EXECUTIVE SUMMARY

Enhancement in the Productivity of Major Hill Crops

During the year 2007-08, three varieties/ hybrids (two maize and one wheat) developed by the institute, were released by Central Sub-Committee of Crop Standards, Notification and Release of Varieties (CSCSNRV).

An extra early single cross hybrid **Vivek Maize Hybrid 25** (V 341 X V 346) was released and notified for Zone-I (Uttarakhand, Himachal Pradesh, Jammu & Kashmir and NEH region) and yielded 60-65 q/ha. Another extra-early single cross hybrid **Vivek Maize Hybrid 27** (V 335 X V 345) was released for Zone-III (Eastern UP, Bihar, Jharkhand, Orissa, Chattisgarh and West Bengal) and Zone-IV (Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu) and yielded 40-45 q/ha and 45-50 q/ha, respectively in these zones and matures in 80-85 days (Zone-III) and 85-88 days (Zone-IV). **VL Gehun 892** (WH 542 x PBW266) with an average yield of 30-35 q/ha, was released for Himachal Pradesh and Uttarakhand hills for late sown restricted irrigations. It is nutritionally rich owing to high Fe and Zn content.

VQL 1 (INGR 08011) and **VQL 2 (INGR 0812)** were registered with NBPGR for high tryptophan and lysine contents. Marker Assisted Selection (MAS) was used for the first time in the country to develop VQL 1 and VQL 2 from CM 212 and CM 145, respectively. VQL 1 has high tryptophan (71.4% increase) and lysine content (26.0% increase) while in VQL 2, there is high tryptophan (44.0% increase) and lysine content (8.0% increase).

A total of 232 q of breeder seed of 46 released varieties/ inbred lines were produced. A total of 38.11 q of TL seed of released varieties was produced at Hawalbagh to meet the requirement of the extension activities. In addition, the institute produced nearly 15.7 q nucleus seed of 35 released varieties following standard methods to maintain the genetic purity in breeder seed. A total of 201.80 q breeder seed was supplied to different seed producing agencies to take up further multiplication.

The reduced level of zein improves the nutritional quality of the QPM maize hybrid developed at this institute *viz.*, Vivek QPM 9, which contains 40% more tryptophan and 30% more lysine over the non-QPM hybrid. New QPM hybrids *viz.*, FQH 38, FQH 40, FQH 44 and FQH 55 are under the multi-location trials. Of these, FQH 38 is the QPM version of Vivek Maize Hybrid 21 and FQH 55 is the QPM version of Vivek Maize Hybrid 23. 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 to QPM using two donors *viz.*, CML 173 and CML 189.

Crop Production

Hill agro-ecosystems are highly variable in growing conditions, hence site specific land use was evolved for maximizing farm production. Suitable adoption of cropping systems, silvi-pastoral and agri-horti systems raised the production to 48 q wheat equivalent yield/ha, compared to only 27 q/ha under prevailing cropping pattern. Inclusion of water harvesting component could raise it further to 65 q/ha. In a crop production experiment, cauliflower-tomato-rice sequence recorded the highest rice-equivalent yield (652 q/ha) followed by cauliflower-squash-rice (574 q/ha) as compared to wheat-rice traditional sequence

(109 q/ha). In a study to manage the sulphur deficiency in the rainfed upland rice, application of 3 sprays of 0.5% K_2SO_4 has been found effective.

The crop varieties suitable for organic conditions have been identified. These include VL Dhan 154 (22 q/ha) in rice, VL Mandua 149, VL Mandua 146, VL Mandua 315 (23-25 q/ha) in finger millet, VL Matar 40 (12-13 q/ha) in field pea, VL Masoor125, VL Masoor 126, VL Masoor 507, VL Masoor 4 and VL Masoor 103 (11-15 q/ha) in lentil and VL Gehun 804 and VL Gehun 829 (24-28 q/ha) in wheat. The aromatic rice produced 50 q/ha grain yield using 20 t/ha FYM and was found 1.5 times rich (54 ppm) in iron content.

