and Further Enhancement of Limiting Amino Acids in Elite Inbreds through Marker Assisted Selection (Dr. P.K. Agrawal)
- Development of Micronutrient Enriched Maize through Molecular Breeding (Dr. P.K. Agrawal)
- Genetic Enhancement of Wheat and Pyramiding Rust Resistance Genes through Molecular Approaches in Northern Hill India (Dr. P.K. Agrawal)

Network Project on Transgenics
- Development of Transgenic Maize with Resistance to Stem Borers (Dr. P.K. Agrawal)

NAIP Project
- Enhancement of Livelihood Security through Sustainable Farming Systems and Related Farm Enterprises in N-W Himalaya [(Dr. A.K. Srivastava, upto December 31), Dr. P.K. Agrawal, w.e.f. March]
- Enabling Small Holders to Improve their Livelihoods from Carbon Finance (Dr. D. Mahanta)
- Bio-prospecting of Genes and Allele Mining for Abiotic Stress Tolerance (Rice and Maize) (Dr. P.K. Agrawal)

All India Coordinated Research Projects (AICRPs)
- Post Harvest Technology for Value Addition and Marketing of Agricultural Produce [(Dr. K.P. Singh, upto January 12), Dr. B.M. Pandey, w.e.f. January 13]
- Use of Plastics in Agriculture Particularly in Protected Cultivation, Water Harvesting and Packaging (Dr. K.P. Singh, upto Jan. 12), Dr. B.M. Pandey (w.e.f. January 13)

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

DUS Project
- Preparation of DUS Testing Guideline through ICAR-SAU System (Dr. Arun Gupta)
2.5. Other Research Projects

The projects under Horticulture Mission for North East & Himalayan States, All India Coordinated Research Projects, Application of Micro-organisms in Agriculture and Allied Sectors (AMAAIS) and National Agriculture Innovative Project (NAIP) on ‘Enhancement of livelihood security through sustainable farming systems and related farm enterprises in North-West Himalaya’ are the driving force for the diversification of institute research activities. The funds received under these projects are utilized to complement existing resources and augment the research capability of the institute.

2.5.1. Horticulture Mission for North East & Himalayan States Projects

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

A total of 1810.7 kg quality seeds (Table 2.5.1) were produced against the target of 1489.0 kg, in targeted vegetables (garden pea, onion, okra, french bean and tomato). About seventy eight thousand seedlings of VL Piazz 3 were produced and supplied to different groups of consumers.

2.5.1.2. On Farm Sustainable Production and Demonstration of Fruits and Vegetables Farming Systems

During the year, twenty polyhouses and two polytanks were constructed, taking the total to 97 polyhouse (average floor area 85 m²) and 68 polytanks (average capacity 45,000 liters) so far. The total worth of the vegetable produced under open and protected cultivation this year was 5.60 and 7.22 lakh Rupees, respectively.

The traditional cropping component of cereals and pulses was improved by interventions of high yielding varieties, seed drill sowing and mechanized threshing. Soybean, maize, barnyard millet, finger millet, wheat and lentil were the major crops, covering a total area of 8.57 ha during the reporting period.

Animal husbandry component was also taken up for the integrated development of the farming system. Under this, de-worming of animals was done along with feed supplementation to enhance the milk yield and improve their growth. Jute cloth has also been used to protect the animals against severe cold during winter. Two chaff cutters were installed at the project site too.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Achievement (Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garden pea</td>
<td>VL 7, VM 10 &amp; VM 11</td>
<td>780</td>
</tr>
<tr>
<td>Onion</td>
<td>VL Piazz 3 (bulb)</td>
<td>650</td>
</tr>
<tr>
<td></td>
<td>VL Piazz 3 (seed)</td>
<td>35</td>
</tr>
<tr>
<td>French Bean</td>
<td>VL B. Bean 1 &amp; 2</td>
<td>170</td>
</tr>
<tr>
<td>Okra</td>
<td>VL Rhendi 1 &amp; 2</td>
<td>171</td>
</tr>
<tr>
<td>Tomato</td>
<td>VL Tarnatar 4</td>
<td>2.7</td>
</tr>
<tr>
<td>Total Seed production (Kg)</td>
<td>1810.7</td>
<td></td>
</tr>
<tr>
<td>Onion seeding (VL Piazz 3)</td>
<td>78,800.0</td>
<td></td>
</tr>
</tbody>
</table>

Activities under sustainability project
Skill development and capacity building are basic interventions required for success of any such programme. This aspect was attended by organizing five on-farm trainings and holding the farmers’ fair twice.

2.5.1.3. Training and Demonstration on Micro-irrigation System for Enhancing Irrigation in Terrace Level for Vegetable Cultivation

Six demonstration-cum-training programmes, involving 186 farmers, were organized at six villages of Almora and Bageshwar districts. Sixteen tanks of 760 m³ capacity were constructed with farmer’s participation in Dunagiri cluster of villages. Of these three were lined with MLCL polyfilm and the remaining with LDPE. The design and estimate for installation of MIS in 0.3 ha on farmers’ fields were prepared. Besides, a total of 137 demonstrations on water harvesting and gravity-based micro-irrigation system for vegetables in terraced lands (0.1 ha) have been laid out in four villages.

2.5.1.4. Training and Demonstration of Growing Off-Season Vegetables under Protected Environment

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

A total of 208 unit field demonstrations (6.09 ha) were conducted during February-March, 2010, the details of which are given in Table 2.5.2.

Table 2.5.3. Details of demonstrations conducted during April 2010 - March 2011

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Demonstrations Area (ha)</th>
<th>Average Yield (kg/ha)</th>
<th>Average Price (Rs./kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>April-December 2010</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>French bean (April sown)</td>
<td>56</td>
<td>1.80</td>
<td></td>
</tr>
<tr>
<td>Pea (August sown)</td>
<td>20</td>
<td>0.92</td>
<td></td>
</tr>
<tr>
<td>French bean (September sown)</td>
<td>49</td>
<td>1.34</td>
<td></td>
</tr>
<tr>
<td>Pea (Nov. sown)</td>
<td>106</td>
<td>5.22</td>
<td></td>
</tr>
<tr>
<td>Sub-total</td>
<td>231</td>
<td>9.28</td>
<td></td>
</tr>
</tbody>
</table>

| February-March 2011        |                           |                       |                        |
| French bean                | 20                        | 0.47                  |                        |
| Tomato                     | 83                        | 1.92                  |                        |
| Cabbage                    | 102                       | 3.60                  |                        |
| Cauliflower                | 9                         | 0.18                  |                        |
| Cucumber                   | 8                         | 0.10                  |                        |
| Summer-squash              | 77                        | 0.21                  |                        |
| Capsicum                   | 79                        | 1.14                  |                        |
| Onion                      | 34                        | 0.06                  |                        |
| Sub-total                  | 414                       | 7.78                  |                        |
| Grand total                | 645                       | 17.06                 |                        |

Table 2.5.2. Details of demonstrations conducted during February-March 2010

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Demonstrations</th>
<th>Area (ha)</th>
<th>Avg. Yield (kg/ha)</th>
<th>Avg. price (Rs./kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>French bean (February sown)</td>
<td>13</td>
<td>0.23</td>
<td>105</td>
<td>2200</td>
</tr>
<tr>
<td>Tomato (open)</td>
<td>72</td>
<td>3.04</td>
<td>249</td>
<td>2250</td>
</tr>
<tr>
<td>Tomato (polyhouse)</td>
<td>10</td>
<td>0.08</td>
<td>424</td>
<td>2250</td>
</tr>
<tr>
<td>Capsicum (open)</td>
<td>28</td>
<td>0.54</td>
<td>102</td>
<td>2750</td>
</tr>
<tr>
<td>Capsicum (polyhouse)</td>
<td>4</td>
<td>0.03</td>
<td>363</td>
<td>2750</td>
</tr>
<tr>
<td>Cabbage</td>
<td>63</td>
<td>2.02</td>
<td>396</td>
<td>500</td>
</tr>
<tr>
<td>Summer squash</td>
<td>13</td>
<td>0.11</td>
<td>580</td>
<td>1200</td>
</tr>
<tr>
<td>Cucumber</td>
<td>4</td>
<td>0.02</td>
<td>573</td>
<td>1800</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>1</td>
<td>0.02</td>
<td>450</td>
<td>2750</td>
</tr>
<tr>
<td>Total</td>
<td>208</td>
<td>6.09</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Annual Report 2010 - 2011
A total of 645 demonstrations (17.06 ha) were laid during April 2010-March 2011 and the details are presented in Table 2.5.3. Due to almost continuous rain during August to mid-September, 100% seed of August-sown pea and September-sown French bean were rotted resulting in crop failure.

One poly tank of 43.2 m³ capacity and six low-cost polyhouses, covering 600 m² floor areas, were constructed. Three on-site training programmes for farmers were conducted in the adopted villages in which 119 farmers and farm women participated.

2.5.1.5. Demonstration of Existing Mushroom Production Technologies

A total of 29 demonstrations of button mushroom (Agaricus bisporus), oyster (dhingari) mushroom (Pleurotus sujar-caju) and milky mushroom (Calocybe indica) were laid down at farmer’s fields and three were laid at Experimental Farm, Hawalbagh. A total of 300 kg spawn of Pleurotus spp. and Calocybe indica, was produced. Pasteurized compost (23.6 t), spawn (165 kg) and casing soil (46 q) for button mushroom cultivation and wheat straw (6 q) and spawn (15 kg) for dhingari mushroom were supplied to the growers. Careful layout of demonstrations, periodic monitoring and consequent high yield were instrumental in generating enthusiasm among the farmers for mushroom cultivation. During the crop season, because of fluctuation in climatic parameters, the dhingari crop was delayed by a month. A good crop could be realized only when the temperature became suitable for the crop growth.

Eleven training programmes, including two at experimental farm, Hawalbagh, were organized for 597 interested growers of Almora and Nainital districts on dhingari and button mushroom production technologies. Farmers of Dualaghat, Dwason, Sheetalakhet and Dhaspar continued to undertake mushroom cultivation for their economic upliftment and better livelihood.

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

Under protected condition (700 m² area), 4.4 kg of capsicum (California Wonder) and 52.0 kg of squash (Australian Green) seeds in spring season and 52 kg of french bean (VL Bauni Bean 1 and 2) in kharif were produced.

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

A two pronged strategy involving an efficient, light weight, eco-friendly, CFL/bulb illuminated insect trap for mass capturing of adult beetles and an entomopathogen, viz., Bacillus cereus strain WGPSB-2, was used for the management of grubs (Coleoptera: Scarabaeidae), which is an important group of destructive polyphagous insect pests causing severe damage to all the rained crops in the region. Large-scale deployment of this strategy was undertaken on community basis in 15 villages of low, mid and high altitude areas and two Experimental Farms of Uttarakhand hills. Altogether, 176 light traps (VL White Grub Beetle Trap-1) were installed at strategic locations and a total of 15, 76 and 41 thousand beetles, respectively, were trapped in low, mid and high hill regions during 2010. A significant
reduction of the grub population was recorded in all the adopted villages. The mean grub occurrence ranged between 0.04-0.18 per square feet in the adopted villages against 2.18-2.55 per square feet in a non-adopted village of mid hills, which resulted in significant increase in yields of different crops over the years of experimentation in the adopted villages over non-adopted villages. Besides, 437 kg of talc-based formulation of the bio-pesticide (*B. cereus* strain WGPSB-2) was prepared, of which 305 kg was distributed to the farmers in Uttarakhand and the rest was supplied to other states like Sikkim, Himachal Pradesh, Jammu & Kashmir. Likewise, *Brevibacterium frigoritolerans* HSB-15 formulation was also produced (15 kg) for trial, which, however, was not found as effective as *B. cereus* formulation. Compatibility of *B. cereus* WGPSB2 with *Trichoderma harzianum* (Tr-11) offers a solution which has significant effect in controlling white grubs as well as soil borne diseases when used together, which has been amply proved in seven farmers’ fields covering an area of 0.22 hectare.

The cost effective and environmentally safe technology for control of scarabaeid has gained popularity under the network project initiated in November 2005 at three centers located at low, mid and high altitudes of Uttarakhand. So far, about 430 ha area, benefitting about 1455 farmers, has been covered under the project.

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

Impact of planned honey bee pollination on crop productivity was demonstrated in 17 villages and 2 experimental farms of Kumaon and Garhwal region. Apiaries were established at the experimental farms. Bee boxes were rectified and kept in the places wherever necessary, besides the rectification and treatment of wall hives (*maan jala*) to enhance bee activity in the adopted villages. Vegetable and fruit growing farmers of the adopted villages were trained in different aspects of bee keeping and planned honey bee pollination during farmers’ field schools (24) and field days (16) conducted during 2010-11 by all the three centres, *viz.*, VPKAS, Almora, HREC, Chaubattia, and GBPUAT, Bharsar. About 230 bee colonies of Indian bees (*Apis cerana*) were used for planned honey bee pollination in the adopted villages.

The average increase in seed yield of onion, coriander, lahi and radish was found to be 25.46, 8.98, 17.42 and 9.43 per cent, respectively, in planned honey bee pollinated crops with respect to naturally pollinated crops. An average fruit yield
increase of 8.11% in apple and 4.17% in pear was recorded in the adopted villages of VPKAS, Almora and an increase in fruit yield of 7.7-19.5% in apple, 8.9-12.3% in pear and 5.7-9.5% in apricot were recorded in different adopted villages of HREC, Chaubattia. Similarly, in the adopted villages of GBPUAT, Bharat, an average increase in yield of 18.54 and 13.33% was recorded in honey bee introduced apple and pear orchards. Approximately, 87 hectare area was covered and 725 farmers were benefited through planned honey bee pollination. In addition, the farmers also extracted honey from the hives, which increased their income.

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

Data were collected from 100 farmers of three clusters of villages, viz., Bhagartola, Darim and Dunagar. Fig. 2.35, Fig. 2.36 and Fig. 2.37 represent the composition of area allocation by farmers in three clusters. All three clusters have diversified vegetable cultivation.

Crop-wise performance indicates that yields of tomato (373 q/ha) and capsicum (275 q/ha) under protected condition were much higher than their respective yields 140 and 103 q/ha under open condition. Higher price of capsicum (Rs. 2,785 against 2,303/q) and tomato (Rs. 2,025/q against 1,888/q) grown under protected condition is on account of their superior quality to those of the crops grown under open field condition. As per estimated variable cost of vegetables, the profit generated from tomato (Rs. 5,59,716/ha) and capsicum (Rs. 5,51,242/ha) under protected cultivation was much higher than tomato (Rs. 1,40,057/ha) and capsicum (Rs. 1,14,257/ha) under open field condition. Cucumber was grown under protected cultivation alone and its yield was 600 q/ha which fetched an average price Rs. 1,319/q and profit of Rs. 5,31,975/ha.