Pseudomonas fragi (MTCC 8984), a novel cold tolerant phosphate solubilizing bacterium isolated from garlic rhizosphere collected from high altitude area (1800 m amsl), was able to solubilize 16.92 and 7.19 $\mu g\ ml^{-1}$ of P per day, at 15°C and 4°C, respectively with a progressive decrease in the pH of the medium, containing tricalcium phosphate as an insoluble phosphate source. The plant growth promotion ability of the bacterium *Bacillus cereus* (MTCC 7182), determined was in terms of 11.18 and 20.12 ppm of IAA at 15 and 30°C, respectively.

Dual purpose wheat, which gives grain and green forage during winters, can be a suitable option to meet fodder requirement. Cutting of wheat at 5 cm height produced significantly higher forage (88 q/ha) than cutting at 10 cm height from ground, however grain yield did not affect significantly with different cutting heights. Multiplication of *Bhimal* through seeds has been established.

Hill springs are major water source in the Himalaya. Water harvesting by trenches increased the annual discharge of selected springs by 70% in 2007 than 2000. The run-off water harvesting tank of $70m^3$ could support $100m^2$ of vegetable and $200m^2$ cereal cultivation. Land modification in rainfed farming of wheat gave 40 q/ha yield (16% higher than flat bed) in sunken bed. Sixty eight LDPE lined tank and sixty poly houses were constructed under different programmes of the institute. Under protected cultivation, use of soil, sand, FYM and vermin compost in 1:1:0.5:0.5 ratio upto 15 cm depth, resulted 65% higher production of capsicum (225 q/ha).

The Agro-Processing Centre, Takula has undertaken the processing and value addition of the produce of finger millet, barnyard millet, pulses, oil and spices. This showed 130-330 % increase in selling price of agriculture produce.

Integrated Pest Management

The disease and insect scenario monitored through surveys revealed that blast, brown spot & grain discolouration in rice, and turcicum & maydis blight in maize are the prevalent diseases in hills. In wheat, brown rust was moderate with race 104-2 (21R55). Besides the prevailing diseases occurring in low-moderate intensity in different crops, purple blotch of garlic, early blight & buckeye rot of tomato, powdery mildew of pea, tikka of groundnut and anthraonose of horsegram appeared in moderate to severe intensities. Among insects, white grubs continued to be the major pest of rainfed crops of *kharif* in which the species diversity and their abundance was investigated. A predatory bird, red billed blue magpie, *Urocissa erythrorhyncha* was found to feed voraciously on the grubs. The damages caused by *Atherigona* sp. in proso millet, *Heterodera avenae* in wheat and *Meloidogyne* in tomato were recorded as severe in some locations. Besides, *Helicoverpa armigera* wilh peak period from April to June severely damaged the vegetable crops. An entomopathogenic bacteriam, *Serratia marcescens* strain SRM (MTCC 8708) against *H. armigera* was isolated form the summer squash plants.

In studies on management of diseases and insect pest, Florezen-P (*Pseudomonas fluorescens* cfu 2x 10^6 g) followed by Biofer and Flubendiamide 36% + Fipronil 30% (66WG) @ 33 g ai/ha gave superior results in managing the blast disease and stem borer/ leaf folder, respectively, in rice. The organic, IPM and chemical modules were re-evaluated for management of diseases and pests in vegetable pea, which got reduced in all the modules with significant yield increase over control but chemical and IPM modules were superior to organic module. The studies on *Trichoderma* were confined to three indigenous promising isolates (Tr-11, Tr-28 and Tr-34) of *T. harzianum*, through applying them alone and in combinations, for management of soil-borne and foliar diseases in French bean, vegetable pea and lentil. These isolates showed high antagonistic activity and were found superior to remaining isolates showing highest competitive ability when tested for their ability to compete with native soil microflora. In French bean, seed treatment and drenching with Tr-11 isolate of *T. harzianum* and its soil application through fortified FYM or poultry manure was superior in controlling root rot disease. Tr-34 isolate was best after the chemical treatment in reducing foliar diseases when applied as foliar spray. In vegetable pea and lentil, though all the isolates and combinations were effective, but the use of Tr-28 and the combination Tr-11+ Tr-28 and Tr-11+Tr-34 gave superior results in reducing diseases and increasing yield comparable to the chemical treatment. Cartap hydrochloride followed by azadirachtin and *Batain* Seed Kernel extract (BSKE) were effective in suppressing the population of sucking bugs and pod borer in French bean.

In studies on white grubs, the WGPSB-2 strain of *Bacillus cereus* continued to be the most promising which caused more than 85% mortality of the grubs. The technology involving two components *viz.,* use of light-based insect trap for mass trapping of adult beetles and the entomopathogenic bio-agent for killing the subterranean grubs has shown great promise in management of the pest.

In studies on evaluation of antagonistic activity against the wilt pathogen, *Ralstonia solanacearum*, 12 isolates of *Pseudomonas* showed promise and formed the inhibition zone against the pathogen. Of these, seven isolates produced strong lipase toxin phospholipase C. In tests conducted with essential oils (thymol, linalool and citral), thymol was superior (except citral 1000 ppm) in reducing the population of *R. solanacearum* at 500, 750 and 1000 ppm concentrations.

In *Bacillus thuringiensis,* a highly cost effective and simple technique was developed for the mass production of Bt strain VLBt 6 (MTCC-8997).

Socio-Economic Studies and Transfer of Technology

The 'Pest Manager' module was developed for wheat. NAIP web pages were developed and uploaded to institute's website. Institute website and databases for agriculture in North-Western Himalayan states, digital photo library, 'Information Bank', PERMISnet and 'Intelligent Report System' were updated. Database management information systems for 'Production Oriented Survey of Rice' and 'Status of Horticulture and Market Opportunities in Uttarakhand' were developed.

The institute supplied around 400 q breeder seed of improved varieties of different crops for multiplication to the seed multiplication agencies during 2004-05 to 2006-07 from which about 6200 q certified seed was produced.

Gross state domestic product registered a positive growth in economy after the creation of Uttarakhand, however, the growth rate of expenditure in agriculture and allied sector was very low (2.33%) in X Plan; which explains the

low growth rate in agriculture sector (1.03%). Thus, higher investment in agriculture is essential to support the intensification and diversification of production system.

Twelve training programs, involving a total of 223 trainees, were conducted.

Other Research Projects

Significant progress has been made in the research and extension work under HTMM-I, AMAAS and NAIP projects. The salient accomplishments are mentioned here.

HTMM - I

Five varieties each of vegetable pea, French bean and okra were evaluated under organic and ICM modules. Under organic condition, Azad Pea 1 in vegetable pea recorded highest green pod yield (72.1 q/ha) followed by VL Matar 9 (71.3 q/ha) and VL Matar 8 (66.8 q/ha). VL Bean 2 in French bean recorded highest pod yield (124.3 q/ha) closely followed by VL Bauni Bean 1 (120.3 q/ha) and in okra VL Bhnidi 1 recorded maximum fruit yield (116.8 q/ha) followed by VL Bhindi 2 (116.2 q/ha). The plots treated with organic manures were found rich in pH and soil organic carbon. In a study of four organic modules against ICM module, vegetable pea VL Matar 8 gave significantly higher green pod yield (75.2 q/ha) with application of FYM @ 10 t/ha + poultry manure and vermin-compost (each 1.5 t/ha) + biofertilizers than all other modules.

A total of 222.2 kg quality seeds were produced against the target of 171.5 kg in targeted vegetables (vegetable pea, okra, French bean and tomato). About one lakh seedlings of cauliflower (PSBK-1) were produced under protected condition and supplied to the farmers for the off-season production of cauliflower.