Crop-wise performance under open field condition indicates that yields of cabbage, potato, cauliflower, capsicum, bean, radish and pea were 193, 132, 151, 84, 83, 73 q/ha, respectively, and the respective selling prices were Rs. 834, 1,116, 1,502, 2,303, 1,607, 1,209 and 1,569 per quintal. As per estimated variable costs of vegetables, the profit earned by farmers was Rs. 1,19,305, 1,11,931, 71,436, 92,111, 96,305 and 55,691 per hectare from cauliflower, cabbage, pea, potato, bean and radish, respectively, under open field condition.

2.5.1.10. Training in Mechanization of Horticulture

Nine training programmes were organized at different villages of Almora and Bageshwar districts for demonstration of light weight modified small horticultural hand tools and
equipment suitable for hill region in which 369 farmers participated. Secateurs, pruning tool, pruning saw, hajara, improved kutla (wooden and steel handle), khurpi, spade, circular blade type weeder, hand wheel hoe, sprayers (hand operated), hand fork, machete and sickle were demonstrated to the farmers.

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

MAS in Developing Quality Protein Maize (QPM)

Vivek QPM 9, the QPM version of Vivek Maize Hybrid 9 was released in 2008. It is first MAS product of QPM maize. The F₁, seed of this QPM hybrid seed was produced and distributed to many governments, NGOs, SAUs and farmers. Besides seeds were produced not only at the institute but also at many SAUs, ICAR institutes, farmers' field and KVKs. Seeds were distributed to NSC, Tarai Seeds, Sikkim government, Maharashtra Seed Corporation and many other organizations. Licences are also given to three private companies for production and marketing of hybrid seeds of Vivek QPM 9.

Two hybrids viz., FHQ 38, and FHQ 55, which are either equal to or better than Vivek QPM 9 are under the multilocational trial. FHQ 38 is the QPM version of Vivek Maize Hybrid 21 and shows more than 70% increase in tryptophan content over the original hybrid. It has completed three years of testing under AICRP (Maize) and two years under SVT and has been found promising under these multilocational trials. The hybrid FQH 55 is the QPM version of Vivek Maize Hybrid 23 and shows 65% increase in tryptophan content over the original hybrid.

Presently eight elite inbreds, viz., V 364, V 366, V 368, V 370, V 371, V 372, V 373 and V 374 are under conversion into QPM inbreds using two donors for QPM, viz., CML 173 and CML 189. The foreground selection was done with the internal primers like umc 1066, phi 057 and phi 112 available within the opaque-2 gene. About 100 SSR markers were used for background selection in every generation. The populations under the conversion programme are at BC₁,F₁ generation and the inbreds derived are nearly fixed. They are evaluated for their agronomic worth and amino acid profile.

Development of QPM Composites: Second cycle of intermixing was performed in QPM population synthesised from bulk of equal quantity of seed from 10 crosses, obtained through chain crossing among 10 converted QPM lines with high tryptophan content (0.65- 0.85%).

Further Enhancement of Tryptophan Content in VQL Inbreds: Under this 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 CML 180, CML 170 and CML 189, respectively, in order to improve the nutritional quality of the elite inbreds. Eight hundred SSR markers were employed to find polymorphic markers available between respective parents (recipients and donors). One hundred polymorphic markers were selected for each cross combination in a way that those were evenly distributed across the genome. The breeding populations are in BC₁,F₁ generation. Each of the three populations had approximately 500 plants. Based on the foreground selection, background selection and phenotypic selection, a total of 130 plants were selected which are grown at Hyderabad in Rabi 2010-11. Plants with more than 95% genome of the respective recipient parents with better nutritional and agronomic traits will be advanced to further generation and hybrids will be reconstituted.
2.5.2.2. Development of Micronutrient Enriched Maize through Molecular Breeding

Molecular Breeding for Biofortification in Maize for High Fe, Zn and Low Phytate

Analysis of Genetic Variability for Kernel Micronutrient Content of the Indian Maize Germplasm: Evaluation of maize genotypes over three locations for three years resulted in identification of many stable genotypes that possess relatively high level of kernel iron and zinc. Four lines viz. V 336, V 348, CM 129 and BAJIM 06-3 were found promising for both the micronutrients. HPKFP2, BAJIM06-3, BAJIM06-20, V 348, V 336, V 334, CM 129, CM 212 and VQL1 were, however, found promising for kernel-iron whereas BAJIM 06-10, CM129, BAJIM06-3, VQL 5, V 336, V 348 and V 340 were promising for kernel zinc content and they were used in genetic studies, mapping and breeding.

In addition to the study on kernel Fe and Zn, analysis of genetic variability for provitamin A content showed considerable variability in β-carotene among the inbred lines that ranged from 0.2 to 14.9 μg/g. Based on the data set from 58 samples, the total carotenoid content ranged from 16.76 – 69.50 μg/g, while β-carotene varied from 0.52 – 15.15 μg/g. In order to understand the variability and stability of total carotenoid and β-carotene, a common set of 100 inbred lines were evaluated at three locations during kharif 2010. The estimation of total carotenoid and 4-carotene content is under way.

Development of Mapping Populations for Genetics and Molecular Localization of Fe and Zn:
Phenotypically contrasting lines in respect of kernel Fe and Zn were used for developing mapping populations (Fig 2.38). Three \( F_2 \) mapping populations were developed and used for mapping kernel Fe and Zn. The genotyping and phenotyping of these mapping populations have been completed and the data are being analysed for the identification and validation of QTLs influencing kernel micronutrients. In addition, analysis of \( F_3 \), plant harvests (120 \( F_3 \) seeds) of four populations (V 336 x VQL 1; V 336 x VQL 2; VQL 1 x V 336; VQL 2 x V 336) for kernel Fe content showed several individuals with transgressive segregation. These progenies are being grown for obtaining stable lines with high kernel Fe content.

Validation of PCR-based Molecular Markers Associated with Low Phytate Trait in Maize: A set of low phytate donors were used to study polymorphism between the donors and 40 recipient inbreds. The amplified products of both the donors and the recipients were digested with 8 different restriction enzymes. MspI was found to have restriction sites within the amplified products and showed polymorphism among the low phytate donor and few promising inbred lines. Based on the availability of polymorphism, usefulness in the breeding programme and phytate content, four low phytate donors and five recipient inbreds were selected. The phytate content among the donors ranged from 50.27 to 69.10% where as it was 79.32 to 96.63% for the recipient parents.

Two crosses viz., CM145 x \( lpa1 \) and V334 x \( lpa2 \) were generated for transferring low phytate trait to elite Indian inbreds through MAS.
Foreground selection was applied on approximately 1,000 plants while background selection was done employing 60 polymorphic SSR markers. The level of homozygosity among the best 10 plants in the cross CM 145 x lpa 1 was found to be more than 95% while the same level was exhibited by 14 plants in case of V 334 x lpa 2. The BC₁F₁ plants for both the crosses totaling 100 plant-progenies are being raised during the current nabi season.

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

Marker Assisted Selection for Yellow Rust Resistance in Wheat

Yellow rust is a devastating disease of wheat in the hilly areas of the NW Himalayan states. A high yielding awnless variety VL738 from the institute was highly resistant to about 12 races of yellow rust but has started showing susceptibility to yellow rust of late. Yr5 and Yr10, two yellow rust resistant genes were found to be effective against yellow rust. Hence, under this project, we aimed to utilize broad spectrum resistance genes Yr5 and Yr10 for transferring yellow rust resistance to VL 738 using MAS. The SSR Xpsp3000 reportedly 1.2 cm from Yr10 gene was found polymorphic between VL 738 and the resistant lines for Yr10 (Moro) and FLW10. Similarly, the SSR XWmc175 reportedly 4.5 cm from Yr5 gene was found polymorphic between VL 738 and the resistant lines for Yr5, Triticeum spelta altum (TSA) and FLW16 whereas the SCARs reportedly developed from the AFLP markers S23M41 (0.7 cm from the other side of the gene) and S19M93 (that reportedly cosegregated with the gene) were monomorphic. The reported linked markers for Yr10 and Yr5 are being used for MAS. A set of 150 markers were evaluated for availability of polymorphism between the recipient and respective donor parents for background selection. Initially, six backcrossed populations were generated for the marker aided breeding. Those crosses were VL 738 x FLW 10 (Yr 10), VL 738 x FLW 16 (Yr 5), VL 738 x China 84 (Yr 10), VL 738 x TSA (Yr 5) and VL 738 x MORO (Yr 10). All are in BC₁F₁ generation. Approximately 500 plants from each cross were grown in nabi 2010-11 for foreground and background selection. The linked markers for Yr 5 and Yr 10 were validated and two populations were retained. Foreground selection was completed for both these populations and crosses were made with selected plants and the recipient parents.

2.5.3. Network Project on Transgenics

2.5.3.1. Development of Transgenic Maize with Resistance to Stem Borer

The calli were induced from seed-derived nodal segment of QQL 2 for gene transformation and regeneration. Agrobacterium-mediated transformation was followed for transformation of Cry 1Ab gene. Many factors like sonication, duration of cocultivation and concentrations of different chemicals were done to understand the factors for maize transformation. Approximately 50 putative transgenic plants were regenerated and DNA was extracted from them when the seedlings were of 21 days old. The DNAs were amplified with bar specific primers. A total of ten plants gave PCR positive which need to be confirmed following Southern analysis.

2.5.4. NAIP Project

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

The sub-project was sanctioned on 26th June 2007 for the period of five years and the Launch workshop was held on 30th January 2008. The consortium leader of the project is VPKAS, Almora with partners viz., SKUAST-K, Srinagar (Jammu and Kashmir), SKUAST-J, Jammu (Jammu and Kashmir), CSKHPKV, Palampur (Himachal Pradesh), University of Forestry & Horticulture, Ranchi, (Jharkhand), CSWCTI, Dehradun (Uttarakhand), GBPWHED, Kosi-Katarmal (Uttarakhand), IIT Delhi (Delhi) and BAIF, Haridwar (Uttarakhand). The operational sites are located in compact clusters in order to have significant impact and
not to defuse the achievements. These clusters are arrived to provide replicable development models for the region. Considering the extreme variability of agro-ecosystem in the hill region, a total of fifteen clusters of villages in five districts, representing predominant growing conditions were identified. The targeted farm families covered under this programme is 745 in Kupwara, 700 in Doda, 850 in Chamba, 761 in Tehri Garhwal and 681 in Champawat districts, with a total of 3737 families.

Knowledge-based, science-led, appropriate utilization of resources, efficient management of diversified farming systems and vibrant agro-based and allied enterprises are expected to help ensure adequate food and nutrition along with livelihood security in these five districts of N-W Himalaya. Accordingly, the specific objectives of the project are as follows; i) Enhancement in the agricultural productivity through proven technological interventions, ii) Upgradation and management of natural resource base, iii) Agro-processing, value addition and improved marketing for enhancing profitability and employment opportunities, and iv) Empowerment through capacity building and skill development, in core and allied agricultural sectors, along with employment generation.

To meet these objectives, 39, 10, 30 and 17 interventions, respectively, were taken up in each objective during 2010-11. The last 17 interventions included establishment of knowledge centres, trainings, group meetings, etc. Some of the most beneficial interventions observed during the study were; i) commercial cultivation of papaya, ii) high value vegetable cultivation, iii) potato cultivation in Champawat, iv) polyhouse construction for high value crops, v) backyard poultry, and vi) water conservation tanks. Some of the high pay off interventions planned for expansion are vegetable and high value crops, mushroom cultivation, quality protein maize for nutritional security, livestock rearing, backyard poultry and, integration of water harvesting, fisheries, vegetables and vermi-composting.

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

Agricultural practices, like agri-horti system and agroforestry, can significantly sequester carbon, reduce the effects of climate change and simultaneously contribute to improved livelihood. Considering this, the project takes a grid-based community approach, which allows the farmers to practice their normal farming and/or livelihood activities, but are also encouraged to incorporate carbon sequestering and/or emission reducing practices into their systems, so that their minimum carbon volume requirement is met and the rest could be traded in the carbon market.

The grid area selected for the study consists of about 2,200 ha geographical area, 13 villages and 1,200 households. A PRA study as well as detailed household survey was conducted in all the villages. The interventions for carbon sequestration and emission reduction have been finalized. Around 28,400 saplings of apple, kiwi, almond, peach, plum, pecan-nut, walnut, pear and apricot have been planted. One thousand oak and 1500 alder trees have also been planted in community land. Besides, 30 solar lanterns have been installed and 10 q of root cuttings of Hybrid Napier have been planted. Also, wheat crop has been sown through zero tillage method for carbon financing.

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

Phenotypic Evaluation of Rice Genotypes for Cold Stress Tolerance: A field experiment was conducted to study the mechanism as well to screen 150 diverse rice genotypes in Mallahata farm (VPKAS) during Khair-09. Delayed sowing was done i.e. 30-06-09 in order to favour for cold weather conditions. Cold weather was observed particularly during flowering and post flowering stages. The genotypes Dullo, GGAF- BYEO, RCPL-1-8C, RCPL-1-4C, IRI-386, 6K-393-29-1, Local Ahu, IR3941-23, IRCTN91-90 and BR13363-28-2-1 were found to possess better cold tolerance compared to other genotypes.
Standardization of Callus Induction, Regeneration and Transformation System in Rice:
A set of 25 genotypes were evaluated for their potential for callus induction, regeneration and plant transformation. Five genotypes viz., VL Dhan 206, VL Dhan 82, VL Dhan 86, VL Dhan 65 and VLD Bio97 were found promising for their regeneration potential. More than 200 calli were bombarded with a test construct with gus and lpt.
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.

Screening Maize Inbreds for Drought Tolerance:
A set of 100 genotypes were evaluated for drought tolerance at Howalbag. Traits like 'Relative Water Content', 'Leaf Rolling' and 'Leaf senescence' were observed. Wider variations were observed among the genotypes for these traits. A set of 20 genotypes were identified as tolerant. The promising genotypes for relative water content were MAP 103, MAP 116, MAP 123, MAP 132, MAP 133, MAP 137, MAP 138, MAP 170, MAP 174, MAP 177, CM 153, CM 212, V 25, V 335, V 356, V 395, V 401, MGUD 10 and MGUD 38.

2.5.5. AICRP Projects
2.5.5.1. Post Harvest Technology for Value Addition and Marketing of Agricultural Produce
Design, Development and Evaluation of Pedal Operated Low Cost Light Weight Winnowing-Cleaner of Millets

In hills, farmers do winnowing, cleaning and grading by traditional method which takes more time and labour. A winnower-cleaner-grader for millets was fabricated using locally available materials, which is capable for performing all the three operations in one pass. It consists of a body, feeding hopper, 2 sieves, 2 gears, one handle, 2 fans for winnowing and cleaning, winnower fan safety guard and pedal. Material is cleaned by winnower fan, which is placed outside corner of the machine. The material is fed from top side. One person can easily run the machine for cleaning and grading operations whereas one more person is required for winnowing operation. The machine has fared equally well for cereals, pulses and oilseeds.

Optimization of Machine and Process Parameter of Newly Developed Barnyard Millet Dehuller

The optimum machine parameters for number of canvas strip over impeller of impeller and over hanging width of canvas strip were found to be 9 and 3 mm, respectively, whereas process parameters for peripheral speed, number of passes and moisture content were 8.6 m s⁻¹, 5 and 8.4%, respectively.

Compilation of Status and Potential of Agro Processing Industries in Uttarakhand

Based on their production capacity, 80 agro-processing units of Uttarakhand were assigned in four categories, viz., household scale (capacity = 10 MT, 43 units), cottage scale (capacity=10-50 MT, 24 units), small scale (capacity=50-100 MT, 7 units) and large scale (capacity=100-200 MT, 4 units). These units prepare processed products, like jam (apple and mixed fruits), squash [malta (Citrus sinensis), lemon, litchi, mango and rhododendron), pickle (lemon, garlic, mango, chilli and mixed), candy (gooseberry and apple), ketchup (tomato and mixed) and chutney (apple, plum, papaya and tomato). Data were collected from a sample of twelve units in which 7, 2 and 3 units are under private, state government and
cooperative management, respectively. Of these, nine units were operational for more than 15 years, two for 7–15 years and one for less than 7 years. The survey revealed that the strength of household and cottage scale units is the availability of raw materials in local market but they face the problem of marketing of their processed products. The availability of raw material in local market is a big problem for small and large scale units, however, they have good market network for their processed produces.

Establishment of Agro Processing Centres

Consequent upon successful functioning of APC established at Takula (dist. Almora), two more APCs were established, at two villages, Rawalshera (dist. Almora) and Ganai Gangoli (dist. Pithoragarh). Uttarakhand Govt. is also planning to establish APCs in each districts of the State.

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

The hopper, main body, winnowing and cleaning-cum-grading fans of pedal operated winnower-cleaner-grader were fabricated using fiber reinforced plastic (FRP). It resulted in reduction not only in weight but also in mechanical vibrations as compared to the MS sheet fabricated counterpart. Besides, 20 farmers of villages Jantola and Dharonj (Dist. Champawat) were trained in the synthesis of FRP from raw material to make sheets.

2.5.6. Application of Microorganisms in Agriculture and Allied Sectors (AMMAS)

2.5.6.1. Development of a Bacterial Consortium to Alleviate Cold Stress

Cold tolerant bacterial consortia possessed type III class ice nucleation activity (log ice nuclei per cfu) ranging from -9 to -12 at -10°C after 96 hours. The consortium C1 showed minimum ice nucleation activity (-11.9), followed by C8 (-11.3) and C2 (-11.3) at -10°C (Table 2.5.4). Cold tolerant bacterial consortia showed higher freezing resistance ranging between 87.8%–92.2% and 72.4%–80.8% at -10 and -40°C, respectively after 96 hours. Maximum freezing resistance was observed in consortia C8 (80.8%), followed by C1 (78.95) and C7 (78.7%) at -40°C (Fig. 2.39).

![Freezing resistances of cold tolerant bacterial consortia at -10 and -40°C](image)

Bacterization with cold tolerant bacterial consortia had significantly improved wheat root length (6.9-47%, except C8), shoot length (2.6-28.9%, except C3), root biomass (6.3-175.2%),
shoot biomass (1.7-2.4 fold, except C3), proline content (1.1-52.5%, except C4), total phenolics (3.6-45.5%) and relative water content and decreased the electrolyte leakage over uninoculated control at 60 DAS under pot condition. Cold tolerant bacterial consortia C8, C5, C7 and C4 significantly increased wheat yield by 32.0, 15.4, 13.5 and 11.7%, respectively, over uninoculated control.

### 2.5.6.2. Development of a Cold Tolerant Phosphate Solubilizing Bacterial Inoculant

The locally available (raw talc, deodor sawdust and red cedar sawdust) low cost carrier material and standard (Ca-alginate beads, purified t alc, charcoal and charcoal + soil) carrier based bacterial formulations were evaluated for their shelf life under refrigerated and non-refrigerated condition for a period of six months. Locally available, accessible and inexpensive carrier material showed log cfu ranging from 7.3 to 7.9 and 7.0 to 7.9, whereas the standard carrier materials showed log cfu in the range of 7.9 to 8.6 and 7.6 to 8.5 under refrigerated and non-refrigerated condition, respectively.

Five promising *Pseudomonas* strains were subjected for rock phosphate solubilization at three different temperatures (4, 15, 28℃) and *Pseudomonas* strain CS11RP1 showed maximum P solubilization (40.3 ppm) at 15℃ under shaking condition. All the fourteen *Pseudomonas* strains showed the presence of *pqqC* (568 bp) and *pqqE* (900bp) gene that play a major role in P solubilization using glucose dehydrogenase metabolic pathway (Fig. 2.40).

![Fig. 2.40. Identification of Phosphate solubilizing gene (*pqqC* and *pqqE*) in cold tolerant bacterial strain](image)

Eight bacterial consortia developed from five elite cold tolerant P solubilizing strains were evaluated under field condition. Significantly enhanced nutrient parameters (shoot dry weight, shoot length and root length by 2, 1.3 and 1.65 fold, respectively) and cold stress response (phenolics, proline, starch, EC and relative water content) after 60 DAS were observed. In field condition, four bacterial consortia enhanced P content of wheat (VL 804) stover (11.1-33.3%), seed (17.2-31.0%) and significantly increased wheat yield 16.9-39.4% as compared to uninoculated control (Fig. 2.41).
2.5.6. DUS Project

- A total of institute's 21 released hybrid (12) and composites (9) varieties of early and medium duration and 21 inbreds were characterized, as per the National Test Guidelines, for 30 characters.

- Ninety released and notified varieties of soybean from different SAUs/Institutes were maintained by growing in the field. For maintaining the purity of these varieties, seeds from single true to the plant type, selected from previous year harvest, were sown in plot size of 3.0 x 1.35 m² (3 rows). All these varieties have been characterized for reconfirmation of 20 characters in accordance with the National Test Guidelines.

- Farmers of Todhara-Dudholi Kisan Club, Dunagiri, were motivated to submit application for “Plant Genome Savior Community Award” for the financial year 2009-10. The institute helped the group in filing the application and provided sponsorship.
MISCELLANEOUS ACTIVITIES
The institute has one KVK at Uttarkashi and another at Bageshwar district for wider dissemination of developed technologies to the farmers of the region. Vocational training programmes are organized by KVKs for farmers and extension workers. These KVKs also serve as active link between research-extension and farmers and provide critical feedback to the ICAR-SAU Research System on one hand and extension system on the other. Front Line Demonstrations are conducted to demonstrate latest technology on farmers' fields and field days and training programmes are organized to acquaint farmers with the advances in the field of hill agriculture, provide answers to farmers queries and to suggest ways to enhance their income and living standards.

3.1. KVK Chinyalisaur

3.1.1. Trainings

The KVK organized 111 training programmes for the practicing farmers, farm women, rural youth and extension functionaries on various topics (Table 3.1.1), including eight sponsored training programmes [one for ATMA, Uttarakashi, two each for Rashtriya Jalagam, Barkot (Dist. Uttarkashi), and UPASaC, New Tehri (Dist. Tehri Garhwal), and three for Deptt. of Agriculture, Uttarkashi]. All the training programmes were fully skill oriented and conducted following the principle of “Teaching by doing” and “Learning by doing”.

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<tr>
<td>Animal science</td>
<td>20</td>
<td>220</td>
<td>211</td>
<td>9</td>
<td>431</td>
</tr>
<tr>
<td>Home Science</td>
<td>19</td>
<td>21</td>
<td>360</td>
<td>50</td>
<td>381</td>
</tr>
<tr>
<td>Sponsored trainings</td>
<td>08</td>
<td>160</td>
<td>50</td>
<td>110</td>
<td>210</td>
</tr>
<tr>
<td>Total</td>
<td>111</td>
<td>1313</td>
<td>1123</td>
<td>2436</td>
<td></td>
</tr>
</tbody>
</table>
3.1.2. Front Line Demonstrations

Front line demonstration on cereals, pulses, oilseeds, and vegetables were conducted on 39 ha (20 ha in kharif and 19 ha in rabi) benefitting 791 farmers (Table 3.1.2). FLDs on Backyard poultry were also conducted at 14 farmer’s places with 330 one day-old chicks.

Table 3.1.2. Details of FLD conducted

<table>
<thead>
<tr>
<th>Season</th>
<th>Crops</th>
<th>Variety/technology</th>
<th>Area (ha.)</th>
<th>No. of farmers</th>
<th>Average yield FLD</th>
<th>+ Local check</th>
<th>Increase in yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kharif</td>
<td>Paddy</td>
<td>VL Dhan 85</td>
<td>3.0</td>
<td>44</td>
<td>38.44</td>
<td>30.15</td>
<td>21.57</td>
</tr>
<tr>
<td>2010</td>
<td>Maize</td>
<td>Vivek Sankal Makka</td>
<td>3.0</td>
<td>68</td>
<td>30.30</td>
<td>22.90</td>
<td>24.42</td>
</tr>
<tr>
<td></td>
<td>Barnyard millet</td>
<td>VL Madira 172</td>
<td>1.0</td>
<td>19</td>
<td>12.56</td>
<td>10.20</td>
<td>18.79</td>
</tr>
<tr>
<td></td>
<td>Horse gram</td>
<td>VL Gahat 8</td>
<td>1.0</td>
<td>30</td>
<td>6.50</td>
<td>3.25</td>
<td>50.00</td>
</tr>
<tr>
<td></td>
<td>Pigeon pea</td>
<td>VL Arhar 1</td>
<td>2.5</td>
<td>61</td>
<td>12.68</td>
<td>8.25</td>
<td>34.94</td>
</tr>
<tr>
<td></td>
<td>Soyabean</td>
<td>VLS 47</td>
<td>3.5</td>
<td>106</td>
<td>21.38</td>
<td>14.25</td>
<td>32.89</td>
</tr>
<tr>
<td></td>
<td>Sesamum</td>
<td>Shikhar</td>
<td>1.0</td>
<td>18</td>
<td>5.20</td>
<td>3.50</td>
<td>30.56</td>
</tr>
<tr>
<td></td>
<td>French bean</td>
<td>Contender</td>
<td>1.0</td>
<td>25</td>
<td>93.50</td>
<td>72.30</td>
<td>22.67</td>
</tr>
<tr>
<td></td>
<td>Okra</td>
<td>VL Bhindi 2</td>
<td>1.0</td>
<td>29</td>
<td>112.50</td>
<td>75.20</td>
<td>33.07</td>
</tr>
<tr>
<td></td>
<td>Garden pea</td>
<td>Vivek Matar 10</td>
<td>0.5</td>
<td>10</td>
<td>83.50</td>
<td>63.20</td>
<td>24.30</td>
</tr>
<tr>
<td></td>
<td>Brinjal</td>
<td>Hybrid 6</td>
<td>0.5</td>
<td>10</td>
<td>285.50</td>
<td>170.50</td>
<td>40.28</td>
</tr>
<tr>
<td></td>
<td>Hybrid Napier</td>
<td>CO 3</td>
<td>2.0</td>
<td>24</td>
<td>200.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td><strong>Sub-total</strong></td>
<td></td>
<td><strong>20.0</strong></td>
<td><strong>430</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rabi</td>
<td>Wheat</td>
<td>VL Gehrung 829</td>
<td>10.0</td>
<td>136</td>
<td></td>
<td>Results awaited</td>
<td></td>
</tr>
<tr>
<td>2010-11</td>
<td>Toria</td>
<td>PT 303</td>
<td>2.0</td>
<td>37</td>
<td>7.56</td>
<td>4.20</td>
<td>44.44</td>
</tr>
<tr>
<td></td>
<td>Toria</td>
<td>IPM</td>
<td>1.0</td>
<td>25</td>
<td>7.16</td>
<td>3.55</td>
<td>50.42</td>
</tr>
<tr>
<td></td>
<td>Lentil</td>
<td>PL 4</td>
<td>2.0</td>
<td>44</td>
<td>Results awaited</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Barseaem</td>
<td>Meskavi</td>
<td>1.0</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Garden pea</td>
<td>Vivek Matar 10</td>
<td>1.0</td>
<td>35</td>
<td>93.50</td>
<td>75.00</td>
<td>19.70</td>
</tr>
<tr>
<td></td>
<td>Cabbage</td>
<td>INM (Borex)</td>
<td>1.0</td>
<td>29</td>
<td>205.50</td>
<td>160.00</td>
<td>22.50</td>
</tr>
<tr>
<td></td>
<td>Potato</td>
<td>INM (Zinc Sulphate)</td>
<td>1.0</td>
<td>25</td>
<td>Results awaited</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Sub-total</strong></td>
<td></td>
<td><strong>19.0</strong></td>
<td><strong>361</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Grand total</strong></td>
<td></td>
<td><strong>39.0</strong></td>
<td><strong>791</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Transfer of technology through front line demonstrations
Seed/Seedling Production

The details of seed/seedling production at KVK are presented in Table 3.1.3.

Table 3.1.3. Truthfully Labeled Seed Production

<table>
<thead>
<tr>
<th>Crop</th>
<th>Varieties</th>
<th>Production (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Kabi (2009-10)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>VL Gahun 829</td>
<td>2,400.00</td>
</tr>
<tr>
<td></td>
<td>VL Gahun 802</td>
<td>900.00</td>
</tr>
<tr>
<td>Lentil</td>
<td>VL Masoor 103</td>
<td>170.00</td>
</tr>
<tr>
<td>Field pea</td>
<td>VL Matar 42</td>
<td>135.00</td>
</tr>
<tr>
<td>Garden pea</td>
<td>Vivek Matar 10</td>
<td>230.00</td>
</tr>
<tr>
<td></td>
<td>Vivek matar 11</td>
<td>50.00</td>
</tr>
<tr>
<td>Onion</td>
<td>VL Piaz 3</td>
<td>2.00</td>
</tr>
<tr>
<td>Okra</td>
<td>VL Bhindi 2</td>
<td>60.00</td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td></td>
<td><strong>3,947.00</strong></td>
</tr>
<tr>
<td><strong>Kharif (2010)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horse gram</td>
<td>VLG 10</td>
<td>255.00</td>
</tr>
<tr>
<td>Soybean</td>
<td>VLS 47</td>
<td>70.00</td>
</tr>
<tr>
<td>Tomato</td>
<td>VLT 4</td>
<td>0.40</td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td></td>
<td><strong>325.40</strong></td>
</tr>
<tr>
<td><strong>Grand total</strong></td>
<td></td>
<td><strong>4,272.40</strong></td>
</tr>
<tr>
<td>Seedling produced</td>
<td>(different vegetables)</td>
<td><strong>57,600</strong></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, toria and wheat.

Other Extension Activities: The Kendra organized eight kisan goshties, two kisan mela, three exhibitions, two field days, six farmers–scientists interactions, four multi-disciplinary camps at different villages of development blocks of the district and a total of twenty activities were covered by newspapers. Approximately four thousand farmers were benefited by these activities. SMS and staff members attended the Kharif 2010 and Kabi 2010-11 Krishi Mela organized by Uttarakhand Government benefitting around twelve thousand farmers and state employees.

3.2. KVK, Bageshwar

3.2.1. Trainings

The KVK organized 92 training programmes, with 2,114 total beneficiaries, for the practicing farmers, farm women, rural youth and extension functionaries on various topics (Table 3.1.4), including 15 sponsored training programmes.

Table 3.1.4. Training programmes conducted

<table>
<thead>
<tr>
<th>Discipline</th>
<th>No. of courses</th>
<th>No. of trainees</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Crop production</td>
<td>15</td>
<td>259</td>
</tr>
<tr>
<td>Horticulture</td>
<td>14</td>
<td>226</td>
</tr>
<tr>
<td>Plant Protection</td>
<td>4</td>
<td>42</td>
</tr>
<tr>
<td>Agricultural Extension</td>
<td>15</td>
<td>241</td>
</tr>
<tr>
<td>Home Science</td>
<td>12</td>
<td>49</td>
</tr>
<tr>
<td>Animal Science</td>
<td>17</td>
<td>167</td>
</tr>
<tr>
<td>Sponsored trainings</td>
<td>15</td>
<td>311</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>92</strong></td>
<td><strong>1295</strong></td>
</tr>
</tbody>
</table>
### Table 3.1.5. Details of Front line demonstrations on crops

<table>
<thead>
<tr>
<th>Season</th>
<th>Crop/technology</th>
<th>Variety</th>
<th>Area (ha)</th>
<th>No. of farmers</th>
<th>Average yield (q/ha) FLD</th>
<th>Farmers’ practices*</th>
<th>Increase in yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kharif</td>
<td>Paddy</td>
<td>VL Dhan 65</td>
<td>1.70</td>
<td>24</td>
<td>33.4</td>
<td>30.0</td>
<td>11.33</td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td>Vivek Dhan 62</td>
<td>2.46</td>
<td>30</td>
<td>33.0</td>
<td>30.0</td>
<td>10.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vivek Dhan 154</td>
<td>0.14</td>
<td>7</td>
<td>25.0</td>
<td>16.0</td>
<td>56.25</td>
</tr>
<tr>
<td>Maize</td>
<td>VL Sankul Makka 35</td>
<td>1.96</td>
<td>20</td>
<td>34.0</td>
<td>25.0</td>
<td>36.00</td>
<td></td>
</tr>
<tr>
<td>Mandua</td>
<td>VL Mandua 324</td>
<td>0.79</td>
<td>53</td>
<td>16.0</td>
<td>12.0</td>
<td>33.33</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VL Mandua 149</td>
<td>0.16</td>
<td>2</td>
<td>14.0</td>
<td>12.0</td>
<td>16.66</td>
<td></td>
</tr>
<tr>
<td>Amanth</td>
<td>VL Chua 44</td>
<td>0.10</td>
<td>5</td>
<td>7.2</td>
<td>5.0</td>
<td>44.00</td>
<td></td>
</tr>
<tr>
<td>Pigeon pea**</td>
<td>VL Arhar 1</td>
<td>6.19</td>
<td>198</td>
<td>15.0</td>
<td>10.0</td>
<td>40.0</td>
<td></td>
</tr>
<tr>
<td>Soybean</td>
<td>VL Soya 47</td>
<td>2.27</td>
<td>19</td>
<td>15.0</td>
<td>10.6</td>
<td>41.0</td>
<td></td>
</tr>
<tr>
<td>Summer green gram**</td>
<td>SML 668</td>
<td>0.17</td>
<td>5</td>
<td>9.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Okra**</td>
<td>Arka Anamika</td>
<td>0.20</td>
<td>22</td>
<td>118.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weed management in paddy</td>
<td>VL Dhan 65</td>
<td>2.24</td>
<td>20</td>
<td>36.5</td>
<td>30.0</td>
<td>21.66</td>
<td></td>
</tr>
</tbody>
</table>

| Sub-total | 18.34 | 405 |

<table>
<thead>
<tr>
<th>Rabi</th>
<th>Toria</th>
<th>VLT-3</th>
<th>0.50</th>
<th>10</th>
<th>Results awaited</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010-11</td>
<td>Mustard</td>
<td>Pusa Bold</td>
<td>0.18</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Garden pea</td>
<td>Arkil</td>
<td>2.18</td>
<td>155</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wheat</td>
<td>VL Gabun 829</td>
<td>6.73</td>
<td>137</td>
<td></td>
</tr>
</tbody>
</table>

| Sub-total | 9.59 | 311 |

| Grand total | 27.93 | 716 |

* - The variety was same as under FLD.  ** - New introductions

Field day at farmers field organized by KVK, Bageshwar
Seed production of ground nut at KVK, Bageshwar
3.2.2. Front Line Demonstrations

Front line demonstration on cereals, pulses, oilseeds and vegetables were conducted on 27.93 ha (18.34 ha in kharif and 9.59 ha in rabi) benefitting 716 farmers (Table 3.1.5). Besides, FLDs were also conducted on poultry rearing and fodder productions (Table 3.1.6).

3.2.3. On Farm Trials

The following trials were conducted at farmers’ fields:

**Fertilizers Management in Vegetable PEA for Yield Enhancement:** Seed treatment with phosphorus solubilizing bacteria along with recommended doses of NPK (20:40:60) and compost 10 t/ha produced 73% higher green pods over farmer’s practice i.e. 7 t/ha compost alone. The B:C ratio of the technology was 2.79.

**Integrated Pest Management in Tomato:** Seed treatment with bio control agent *Trichoderma harzianum* @ 10 gm/kg of seed, *P. fluorescens* @ 0.5% spray and release of *Trichogramma chilonis* @ 50,000 insects/ha gave 47% higher yield over farmers’ practice. The B:C ratio of the technology was 3.15.

**Enhancement of Livestock (Buffalo) Health and Production through Scientific Management Practices:** Complete package of deworming, mineral mixture and vaccination in buffaloes increased milk production by 50% over the farmers’ rearing practices and also maintained their sound health. The B:C ratio of the technology was 3.26.

3.2.4. Farmers Field Days

The following five field days were conducted in which 300 farmers participated.

1. Field day on summer moong at Budchar on June 17.
3. *Arhar Divas* at Karala gaon on September 19.
4. Field day on vegetable pea at Chauna on March 25.
5. Field day on wheat at Kholiseer on March 28.

<table>
<thead>
<tr>
<th>Enterprises</th>
<th>Aspect</th>
<th>No./Area (ha)</th>
<th>No. of farmers</th>
<th>Data on parameter in relation to technology demonstrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poultry</td>
<td>Broiler</td>
<td>600 chicks</td>
<td>32</td>
<td>Survival rate 90% (540) Growth performance: a. Growth rate 1-1.5 kg in 8 weeks. Growth rate 1 kg in 15 weeks. Feed consumption 2.5 kg-local grasses. Feed consumption 2.5 kg-local grasses. Egg laying capacity 2.5 kg-local grasses. Egg laying is continued</td>
</tr>
<tr>
<td>Fodder production</td>
<td>Hybrid napier</td>
<td>0.84</td>
<td>12</td>
<td>Establishment EP: 75% Percentage (EP) - 85% Yield Percentage (YP) - 300 q/ha</td>
</tr>
</tbody>
</table>
3.3. Institute Headquarter's Endeavour on Transfer of Technology

3.3.1. Trainings

Thirty four training programmes were organized for the state officials and farmers of Uttarakhand, Himachal Pradesh and Sikkim on different aspects of improved hill agriculture. The total number of beneficiaries from these trainings were 424. Three one-week training programmes on post-harvest technology under AICRP on PHT (Central Sector Scheme-Component-4) were also conducted in which 50 farmers participated.

3.3.2. Front Line Demonstrations

Rice: Front line demonstration on improved cultivars was conducted among 102 farmers in 18 different villages covering an area of 10.12 ha. Both the improved cultivars, viz., VL Dhan 85 (336.89 q from 7.13 ha) and VL Dhan 65 (159.01 q from 2.99 ha) showed significant yield advantage (average 28.60 and 48.75%, respectively) over local check in all the villages.

Wheat: Wheat FLDs were conducted in 12 ha area involving 135 farmers of Nainital, Bageshwar, Uttarkashi, Pithoragarh and Almora districts with three high yielding varieties, namely, VL Gehun 892, VL Gehun 829 and VL Gehun 802. VL Gehun 892, gave an average yield of 24.72 q/ha which was 83.66% higher than the local check.

3.3.3. Krishi Samriddhi (कृषि समृद्धि)

This institute sponsored programme deals with the topical issues relating to hill agriculture in a lucid and interactive manner for the benefit of farmers. The programme is broadcasted every Sunday at 6 pm from All India Radio, Almora.

3.3.4. Krishak Helpline

It offers a toll-free telephone (1800 180 2311) service to the farmers by providing answers to the queries raised by them.
## 4.1 Training of Institute’s Staff at Other Institutes

The following institute personnel were deputed for different HRD programmes during 2010-11.

### International Training

<table>
<thead>
<tr>
<th>Duration</th>
<th>Participant</th>
<th>Topic</th>
<th>Venue</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 15 to May 14</td>
<td>Dr. Lakshmi Kant</td>
<td>Training on Wheat Improvement &amp; Pathology</td>
<td>CIMMYT, Mexico</td>
</tr>
<tr>
<td>April 24 to May 7</td>
<td>Dr. Gyanendra Singh</td>
<td>Breders Training Programme on Lentil Improvement</td>
<td>ICARDA, Syria</td>
</tr>
<tr>
<td>August 24 to November 24</td>
<td>Dr. Lakshmi Kant</td>
<td>Australian Leadership Award Fellow on Wheat Rust Resistance</td>
<td>P.B.I.C., University of Sydney, Australia</td>
</tr>
</tbody>
</table>

### National Training

<table>
<thead>
<tr>
<th>Duration</th>
<th>Participant</th>
<th>Topic</th>
<th>Venue</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 09-10</td>
<td>Ms. Shobha</td>
<td>Orientation Training cum workshop on Home Science</td>
<td>GBPUA&amp;T, Pantnagar</td>
</tr>
<tr>
<td>April 11-22</td>
<td>Mr. ARNS Subbanna</td>
<td>Training on Bacillus thuringiensis</td>
<td>DRR, Hyderabad</td>
</tr>
<tr>
<td>April 28-30</td>
<td>Dr. P. K. Agrawal</td>
<td>Genetic Analyzer Sequencing &amp; Fragment Analysis Applications</td>
<td>Labindia Research and Development Laboratory, Gurgaon</td>
</tr>
<tr>
<td>May 10-15</td>
<td>Mr. T.B. Pal &amp; Mrs. Renu Sanwal</td>
<td>Creative Writing on Agriculture</td>
<td>IIIMC, Bhubaneswar, Odisha</td>
</tr>
<tr>
<td>June 18-19</td>
<td>Mr. K.K.S Bisht</td>
<td>Installation of SAS software</td>
<td>IVRI, Izmnagar</td>
</tr>
<tr>
<td>August 30</td>
<td>Dr. Arun Gupta</td>
<td>National Information Sharing Mechanism on Conservation and Utilization of Paddy Genetic Resources for Food and Agriculture</td>
<td>IASRI, New Delhi</td>
</tr>
<tr>
<td>September 1 to December 29</td>
<td>Dr. Salej Sood</td>
<td>92nd FOCARS training</td>
<td>NAARM, Hyderabad</td>
</tr>
<tr>
<td>September 14-16</td>
<td>Dr. R.K. Tiwari &amp; Mr. Kamal Pande</td>
<td>Training programme &quot;Krishi Prasar Prabhushan- Naye Ayam&quot;</td>
<td>GBPUA&amp;T, Pantnagar</td>
</tr>
<tr>
<td>November 5-7</td>
<td>Dr. Gyanendra Singh</td>
<td>Pigeon pea Improvement Programme</td>
<td>ICRISAT, Hyderabad</td>
</tr>
<tr>
<td>November 15</td>
<td>Dr. Mukesh Kumar</td>
<td>Training-cum-Sensitization workshop on Project Information &amp; Management System for Indian Council of Agricultural Research (PIMS-ICAR)</td>
<td>IASRI, New Delhi</td>
</tr>
<tr>
<td>January 15-20</td>
<td>Des. D. Mahanta &amp; Anuradha Bhartiya</td>
<td>Training on Data Analysis using SAS</td>
<td>IVRI, Izmnagar</td>
</tr>
<tr>
<td>February 21-26</td>
<td>Des. Mukesh Kumar &amp; S.K. Jha</td>
<td>Training on Data Analysis using SAS</td>
<td>IVRI, Izmnagar</td>
</tr>
</tbody>
</table>
4.2 Important Trainings Organized for Farmers at the Institute

<table>
<thead>
<tr>
<th>Topic</th>
<th>Duration</th>
<th>No. of days</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jawak Kheti</td>
<td>3.4.2010 to 6.4.2010</td>
<td>4 days</td>
<td>40 farmers</td>
</tr>
<tr>
<td>Parvatiya khetron me fasaloupadan ki unnat</td>
<td>7-4-2010 to 9-4-2010</td>
<td>3 days</td>
<td>25 farmers</td>
</tr>
<tr>
<td>taakneeke (Sikkim farmers)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parvatiya khetron me fasaloupadan ki unnat</td>
<td>11-4-2010 to 17-4-2010</td>
<td>7 days</td>
<td>13 farmers</td>
</tr>
<tr>
<td>taakneeke (State Hort. Dept.-Sikkim)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parvatiya khetron me fasaloupadan ki unnat</td>
<td>21-4-2010 to 27-4-2010</td>
<td>7 days</td>
<td>12 farmers</td>
</tr>
<tr>
<td>taakneeke (State Agril. Dept.- Uttaranchal)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parvatiya khetron me fasaloupadan avam unnat</td>
<td>04-6-2010 to 07-6-2010</td>
<td>4 days</td>
<td>13 farmers</td>
</tr>
<tr>
<td>taakneeke (Sikkim farmers)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parvatiya khetron me fasaloupadan avam unnat</td>
<td>21-6-2010 to 23-6-2010</td>
<td>3 days</td>
<td>32 farmers</td>
</tr>
<tr>
<td>taakneeke (State Agril. Dept., H.P)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Parvatiya khetron me fasaloupadan avam unnat</td>
<td>28-6-2010 to 30-6-2010</td>
<td>3 days</td>
<td>34 farmers</td>
</tr>
<tr>
<td>taakneeke (Sikkim Govt.)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Dalhan avan tilhani fasaloo ki unnat kheti</td>
<td>07-10-2010 to 10-10-2010</td>
<td>4 days</td>
<td>28 farmers</td>
</tr>
<tr>
<td>(Swastiki NGO-Pituragai)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.3. Participation in Fairs/Melas

- Dr. Arun Gupta attended Krishi Mahotsav Program at Dehradun, October 24.
- Dr. M.L. Roy & Mr. H.L. Kharbikar attended 61st Gouchar Audyogik Vikas Evam Sanskritik Mela-2010 at Gouchar, Chamoli, November 14-20.
- Dr. J.C. Bhatt, Mr. H.L. Kharbikar & Mr. B.D. Pandey attended AGRIVISION 2011 at NBFG, Lucknow, February 10-12.
- Drs. M.L. Roy & Pratibha Joshi attended Pusa Krishi Vigyan Mela at IARI, New Delhi, March 3-5.
- Dr. Pratibha Joshi & Mr. H.L. Kharbikar attended All India Farmers Fair and Agricultural Exhibition at GBPUA&T Pantnagar, March 9-12.

Besides, the institute participated and put stall during Nanda Devi Mela, Almora, Uttarakhand Mela, Bageshwar and Krishi Mahostav at nearby areas of Almora district.
ICAR Outstanding Team Research Award

- Drs. R. Bhattacharyya, S. Kundu, Ved Prakash, B.L. Mina, S. Saha, S.C. Pandey, A.K. Srivastva and H.S. Gupta received ICAR Outstanding Team Research Award in the subject area of Natural Resource Management (Soil Science, Agronomy, Agro-forestry) for the biennium 2007-08. The team contributed to evaluate the carbon sequestration potential (CSP) of soils in the north-western Himalayas through adoption of integrated nutrient management (INM), conservation tillage, diversified cropping and location specific organic farming. Adoption of INM was the best way to offset global warming under both rainfed and irrigated conditions. The INM practice was very successful in improving soil physical, chemical and biological properties under both the growing conditions. Positive role of short-term zero tillage (ZT) and minimum tillage (MT) in CSP and improvement in soil properties under irrigated rice-wheat, and rainfed soybean and finger millet based cropping systems, respectively, was extensively studied. Other significant achievements include: appraisal of INM effects on sustainability indices (including benefit-cost ratio and selected soil quality indicators) under long-term fertility experiments; quantification of improvement in soil properties and SOC-sequestration under organic farming and relay intercropping; and transfer of technologies related to INM, conservation tillage, organic agriculture and intercropping with providing technologies to prepare vermicomposts and local composts in the farmers' fields and giving trainings on INM and organic farming.

- Dr. R. K. Tiwari, SMS (Animal Science), KVK, Uttarkashi received Young Scientist Award from Uttarakhand State for Science & Technology for best poster presentation in the 5th USSTC held on 10-12 Nov-2010 at Doon University, Dehradun on the topic “Effect of supplementary inorganic mineral mixture on body weight gain of male goat”.

- Dr. R. Bhattacharyya, Scientist received the Golden Jubilee Commemoration Young Scientist Award by the Indian Society of Soil Science in 2010.
LINKAGES AND COLLABORATIONS

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

6.1 Local Institution in the Area
- G.B. Pant Institute of Himalayan Environment, Kosi, Katarmal.
- Defence Institute of Bio-energy Research, Haldwan.
- Kumaun University, Nainital.

6.2. National Institutes and Agricultural Universities
- Indian Agricultural Research Institute, New Delhi.
- Central Rice Research Institute, Cuttack.
- Directorate of Wheat Research, Karnal.
- Directorate of Rice Research, Hyderabad.
- Directorate of Maize Research, New Delhi.
- Directorate of Pulses Research, Kanpur.
- G.B. Pant University of Agriculture & Technology, Pantnagar.
- CSK Himachal Pradesh Krishi Vishwa Vidyalaya, Palampur.
- Y.S.P. University of Horticulture and Forestry, Solan.
- Indian Grassland and Fodder Research Institute, Jhansi.
- Central Institute of Medicinal and Aromatic Plants, Lucknow.
- Sher-e-Kashmir University of Agriculture & Technology, Srinagar.
- Sher-e-Kashmir University of Agriculture & Technology, Jammu.

6.3. International Organizations
- IRRI, Manila, Philippines
- CIMMYT, Mexico
- ICRISAT, Hyderabad, India
- ICARDA, Syria
- World Agroforestry Centre (ICRAF), S.A.R.C, New Delhi

6.4. Extension & Development Agencies
- State Department of Agriculture, Uttarakhand.
- Indian Farmers Fertilizer Cooperative.
- National Agricultural Bank for Rural Development.
- Private agencies
- NGOs
- Department of Horticulture & Processing, Govt. of Uttarakhand.
IMPORTANT COMMITTEES
OF THE INSTITUTE

7.1. Rajmamsha Karyanvayan Samiti

Rajmamsha Hindi me karyanvayan, itihasi prayog, samvad-samvad par hindi me karyanvayan samiti karyakarta hame shau rajmamsha karyanvayan samiti ka nidan karya gaya hai. Samiti me karyakarta samiti se bahut bahut karyakarta nidan karya gaya hai. Rajmamsha karyanvayan samiti ka nidan karya gaya hai. Rajmamsha karyanvayan samiti ka nidan karya gaya hai.

Dr. Jyoti Prasad Chaudhary, Director
Dr. K. N. Singh, Scientist
Dr. B. L. Mina, Scientist
Dr. A. K. Srivastava, Head, Crop Production Division

7.2. Institute Joint Council

The Institute Joint Council met quarterly during the year. The composition of the Committee was as follows:

Chairman - Director

Members (Official Side) - Drs. Gyanendra Singh, Sr. Scientist; P.K. Mishra, Sr. Scientist; B. L. Mina, Scientist; AO and FAO

Members (Staff Side) - Mr. Bahadur Ram, A.A.O. (Member CJS); Mr. Santosh Dafauti, Assistant; Mr. Davendra Lal, T-3; Mr. Ramesh Kanwal, T-3 (Secretary IIC); Mr. Madan Singh, S.S.Gr-II and Bishnu Datt Pandey, S.S.Gr-I

7.3. Study Leave Committee

Chairman - Dr. A.K. Srivastava, Head, Crop Production Division (upto December 31)

Members - Dr. Nirmal Chandra, Pr. Scientist & Dr. Arun Gupta, Sr. Scientist

7.4. Institute Technology Management Committee

Chairman - Director

Members - Head, Crop Improvement & Crop Production Division; Dr. K. S. Negi, Pr. Scientist (NBPG Regional Station, Bhawal); Dr. J.K. Bishay, Pr. Scientist & Coordinator (PME Cell)

Member Secretary - Dr. P.K. Agarwal, Pr. Scientist & OIC (ITMU)

7.5. Institute Technology Management Unit

Chairman - Dr. P.K. Agrawal, Head & Pr. Scientist

Members - Dr. K. Srinivas, Pr. Scientist (upto May 22) Dr. Lakshmi Kant, Pr. Scientist & Dr. B.L. Mina, Scientist (SS)

7.6. Research Advisory Committee (RAC)

Chairman - Dr. S.S. Baghel, Former Vice Chancellor, Assam Agricultural University, Jorhat (Assam)

Members - Dr. C.L. Acharya, Former Director IISS, Bhopal & Director Extension Education, CSKHPKV, Palampur; Dr. R.P. Dua, Assistant Director General (FFC), ICAR; Prof. J. Kumar, Prof. & Head, Plant Pathology Division, GBDU&T, Pantnagar; Dr. T.C. Thakur, National Professor, Dept. of Farm Machinery & Power Engineering, GBDU&T, Pantnagar; Dr. Jagdish Kumar, Prof. & Head, Agricultural Economics, GBDU&T, Pantnagar; Dr. J.C. Bhatt, Director, VPKAS (ICAR), Almora; Shri Vikram Singh Negi, (Member IMC), Shri Jayendra Singh Rana (Member IMC).

Member Secretary - Dr. J.K. Bishay, Pr. Scientist
7.7. Institute Management Committee (IMC)

Chairman - Director

Members - Assistant Director General (FFC); Director, Agriculture HP; Director Research GBPUA&T, Panthagar; Joint Director, Agriculture UK; Finance & Accounts Officer, IVRI, Bareilly; Dr. J.K. Bisht, Principal Scientist; Dr. D.K. Garg, Principal Scientist, NCIPM, New Delhi; Dr. Y.P. Sharma, Principal Scientist & 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

7.8. Institute Research Council

Chairman - Director

Members - All the Scientists of VPKAS, Almora

Member Secretary - Coordinator (PME Cell)

7.9. Committee for Monitoring of Field Experiments

Chairman - Director

Members - Heads, Principal Scientists & Coordinator (PME Cell)

7.10. Nodal Officer IPR Cell

Dr. Lakshmi Kant, Pr. Scientist

7.11. Vigilance Cell

Dr. J.K. Bisht, Pr. Scientist

7.12. Purchase Advisory Committee

Chairman - Dr. P.K. Agrawal, Head & Pr. Scientist

Members - Drs. P.K. Mishra, Sr. Scientist; A.R.N.S. Subhanna, Scientist, FAO; OIC (Store)/AAO

7.13. Standing Purchase Committee

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

Members - Dr. Mukesh Kumar, Scientist; FAO; OIC (Store)/AAO


Chairman - Director

Members - Dr. Anil Kumar, Head, Molecular Biology & Genetic Engineering, GBPUA&T (Outside Expert); Dr. A.S. Gusai, Medical Officer, Almora

Member Secretary - Dr. P.K. Agrawal, Head & Pr. Scientist

7.15. House Allotment Committee

Chairman - Dr. J.K. Bisht, Pr. Scientist

Members - Mr. K.K.S. Bisht, Scientist (SG); Dr. Mukesh Kumar, Scientist (SS) (upto January 16); Dr. Gyanendra Singh, Sr. Scientist (w.e.f. January 17); Mr. Mahesh Lal, Administrative Officer; Mr. T.B. Pal, Member Secretary (w.e.f. January 17)

7.16. Public Information Cell

Public Information Officer - Dr. K. Srinivas (w.e.f. May 23); Dr. Gyanendra Singh, Sr. Scientist; Mr. M. Lal, A.O.

Assistant Public Information Officer - Mr. M.M. Joshi, AAO; Sri P.S. Singh, Farm Superintendent

Public Information Officer (KVK, Chinyalisaur & Bageshwar)

KVK Bageshwar - Dr. V.K. Sachan, Program Coordinator

KVK Uttarkashi - Mr. Hari Govind, SMS
LIST OF PUBLICATIONS

8.1. Book Chapters


8.2. Scientific Paper Published in Journals/Proceedings

International Journals


**National Journals**


8.3. Papers in Proceedings


8.4. Scientific and Popular Articles


9.3. जैव. एवं जैव. भीम, जैव. एवं जैव. जैविक, जैव. एवं जैविक, एवं जैव. जैविक, जैव वर्षानी 31(6):29–32.
LIST OF ONGOING PROJECTS

9.1 Institute's Core Research Projects

a. Enhancement in the Productivity of Major Hill Crops
   - Genetic Enhancement for Productivity and Quality in Maize.
   - Genetic Enhancement for Productivity and Quality in Rice.
   - Genetic Enhancement for Productivity and Quality in Wheat and Barley.
   - Genetic Enhancement for Productivity and Nutritional Quality in Millets and Under-Utilized Crops.
   - Genetic Enhancement for Productivity, Cooking and Proximate Quality in Pulses and Oilseeds.
   - Genetic Enhancement for Productivity and Quality in Vegetable Crops.
   - Enhancing Quality and Resistance to Biotic Stress through Molecular Breeding.

b. Natural Resource Management for Sustainable Productivity
   - Development of Integrated Farming System Modules for Different Farm Holdings.
   - Enhancing Productivity and Profitability of Major Hill Crops through Diversification and Reduction in Cost of Cultivation.
   - Characterization and Evaluation of Agriculturally Important Microbes for Enhancing Productivity of Hill Crops.
   - Design and Development of Small Tools and Farm Machineries for Hill Agriculture.
   - Wasteland Management with Special Reference to Production of Fodder and Fuel-wood.

c. Integrated Pest Management
   - Development of Integrated Pest Management Modules for French Bean and Cauliflower.
   - Biodiversity of Bacillus thuringiensis in Himalayan Hills and their Utilization in Insect Control.

9.2. Externally Funded Projects

ICAR Funded

- Mega Seed Project on Seed Production in Agricultural Crops & Fisheries
- Development of a Cold Tolerant Phosphate Solubilizing Bacterial Inoculant (AMAAS)
- Development of Bacterial Consortium to Alleviate Cold Stress (AMAAS)
- Post Harvest Technology for Value Addition and Marketing of Agricultural Produce (AICRP)
- Use of Plastics in Agriculture Particularly in Protected Cultivation, Water Harvesting and Packaging (AICRP)
Horticulture Technology Mission Projects

- Production of Quality Seed and Planting Material (Vegetables)
- On Farm Sustainable Production and Demonstration of Fruits and Vegetables Farming Systems
- Training and Demonstration on Micro-irrigation System for Enhancing Irrigation in Terrace Level for Vegetable Cultivation
- Training and Demonstration of Growing Off-Season Vegetables under Protected Environment
- Demonstration of Existing Mushroom Production Technologies
- Quality Seed Production of Capsicum and Squash under Protected Condition
- Deployment of Entomopathogens and Light Traps for the Management of Scarabaeids in Uttarakhand Hills
- Planned Honey Bee Pollination for Improvement in Horticultural Crop Production
- Status of Horticulture & Market Opportunities in the State of Uttarakhand
- Training in Mechanization of Horticulture

DBT Funded

- Development of Micronutrient-Enriched Maize through Molecular Breeding
- Rapid Conversion of Normal Maize Inbreds to Quality Protein Maize and further Enhancement of Limiting Amino Acids in Elite Inbreds through Marker Assisted Selection.

9.3. NAIP Project

- Enhancement of Livelihood Security through Sustainable Farming Systems and Related Farm Enterprises in N-W Himalaya
- Enabling Small Holders to Improve their Livelihoods from Carbon Finance.
- Bio-prospecting of Genes and Allele Mining for Abiotic Stress Tolerance (Rice & Maize).

9.4. Network Project on Transgenics

- Development of Transgenic Maize with Resistance to Stem Borer.

9.5. DUS Project

- Preparation of DUS Testing Guideline through ICAR-SAU System
10.1 Commercialization of Vivek QPM 9

Besides being commercialized earlier with licenses given to two private companies, this elite QPM hybrid, the QPM version of Vivek QPM 9 was licensed to a third company this year. Vivek QPM 9 was commercialized to Bhartiya Beej Nigam Ltd., A-25, Awas Vikas, Rudrapur, District Udham Singh Nagar, Uttarakhand for a period of five years.

10.2 Commercialization of Vivek Mandua Thresher 1

Vivek Mandua Thresher 1 was earlier licensed to M/s Punjab Agricultural Implements Pvt. Ltd., Saharanpur. After the expiry of the license, it was again renewed with newer terms and conditions for another three years.
11.1. Research Advisory Committee (RAC) Meeting

The XV Research Advisory Committee (RAC) meeting of VPKAS, Almora was held on February 18-19, 2011 under the Chairmanship of Dr. C. L. Acharya, Former Director, IISS, Bhopal. The other RAC members, who attended the meeting, were Prof. T. C. Thakur, National Professor, Deptt. of Agricultural Engineering, Dr. Jagdish Kumar, Professor, Deptt. of Agriculture Economics, and Dr. J. Kumar, Prof. and Head, Deptt. of Plant Pathology of GBPUA&T, Fastragar, and the IMC members, Shri Vikram Singh Negi, and Shri J. S. Rana. Besides, Dr. A. K. Srivastva, Former Head, Crop Production Division of VPKAS was also invited. All the scientists of the institute attended the meeting. At the outset Dr. J. C. Bharr, Director VPKAS welcomed Dr. C. L. Acharya, Chairman and other RAC members including two IMC members namely, Shri Vikram Singh Negi and Shri J. S. Rana, who attended the meeting first time.

All RAC members and scientists visited the Experimental Farm, Hawaibagh on 19th Feb., 2011 and appreciated the field layout and maintenance of experiments. Soon after, a Brain Storming Session was conducted for setting the initial path of work for 12th Five Years Plan. Dr. Acharya advised the scientists for encouraging the hill farmers for taking agriculture as a challenging task and making it a remunerative venture. Deliberations were held for reorienting the research aspects for 12th Five Year Plan in the Brainstorming session. In this, Director presented the important issues to be taken into account for next plan and an outline for the work plan was prepared.

11.2. Institute Research Council (IRC) Meeting

The meeting of the Institute Research Council (IRC) was held on May 12-13, 2010 and October 29-30, 2010 to review the progress of research undertaken during kharif 2009 and rabi 2009-10, respectively and to finalize the programme for ensuing kharif 2010 and rabi 2010-11, respectively.

11.3. Evaluation of Experiments by Field Monitoring Team

The monitoring of field experiments planted in rabi 2009-10 was done on April 1 under the Chairmanship of Dr. A. K. Srivastva, Head, Crop Production Division. All the Scientists of the Institute visited and monitored the experiments. The progress was reviewed by the Director.

Besides, all the field experiments conducted during kharif 2010 were reviewed and monitored by the Field Monitoring Team on September 13, 2010. The shortcomings of the experiments, if any, were communicated to the concerned scientists and discussed in the succeeding IRC meeting.
## Participation of Scientists in International and National Conferences, Symposia and Meetings

<table>
<thead>
<tr>
<th>Participants</th>
<th>Programme</th>
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<tbody>
<tr>
<td><strong>International</strong></td>
<td></td>
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<tr>
<td>Dr. Ranjan Bhattacharyya</td>
<td>2nd International Workshop on Carbon Sequestration and Climate Change Mitigation in Agriculture, Beijing, China, June 21-30.</td>
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<tr>
<td><strong>National</strong></td>
<td></td>
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<tr>
<td>Dr. J.C. Bhatt, P.K. Agrawal &amp; B.M. Pandey</td>
<td>45th Annual Rice Group Meetings of AICRP at AAU, Anand, Gujarat, April 3-6.</td>
</tr>
<tr>
<td>Dr. Nirmal Chandra</td>
<td>Annual Review Workshop of NAIP at CIAE, Bhopal, April 2-May 5.</td>
</tr>
<tr>
<td>Dr. Veenika Singh</td>
<td>Convergence of Home Science in Research and Extension GBPUA&amp;T, Pantnagar, April 9-10.</td>
</tr>
<tr>
<td>Drs. Arun Gupta &amp; B.M. Pandey</td>
<td>Annual Workshop of AICRP on Small Millets at BAU, Ranchi, April 9-11.</td>
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<tr>
<td>Dr. Arun Gupta</td>
<td>Stake holder meeting of National Information Sharing Mechanism on conservation and utilization of Plant Genetic resources for Food and Agriculture at NBFRG, New Delhi, April 17.</td>
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<tr>
<td>Dr. J.K. Bisht</td>
<td>AICRP on forage crop National Group Meet at GBPUA&amp;T, Pantnagar, April 21-23.</td>
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<tr>
<td>Mr. Hari Govind &amp; Mr. Pankaj Nauniyal</td>
<td>KVK Interface Meeting 2010 NASC Complex, New Delhi, April. 25-27</td>
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<tr>
<td>Dr. S.C. Pandey</td>
<td>State level Consortium Workshop of Resources organization for Capacity Building under Strengthening Capacity Building for Decentralized Watershed Management, Dehradun, April 30.</td>
</tr>
<tr>
<td>Drs. J.C. Bhatt, A.K. Srivastva, Nirmal Chandra, B.M. Pandey &amp; B.L. Mina</td>
<td>Annual NAIP Workshop and CAC Meeting at Srinagar (J&amp;K), May 3-5.</td>
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<tr>
<td>Dr. Arun Gupta</td>
<td>Seed meeting at Directorate of Agriculture, Dehradun on May 7.</td>
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<tr>
<td>Dr. N.K. Hedau</td>
<td>Meeting on review of progress report of HTM MM-I, Dehradun, May 8.</td>
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<tr>
<td>Dr. N.K. Hedau</td>
<td>AINRP on Onion and Garlic at CITTH, Srinagar, May 11-12.</td>
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<tr>
<td>Dr. N.K. Hedau</td>
<td>SVT (Vegetable Crops) meeting at Directorate of Horticulture, Dehradun, May 22.</td>
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<tr>
<td>Participants</td>
<td>Programme</td>
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<tr>
<td>Dr. Mukesh Kumar</td>
<td>Launching workshop on Strengthening Statistical Computing NARS, IASRI,</td>
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<td>New Delhi, June 8.</td>
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<tr>
<td>Drs. J.C. Bhatt, A.K. Srivastava,</td>
<td>21st Meeting of ICAR Regional Committee No.1. at SKUAST, Jammu,</td>
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<tr>
<td>V.K. Sachan &amp; Mr. Hari Govind</td>
<td>June 10-12.</td>
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<tr>
<td>Dr. A.K. Srivastava</td>
<td>Brain Storming Session on Protected Cultivation at SKUAST-K, Jammu, June</td>
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<td>12.</td>
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<tr>
<td>Drs. J.C. Bhatt &amp; Arun Gupta</td>
<td>Scientific Advisory Meeting at KVK, Chinnalisar, June 21.</td>
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<tr>
<td>Dr. S.C. Pandey</td>
<td>Chief Scientist Meet of AICRP on water management at CSK HPKV, Palampur</td>
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<tr>
<td>Mr. Hari Govind</td>
<td>Workshop on Climate Resilience CRIDA (ICAR), Hyderabad, July 1.</td>
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<tr>
<td>Dr. Lakshmi Kant</td>
<td>Core Valley Seed Production and Rabi Seed Availability meeting, Director</td>
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<td></td>
<td>of Agriculture, Dehradun, July 6-7.</td>
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<tr>
<td>Ms. A.R.N.S. Subbanna</td>
<td>Inception and National Project Coordination Meeting of Global Pollination</td>
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<td></td>
<td>Project GBPHEI, HP Utit, Mohal-Kullu, July 19.</td>
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<tr>
<td>Dr. Lakshmi Kant</td>
<td>Review Meeting of ICAR Seed Project on seed production in agricultural</td>
</tr>
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<td></td>
<td>crops NASC, New Delhi, July 19-20.</td>
</tr>
<tr>
<td>Dr. Lakshmi Kant</td>
<td>QRT of NSP (crops) at IARI, New Delhi, July 21.</td>
</tr>
<tr>
<td>Dr. J.K. Bish</td>
<td>RAG meeting of Uttrakhand Forest Research &amp; Training, Dept., Dehradun,</td>
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<td></td>
<td>July 27.</td>
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<tr>
<td>Dr. B.M. Pandey</td>
<td>Meeting of Site Management Committee of ATIC at GBPUA&amp;T, Pantnagar, July</td>
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<td>29.</td>
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<tr>
<td>Dr. B.M. Pandey &amp; Mr. Hari Govind</td>
<td>Promoting system of wheat Intensification (SWI) for achieving food</td>
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<td>security PSI Dehradun, July 30.</td>
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<tr>
<td>Dr. Arun Gupta</td>
<td>Review the conduct of DUS test at NAARM, Hyderabad, August 10-11.</td>
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<tr>
<td>Dr. Lakshmi Kant</td>
<td>Scientific Advisory Committee meeting of KVK Matela, August 10.</td>
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<tr>
<td>Dr. S.C. Pandey</td>
<td>Meeting related to Soil Health and Judicious use of Fertilizer at Dehradun,</td>
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<tr>
<td></td>
<td>August 20.</td>
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<tr>
<td>Dr. S.C. Pandey</td>
<td>State Level Nodal Agency Meeting related to Coordination of Watershed</td>
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<td>Management, Dehradun, August 23.</td>
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<tr>
<td>Drs. S.K. Jain &amp; D. Mahanta</td>
<td>49th Annual Wheat &amp; Barley Research Workers' Meet, PAU, Ludhiana</td>
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<td>August 27-30.</td>
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<tr>
<td>Drs. A.K. Srivastava &amp; Reeti Jethi</td>
<td>Workshop on Gender in Sustainable Rural Livelihood Security DRWA,</td>
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<td>Bhubaneswar, September 1-2.</td>
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<tr>
<td>Mr. Harigovind &amp; Dr. R.K. Tiwari</td>
<td>Meeting for preparation of annual action plan GBPUA&amp;T, Pantnagar,</td>
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<td>September 4-5.</td>
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<tr>
<td>Drs. J.C. Bhatt, Arun Gupta,</td>
<td>Scientific Advisory Meeting at KVK, Bageshwar, September 10.</td>
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<tr>
<td>Dr. R.K. Tiwari</td>
<td>Conference on Role of Science and Technology in the Development of</td>
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<td>Uttarakhand State, Govt. P.G. College, Bageshwar, October 25.</td>
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<tr>
<td>Dr. P.K. Agrawal</td>
<td>National Seminar on Chemistry Biology Interface- Recent Trends, Govt.</td>
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<tr>
<td>Dr. L. Kant &amp; D. Mahanta</td>
<td>3rd International Group Meeting on Wheat Productivity Enhancement under</td>
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<td>Changing Environment, IIAS, Dharwad, February 9-12.</td>
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<tr>
<td>Dr. B.M. Pandey</td>
<td>Meeting with Cooperative Social and Environment Section of THDC, Rishikesh,</td>
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<td></td>
<td>November 1.</td>
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<tr>
<td>Participants</td>
<td>Programme</td>
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<tr>
<td>Dr. Mukesh Kumar</td>
<td>Interactive Meet on Information and Communication Technology in ICAR of computer application scientists NASC; New Delhi, November 3-4.</td>
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<tr>
<td>Dr. P.K. Agrawal</td>
<td>DBT-Biofortification Review and NAIP-BAM Meeting at IARI, New Delhi, November 7-10.</td>
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<tr>
<td>Drs. P.K. Mishra, Ranjan Bhattacharyya, R.K. Tiwari &amp; Mr. Pankaj Nautilal</td>
<td>5th Uttarakhand State Science Congress Doon University, Dehradun; November 10-12.</td>
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<tr>
<td>Drs. J.K. Bisht &amp; Mukesh Kumar</td>
<td>Interface Meeting for Data Sharing and Management for NRM, Crop Science and Horticulture Division, NASC; New Delhi; November 23.</td>
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<tr>
<td>Dr. P.K. Agrawal</td>
<td>National Symposium on Sustainable Rice Production System under Changing Climate at Central Rice Research Institute, Cuttack; November 27-29.</td>
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<tr>
<td>Dr. Nirmal Chandra</td>
<td>ICAR Sponsored 15th Management Development Programme in Agricultural Research, NAARM, Hyderabad; December 2-7.</td>
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<tr>
<td>Dr. V.K. Sachan &amp; Mr. Hari Govind</td>
<td>Zonal Workshop of KVKS, IIHR, Varanasi; December 9-10.</td>
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<tr>
<td>Drs. P.K. Mishra &amp; J. Jeeravanandan</td>
<td>51st Annual Conference of Association of Microbiologist of India (AMI); Birla Institute of Technology, Ranchi; December 14-17.</td>
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<tr>
<td>Dr. V.K. Sachan &amp; Mr. Hari Govind</td>
<td>5th National Conference on KVKS MRUJAT; Udaipur; December 22-24.</td>
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<tr>
<td>Mr. Kamal Pandey</td>
<td>Workshop on जीवन वातावरण के बीच में विज्ञान की वृद्धि की जरूरत at Gandhi Peace Foundation; New Delhi; December 28-29.</td>
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<tr>
<td>Dr. N.K. Heda</td>
<td>Review meeting on HMNE&amp;H at KV, Dehradun; January 20.</td>
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<tr>
<td>Dr. N.K. Heda</td>
<td>Annual Workshop on AICRP Vegetable Crops at JAU, Junagarh; January 27-30.</td>
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<tr>
<td>Dr. S.C. Pandey</td>
<td>International Conference on Preparing Agriculture for Climate Change at PAU; Ludhiana; February 6-8.</td>
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<tr>
<td>Dr. Lakshmi Kant</td>
<td>Annual Breeder Seed Review Meeting at NBFRGR, New Delhi; February 14.</td>
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<tr>
<td>Dr. S.C. Pandey</td>
<td>Meeting related to Climate Change at Dehradun; February 23.</td>
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<tr>
<td>Dr. B.M. Pandey</td>
<td>Programme Advisory Committee of PSI at Dehradun; February 25.</td>
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<tr>
<td>Dr. Arun Gupta</td>
<td>Review meeting of DUS test centers at NASC; New Delhi; February 25.</td>
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<tr>
<td>Drs. P.K. Agrawal, Nirmal Chandra &amp; B.M. Pandey</td>
<td>Regional Review Workshop of NAIP-SRLS Project at NBFRGR; Lucknow; March 1-2.</td>
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<tr>
<td>Dr. Lakshmi Kant</td>
<td>ZTMU&amp;HPD meeting at IARI; New Delhi; March 17-18.</td>
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13.1. Brainstorming Meet on Conservation Agriculture

A brainstorming session on Conservation Agriculture for hill region was organized at VPKAS on May 11, 2010. Dr. I.P. Abrol (Former Dy. Director General, NRM, ICAR) was the Chief Guest. Chairing the session, Dr. Abrol introduced the house with 3 principles of Conservation Agriculture viz., (i) minimum soil disturbance, (ii) keeping the soil covered and (iii) adopting crop rotation in temporal and spatial scale. Dr. A.K. Srivastava, Head, Crop Production Division briefed resource conservation technologies like, perennial vegetations on bunds, vegetable cultivation through harvested water, seed priming and deep sowing for crop establishment, which may constitute Conservation Agriculture. Dr. P.K. Sharma, Dean, College of Agriculture, CSKHPKV, Palampur addressed the issue of conservation agriculture and emphasized the need of using weeds for nutrient, conservation tillage giving example of rice-wheat cropping system. He urged the house to identify important issues to be taken up and proceed with site specific multi-location trials, which may benefit the hill farmers. Dr. Subhash Chandra, Chief Scientist, Water Management, GBPUA&T, Pantnagar explained conservation agriculture as a driving force for looking alternative technologies. He told that puddling of rice field is one of the main constraints for the adoption of conservation agriculture in irrigated lands. In the concluding session, Dr. Abrol complimented the Institute authorities for their thoughtfulness in organizing this discussion on a very substantive issue and expressed that efforts of the scientists in this direction would be path breaking in addressing the problems facing by the farmers of the region. The Director and all the scientists of the institute participated in the meet.

13.2. Annual Workshop on National Network Research Project on Arid Legumes

XXVI Annual group meeting of National Network Research Project on Arid Legumes was organized at the institute on May 27-28, 2010, in which 65 Arid Legumes research and development workers and officers from government & non-government institutions across the country actively participated. Hon’ble Minister Shri Prakash Chandra Pant from the Cabinet of Uttarakhand also participated in one of the sessions. He was apprised of the activities of the institute during his visit to museum and the institute. He praised the work being conducted by the institute and the help rendered by ICAR. The catalogue entitled “Evaluation of Indigenous Horsegram Germplasm of Uttarakhand Hills for Utilization in Breeding Programme”,

![Brainstorming Meet at VPKAS, Almora](image1)

![Hon’ble Minister of Uttarakhand releasing the publication](image2)
the bulletin “Sustainable Fodder Production Management in NW Himalaya” and VPKAS Hindi Newsletter “Parvatiya Krishi Darpan (Oct. 2009 – March, 2010)”, were released during the workshop. Research work undertaken in various disciplines in Kharch 2009 from different institutes were reviewed and technical programmes for Kharch 2010 were formulated with special emphasis on development of mapping population on the traits like maturity, yield, gum quality in guar and resistance to abiotic and biotic stresses.

13.3. NAIP-SRLS Meeting

The 2nd Annual workshop and 3rd meeting of Consortium Advisory Committee of the NAIP-SRLS Project Component 3 entitled “Enhancement of livelihood Security through Sustainable Farming Systems and Related Farm Enterprises in North-West Himalaya” was organized at Sher-e-Kashmir University of Agricultural Science and Technology, Srinagar, during May 03-05, 2010.

Dr. A.P. Srivastava, National Coordinator of NAIP Component-3 (Sustainable Rural Livelihood Security) setting the goal of the workshop, emphasized high expectations from the project. He dealt with implementation issues leading to success of the project. Dr. J.C. Bhatt, Director and Consortium Leader, highlighted the relevance of project for hill and mountain region.

The consolidated report of the project across five districts (Kupwara, Doda, Chamba, Tehri Garhwal and Champaner) being implemented by 9 Consortium Partners (SKUAST-K, SKUAST-J, CSKHPKV, GBPUAT-R, CSWCRI, GIP-HED, IIT-Delhi, BAIF, led by VPKAS) and two Associate Partners (DCFR and INHERI), was presented by Dr. A. K. Srivastava, Consortium Principal Investigator of the project. The innovative approach included all the 3737 farm families in 15 selected clusters of villages, improving integrated farming system supported by natural resource development, allied activities, processing, marketing and stabilizing community organizations.

Dr. H.S. Gupta, Director, IARI and Founder Consortium Leader, expressed great satisfaction on increasing production of vegetable, food and allied interventions production. He emphasized need for processing, social organization and credit.

Padma Bhushan Dr. Chandi Prasad Bhatt ji highlighting the achievements expressed that now “farm families are themselves speaking, instead of the figures and reports. There has been astonishing transformation in Kupwara villages. Impact has been remarkable and other villages want to be included in the project.

Prof. Anwar Alam, Hon’ble Vice Chancellor of SKUAST-K, elaborated the beginning stage of the project in the district Kupwara. He emphasized the all round development achieved in the project is only way to meet the aspirations of people.

3rd meeting of the Consortium Advisory Committee was held on May 04, 2010, during the Workshop. All the members critically reviewed the progress and expressed great satisfaction on the achievements. The Chairman of CAC Padma Bhushan Dr. Chandi Prasad Bhatt ji concluded by saying that now it is not the data and reports but the people are speaking about the progress of the project.

Plenary session was held on May 05, 2010, under the Chairmanship of Dr. Harbans Singh, Retd. Vice Chancellor SKUAST-K Srinagar. Balanced approach of resource development, diversified farming supported by allied activities and value addition- processing were the key for future thrust of the project. Dr. J.C. Bhatt, Director and Consortium Leader emphasized need for comparative evaluation of enterprises.

13.4. Scientific Advisory Committee Meeting of KVK, Uttarkashi

The Scientific Advisory Committee meeting of KVK, Uttarkashi was held on June 21 under the Chairmanship of Dr. J.C. Bhatt, Director, VPKAS. Mr. M.S. Kotiyal, the CDO, the CAO, NABARD, Uttarkashi, scientists of GBPUA&T hill Campus, Rani Chauri, progressive farmers, Chairman/ members of different farmers federation, scientists, VPKAS and KVK staff participated in the meeting. In the meeting, the progress was reviewed and planning for the ensuing season was done.

13.5. Scientific Advisory Committee Meeting of KVK, Bageshwar

KVK Bageshwar organized Scientific Advisory Committee meeting on September 10 under the Chairmanship of Dr. J.C. Bhatt, Director, VPKAS to review the progress of running season and planning for ensuing season. Dr. S.K. Singh, DDO; Ms. Champa Uperti, District Programme Officer; Mr. B.S. Bishit,
employees and meritorious children of the staff were also honoured on the occasion. The function ended with traditional mango feast.

13.6. VPKAS Celebrated its 87th Foundation Day

The institute celebrated its 87th Foundation day on July 4, 2010. Dr. K.R. Dhiman, Vice-Chancellor, YS Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh was the Chief Guest on the occasion. The function started with lighting of lamp and Saraswati Vandana. Dr. J.C. Bhatt, Director of the institute read the messages conveyed by the Honourable Director General, ICAR, Dr. S. Ayyappan and Deputy Director General, Dr. S.K. Datta and briefed the audience about the research achievements of the institute. The Chief Guest Dr. Dhiman appreciated the work done by the institute. He emphasized that if we conserve 11 per cent of rain water in hills then rain water use efficiency will be increased by 5 per cent, which in turn will increase the crop productivity up to a great extent. Expressing his deep tribute and respect to Prof. Boshri Sen, the Founder Director, he stated that visiting this institute is just like visiting a temple. The function was presided over by Shri Sundarvanand of Shri Ram Krishna Kutir, Almora. He emphasized upon the importance of food and agriculture in human life and briefed some aspects of the life of Swami Vivekananda and appreciated the institute for following his ideologies. Dr. H.S. Sen, Ex-Director, CHAF, Barrackpur, Former Directors and other dignitaries from other institute/departments, farmers and retired persons also attended the celebration. On this occasion, the leaflets entitled "Parvatiya Kshetron mein Piaaz Ka Bhogapadan" and "Parvatiya Kshetron mein Sabji Matar Ka Safal Bhogapadan" were also released. Institute's

13.7. Biodiversity Day Organized at VPKAS, Hauzalbagh (Almora)

The institute organized Biodiversity Day on 17 July, 2010 to mark the International Year of Biodiversity. This day was organized on Harela, a farmers' friendly festival of Uttarakhand, in which farmers sow seeds of various crops in a pot and gets idea about the crop production in ensuing season. A discussion on the importance of biodiversity and Harela was broadcasted through All India Radio, Almora. Special sessions were organized at the institute for the lectures on Plant Genetic Resources of the Indian Himalayan Region—A Critical Component for Food and Environment Security of Mountain People by Dr. K.S. Negi, NBPG Regional Station, Bhowali; Biodiversity in ancient literature, traditional medicine, agriculture, animal husbandry by Prof. P.C. Pande, Kumaon University SSJ Campus, Almora and Folklore associated with biodiversity by Prof. Diwa Bhatt, Kumaon University SSJ Campus, Almora and biodiversity the food crops in N-W Himalaya by Dr. J.C. Bhatt, Director, VPKAS.
Almora. On the day, 501 saplings of different forest trees were also planted by the guests and staff of the institute at VPKAS Experimental Farm, Hawalbargh.

13.8. Parthenium Awareness Week Organized at VPKAS Hawalbargh (Almora)

VPKAS organized the Parthenium Awareness Week from 7-13 August, 2010. In order to create awareness in the people of the region, the institute has initiated a campaign for removal of Parthenium at nearby areas of its Experimental Farm, Hawalbargh on August 7, 2010. Demonstrations were laid on utilization of the weed for preparation of the compost. The Director appraised people about harmful effects of the weed, its removal and utilization. Besides, the experts of the institute had a discussion on the topic, which was broadcasted from All India Radio, Almora on August 8, 2010. Apart from this, awareness was generated amongst farmers at some villages of Almora and Champanawat districts during the week.

13.9. Farmers' Days Organized

Village Khooout

A Farmers' Day was organized to create awareness about global climate change and carbon trading issue under the project entitled, “Enabling small holders to improve their livelihood and benefit from carbon finance” on August 9, 2010 at Khooout village of district Almora. Dr. J.C. Bhatt, Director VPKAS, Almora chaired the function. He explained about how plantation will be helpful in sequestering CO2 from environment into the earth. Dr. A.K. Srivastva, Dr. J.K. Bisht and Dr. D. Mahanta appraised the farmers about the C sequestration and benefits through finance. The progressive farmer Mr. Madhuwanand Joshi appraised the effort of VPKAS scientists about solving the effect of climate change and their overall role in addressing the farmers' problems. The function was attended by 75 farmers from different villages, 6 Gram Pradhan of the project grid area, senior experts from OUTREACH, and scientific and technical staff of VPKAS.

Village - Doonagiri

A Farmers’ Day was organized at village Doonagiri, Block Dwarahat, Almora on September 7, 2010. It was organized on the occasion of inauguration function of Todara-Dudhauli Kisan Club, which was sponsored by NABARD and VPKAS, Almora. The club was inaugurated jointly by Shri Pushpesh Tripathi, MLA, Dwarahat, Chaubuttia and Dr. J.C. Bhatt, Director, VPKAS, Almora. The function was attended by scientists of the institute and 250 farmers of nearby areas.

13.10. Rabi Kisan Mela Organized

A Kisan Mela was organized at Experimental Farm, Hawalbargh on September 18, 2010. Dr. J.C. Bhatt, Director of the institute urged the farmers to make use of newly developed technologies to become economically sound by incorporating improved farming system, protected cultivation, off-season vegetable cultivation, mushroom production, honeybee rearing, etc. for their traditional method of agriculture. Dr. K.B.
Saxena, Principal Scientist, ICRISAT, Hyderabad emphasized that the main component of agriculture progress are self dependency and cooperation of farmers and scientists. He said that pigeonpea production is one of the profitable option for rainfall agriculture. On the occasion farmers were also honoured for their significant contribution in the adoption of the improved technologies. National Award winner farmer Shri Amba Dutt Pandey of Bhagartola village was specially honoured during the function. Besides, seeds of two varieties viz., VL Gehun 907 and VL Masoor 129 were released for farmers.

13.11. Kharif Kisan Mela Organized

Kharif Kisan Mela was organized at Experimental Farm, Hawalbagh on March 29, 2011. Shri Harish Rawat, Hon’ble Minister of State for Agriculture and Food Processing Industries, Govt. of India, was the chief guest on the occasion. Shri Pradeep Tamta, Hon’ble Member of Parliament presided over the function. Twenty five exhibition-cum-sale stalls were put by various line departments, institutes and NGOs. More than 800 farmers participated in Mela. Seeds of some improved varieties were given to the farmers.

13.12. India a Ragi Nation

Mr. Satish Patilak, Indiiaa Oil Corporation, Mumbai presented a model for crafting the economy through Ragi and called it as ‘India – a Ragi Nation’ during an interactive meeting organized at VPKAS experimental farm on October 21, 2010.

13.13. Swami Vivekananda Statue Unveiled

Dr. S. Ayyappan, Secretary (DARE) and Director General (ICAR) visited the institute on January 1, 2011, alongwith Dr. S.K. Datta, Deputy Director General (Crop Science). The DG unveiled the statue of Swami Vivekananda at VPKAS Almora Campus and inaugurated the Museum/Technology Park and performed ‘Bhumi Pujan’ (पूजन) at the location where ‘Mushroom Compost Unit’ is proposed to be built at Experimental Farm, Hawalbagh. He mentioned Hawalbagh as the ‘ICAR’s Top Hill Crop Cafeteria.’ On this occasion, VPKAS Newsletter (July-December, 2010) was also released. During discussion with the scientists of the institute, the Director General stressed on need assessment for hill agriculture, which will be useful in prioritization of research and formulation of projects for 12th Five Year Plan. He appreciated the institute’s contribution to hill agriculture and suggested
Kisan Club Dubkhar, which was sponsored by VPKAS and NABARD, Nanital. The club was inaugurated by Mr G S Chaudhary DDM, NABARD, Nanital. On this occasion Scientists, Research Associates and 27 farmers were present.

13.15. Sensitization of hill farmers on Plant Varieties Protection and Farmers’ Rights

A sensitization workshop on ‘Protection of Plant Varieties and Farmers’ Rights Act (PPV&FRA), 2001’ was organized by VPKAS, Almora, for the hill farmers and army personnel at Junior High School, Mahadev Bishar, Pithoragarh on March 13, 2011. The main purpose of organizing this workshop at village level was to create awareness among the hill farmers on various issues related to PPV&FRA, 2001 and to disseminate latest agricultural technologies to the farmers. Dr. J.C. Bhatt, Director, VPKAS, Almora urged the farmers to come forward for registration of traditional farmers’ varieties. Lectures on different issues related to Protection of Plant Varieties and Farmers’ Rights Act, 2001 were given by the experts. Latest agricultural technologies were also exhibited and demonstrated to the farmers during the workshop.

13.14. Farmers’ Day at Dubkhar, Darim

A farmers’ day was organized at village Dubkhar, Block Darim, Nanital on February 28, 2011. It was organized on the occasion of inauguration function of the Kisan Club Dubkhar, which was sponsored by VPKAS and NABARD, Nanital. On this occasion Scientists, Research Associates and 27 farmers were present.

Dr. Asyappan, during his visit expressed his views as –

“The first day of 2011 was a lifetime experience visiting VPKAS, Almora, to unveil the statue of Swami Virendrananda at the institute founded by Late Dr. Sen. With inspiring ambience, work being carried out on all fronts of VPKAS is highly commendable. VPKAS is the focal point of Indian Hill Agriculture. Compliments to Dr. J.C. Bhatt, Director, VPKAS and all colleagues at the institute; prayers for Swami’s blessings and Best Wishes.”

We, all at VPKAS, express our deep sense of gratitude for the views expressed by our respectable Director General and commit ourselves to even higher expectations. We also thank Dr. Datta for his presence and suggestions on the occasion.
DISTINGUISHED VISITORS

- Dr. D.K. Pandey, Dept. of Science & Technology, New Delhi on April 29.
- Dr. G.J. Samathanam, Advisor, DST, New Delhi on April 29.
- Dr. K.L. Chadha, Former DDG (Horti.), ICAR on May 15.
- Dr. H.S. Gupta, Director, IARI on May 15.
- Dr. S.K. Sinha, Principal Director, FSAD, Krishi Bhawan, Gangtok, Sikkim on May 22.
- Mr. Pankaj Kumar Prasad, GMM, NSC, New Delhi on May 22.
- Rear Admiral (Retd.) K.L. Malhan, Gurgaon on May 25.
- Dr. Ashok Kumar, Director (Seed) CCSHAU, Hisar on May 27.
- Dr. V.D. Patil, ADG (Oilseeds & Pulses) ICAR on May 27-28.
- Dr. N.K. Tyagi, Member, ASRB to KVK, Uttarkashi on June 17-19.
- Dr. J.G. Varshney, Director, Directorate of Weed Science on June 23-24.
- Dr. K.R. Dhiman, Vice-Chancellor, YSPUHF, Solan on July 2-3.
- Dr. K.M.L. Pathak, DDG (A.S.), ICAR on July 5.
- Mr. S.K. Mitra, Dy Secretary (Edn., CS), ICAR, New Delhi from June 26-28 and October 6-7.
- Shri Subhash Kumar, Additional Chief Secretary & Agricultural Commissioner, Uttarakhand on July 1.
- Prof. (Dr.) Ajit Pal, IIT, Kharagpur on July 12.
- Dr. K.B. Saxena, Principal Scientist, ICRI SAT, Patancheru, Andhra Pradesh on September 18.
- Shri P.C. Kumar, AGM, BHEL, Haridwar on October 2.
- Dr. J.S. Sandhu, ADG (Seeds) ICAR on October 6-7.
- Shri V.P. Kothiyal, Director (Works) ICAR on October 6-7.
- Mr. Satish Pathak, Indian Oil Corporation, Mumbai on October 21.
- Mr. Mahadevia, Chairman, Narain Trust on October 21.
- Dr. K.N. Bhatt, Govind Ballabh Pant Institute of Social Science, Allahabad on October 21.
- Dr. E. Sharma, ICIMOD, Kathmandu, Nepal on December 5.
- Dr. S. Ayyappan, Secretary, DARE & Director General, ICAR and Dr. S.K. Datta, DDG (CS), ICAR on January 1.
- Dr. B. Patnaik, Project Director, FMD, Mukteshwar on January 1.
- Dr. A.B. Pandey, Incharge, IVRI Mukteshwar on January 1.
- Dr. B.S. Bhut, Vice Chancellor & Dr. H.S. Sharma, Dean, College of Technology, GBPUA&T, Pantnagar on January 9.
- Shri Harish Rawat, Hon’ble Minister of State for Agriculture and Food Processing Industries, GOI on March 29.
- Shri Pradeep Tamta, Hon’ble Member of Parliament on March 29.
- Dr. Y.P.S. Dabas, Director Extension, GBPUA&T, Pantnagar on March 29.
- Dr. T.P. Rajendran, ADG (PP) ICAR on March 11.
LIST OF SCIENTIFIC, TECHNICAL AND ADMINISTRATIVE STAFF

Crop Improvement Division
Dr. P.K. Agrawal, Head
Dr. Vinay Mahajan, Pr. Scientist (up to May 18)
Dr. Lalchmi Kant, Pr. Scientist (Plant Breeding)
Dr. Arun Gupta, Sr. Scientist (Economic Botany)
Dr. Gyanendra Singh, Sr. Scientist (Plant Breeding)
Dr. (Mrs.) Nadella Kanaka Durga, Sr. Scientist (Plant Breeding) (upto May 12)
Dr. N.K. Hedau, Sr. Scientist (Horticulture- Vegetable Science)
Dr. Navinder Saini, Sr. Scientist (Biotechnology) (w.e.f. Feb. 28)
Dr. B. Kalyan Babu, Scientist (Biotechnology)
Mr. R. Arun Kumar, Scientist (Plant Physiology)
Dr. Jay Prakash Aditya, Scientist (Plant Breeding)
Dr. Anuradha Bhardwaj, Scientist (Plant Breeding)
Mr. Shailendra Kumar Jha, Scientist (Plant Breeding)
Mr. Udai Bhaskar Khetinath, Scientist (Seed Science & Technology)
Dr. Salej Sood, Scientist (Plant Breeding) (w.e.f. May 13)
Mr. Ramesh Singh Pal, Scientist (Biochemistry) (w.e.f. September 18)

Crop Production Division
Dr. A.K. Srivastava, Head (upto December 31)
Dr. J.K. Bish, Pr. Scientist (Agronomy) I/C Head (w.e.f. Jan 1)
Dr. S.C. Pandey, Sr. Scientist (Soil Science)
Dr. P.K. Mishra, Sr. Scientist (Microbiology)
Dr. B.M. Pandey, Sr. Scientist (Agronomy)
Dr. K.P. Singh, Scientist (FM&P) (upto January 12)
Dr. Ranjan Bhattacharyya, Scientist (Soil Physics & Soil Water Conservation)
Dr. B.L. Mina, Scientist (SS) (Soil Science)
Dr. Mangal Deep Tuti, Scientist (Agronomy)
Dr. Dibakar Mahanta, Scientist (Agronomy)
Dr. K. Jeevanandhan, Scientist (Agril. Microbiology)
Mr. Suheel Ahmad Daud, Scientist (Forestry) (w.e.f. April 23 to October 8)
Mr. Ram Prakash Yadav, Scientist (Forestry) (w.e.f. September 18)

Crop Protection Section
Dr. S.K. Jain, Pr. Scientist (Pl. Pathology) I/C Head
Dr. R.M. Srivastava, Sr. Scientist (Agril. Entomology) (w.e.f. December 24)
Dr. K.K. Mishra, Sr. Scientist (Pl. Pathology) (w.e.f. February 1)
Dr. J. Stanley, Scientist (Agril. Entomology)
Mr. A.R.N.S. Subbanna, Scientist (Agril. Entomology)
Dr. Chandrashokara C., Scientist (Pl. Pathology)

Social Science Section
Dr. Nirmal Chandra, Pr. Scientist (Agril. Extension) I/C Head (w.e.f. Dec. 16)
Mr. K.K.S. Bish, Scientist (SG) (Agril. Statistics) I/C Head (upto Dec. 15)
Dr. K. Srivastava, Pr. Scientist (Agril. Economics) (upto May 22)
Dr. Mukesh Kumar, Scientist (SS) (Computer Application)
Dr. Manik Lal Roy, Scientist (Agril. Extension)
Dr. Renu Jethi, Scientist (Home Science) (w.e.f. April 23)
Mr. Hukum Raj Laxmanlal Kharbikar, Scientist (Agril. Economics) (w.e.f. April 23)
Dr. Pratibha Joshi, Scientist (Home Science & Family Resource Management) (w.e.f. August 28)

Coordinator
Library & ARIS Cell
Mr. K.K.S. Bish

PME Cell
Dr. K. Srivastava (upto May 22)
Dr. J.K. Bish (w.e.f. May 23)

Farm
Dr. Gyanendra Singh

Vehicle
Mr. T.B. Pal

Guest House
Mr. Ram Murti (upto August 13)
Mr. T.B. Pal (w.e.f. August 14)
Maintenance
Mr. T.B. Pal

Technical Officers
Mr. Beer Singh  
Mr. P.C. Punj  
Mr. Bhurendra Nath  
Mr. T.B. Pal  
Mr. B.D. Pandey  
Mr. N.C. Belwal  
Mr. D.S. Gosai  
Mr. Ram Murli (upto Aug. 12)  
Mr. P.C. Verma  
Mr. Shankar Lal Arya  
Mr. M.S. Khatri

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

Administration and Finance
Administrative Officer
Mr. Mahesh Lal

Assistant Administrative Officers
Mr. M.M. Joshi  
Mr. Babadur Ram

Finance & Accounts Officer & AFAO
Mrs. Shakkos Goswami, AFAO (upto March 3), FAO (w.e.f. March 4)

Stores
Mr. Mahesh Lal

Managerial Staff at KVK, Chinyalisaur
Mr. Hari Govind, Incharge, SMS, Plant Breeding  
Mr. Pandit Nasijal, SMS, Horticulture  
Dr. Deepak Rai, SMS, Plant Protection  
Dr. Vijay Avinashilingam, SMS, Agril. Extension (upto September 28)

Managerial Staff at KVK, Bageshwar
Dr. V.K. Sachan, Programme Coordinator  
Dr. Khindura Singh, SMS, Plant Protection (upto November 20)  
Dr. Ramareet Singh, SMS, Crop Production  
Dr. N.K. Singh, SMS, Veterinary Science  
Mr. Kamal Kumar Pandey, SMS, Horticulture  
Km. Shobha, SMS, Home Science  
Dr. Ram Prakash Sahu, SMS, Agril. Extension

New Colleagues
- Mr. Hukumraj Laxmanrao Kharbikar, Scientist (Agril. Economics) on April 23.
- Mr. Subel Ahmad Dand, Scientist (Forestry) on April 23.
- Dr. Renu Jethi, Scientist (Home Science Extension) on April 23.
- Dr. Saloj Sood, Scientist (Plant Breeding) on May 13.
- Dr. Pratibha Joshi, Scientist (Home Management and Farmers Resources) on August 28.
- Mr. Ramesh Singh Pal, Scientist (Biochemistry) on September 18.
- Mr. Ramesh Singh Yadav, Scientist (Forestry) on September 18, 2010.
- Miss Pooja Rana, Sorno Gr. III on November 15.
- Dr. R.M. Srivastava, Sr. Scientist (Agril. Entomology) on December 24.
- Dr. K.K. Mishra, Sr. Scientist (PL Pathology) on February 1.
- Dr. Navinder Saini, Sr. Scientist (Biotechnology) on February 28.

Transfer/ Promotion
- Dr. (Mrs.) N.K. Durga, Sr. Scientist to NRCPST, New Delhi on May 12.
- Dr. Dinesh Mahajan, Pr. Scientist to DMR, New Delhi on May 18.
- Dr. K. Srinivas, Pr. Scientist to NAARM, Hyderabad on May 22.
- Mr. Ram Murli, Technical Officer to IISR, Lucknow on August 13.
- Dr. Vijay Avinashilingam, N.A., SMS to join at CAU, Imphal, Manipur on September 28.
- Dr. Subheeb Ahmad Dand, Scientist, Forestry to join at shrine Centre of IGIFR on October 8.
- Mrs. S. Goswami, AFAO to FAO (w.e.f. March 4)
- Mrs. Radhika Arya, Sr. Clerk to Assistant (w.e.f. March 30)
- Mr. L.M. Tripathi, Sr. Clerk to Assistant (w.e.f. March 30)
- Dr. S.K. Pant (Retired Senior Scientist) has been promoted as Principal Scientist w.e.f. May 26, 2008.

Retirement
- Dr. A.K. Srivastava, Head, Crop Production Division on December 31.
- Mr. Pan Singh, Skilled Supporting Staff on February 24.
- Mrs. Goswami Devi, Skilled Supporting Staff on February 28.

Study Leave
- Shri B. Kalyan Babu for Ph.D. at GBPUAT, Pantnagar on July 26, 2010.
- Ms. Shobha, SMS, KVK Bageshwar for Ph.D. at GBPUAT, Pantnagar on September 13, 2010.

Obituary
With profound grief, we inform you that Shri Harish Lal Shah, Skilled Supporting Staff, suddenly passed away on October 27, 2010, who served VP KAS for about 33 years.