A total of 204 farm families were selected across three altitude ranges in Almora, Bageshwar and Nainital Districts, where 2,827 saplings of subtropical fruits and 1,095 of temperate fruits were planted. The average survival of these plants was 60-75%. Fruit plantation of Kiwi was under taken as a major thrust because of its long shelf life and market advantage. Orchards management techniques were demonstrated to the farmers. Diversification to off season vegetables by shifting the cropping pattern, utilizing the fallow land and utilizing the developed command of water resources were demonstrated in an area of 5.80 ha during *kharif* 2007 with a gross income of Rs. 9.73 lakh and 2.96 ha area with gross income of 4.48 lakh in *rabi*. Thus, vegetable farming added to the gross income of Rs. 14.21 lakh from 9.76 ha.

Forty three (7 in 2007-08) LDPE lined tanks with an average capacity of 40 m^3 were constructed, of which 10 ponds were cultivated with fishes for the first time. Depending on the release of finger lings (in March and August), an annual income of Rs. 5,000 to Rs 7,500/- is expected per pond/40m^3 capacity. These tanks were mainly used for irrigation in green houses, open fields and rearing fishes. Besides, 63 green houses were also constructed for cultivation of vegetables like, French bean, capsicum, tomato, cucumber, summer squash, cabbage, cauliflower and green vegetables that gave gross return of Rs. 4.4 lakh.

Sixty five LDPE film tanks with an average capacity of 1,794 m^3 were constructed with different dimensions at farmers' fields in Darim village of Nainital District. The micro-irrigation system provided higher BCR value and IRR in comparison with check basin irrigation.

IPM technology was propagated amongst the farmers of four blocks of Almora district during 3 years period. The activities included Farmers Field Schools, on campus trainings, IPM validations etc. which benefited 480 farmers including 174 in 2007-08. A total of 972 validations (272 in 2007-08) on mandated crops (tomato, French bean, cauliflower,

cabbage, vegetable pea and capsicum) were laid. Average germination of different vegetables in IPM plots ranged between 65 to 90%, which is 20 to 30% higher than the farmers practices. Highest yield upto 7.5 q in bean, 7.5 q in tomato, 7.0 q in capsicum, 6.5 q in cauliflower, 8.0 q in cabbage and 4.5 q in vegetable pea per nali (1 nali = 200 sq. m.) was realized.

A total of 543 demonstrations in 10.9 ha were conducted, out of which 16, 174, 50, 133, 50, 80, and 40 were in August-sown pea, November-sown pea, tomato, french bean, capsicum, cabbage and summer squash, respectively. The average August and November-sown pea yields were 39 (low due to root rot) and 105 q/ha, respectively, in open fields. The yield increase under polyhouse condition, compared to open field, in tomato and capsicum was 243 and 58 per cent, respectively. The average yield of French bean, cabbage and summer squash was 105, 242 and 180 q/ha, respectively in open fields. Four on-farm trainings and two 'Sabji Kisan Diwas' were organized in the adopted villages in which 549 farmers and farmwomen participated.

Twenty-one demonstrations of button mushroom (*Agaricus bisporus*) were laid out at different sites in the villages of Almora district. The yield levels ranged between 15-21%, which made the growers convinced to accept it. Daulaghat village has been developed as a mushroom village where almost all the farmers adopted mushroom cultivation as an economic venture.

In the project on quality seed production of capsicum and squash under protected condition, a total of 87.6 kg seed (capsicum - 3.5, summer squash - 25.3, French bean - 58.8 kg) was produced.

The integrated effect of two novel technologies *viz.*, the light based insect trap and *Bacillus cereus* strain WGPSB-2 based bio-agent for white grubs developed at the institute were demonstrated for the scarabaeids' management at 18 sites located at different altitudes of Uttarakhand. The populations of beetles trapped per trap in 2007-08 were almost half of the beetles trapped in previous year. Besides, 146 kg formulation of bio-agent was applied in the compost pits followed by subsequent applications in the fields. The entomopathogen, *B. cereus* strain WGPSB-2 and fungal antagonist, *Trichoderma harzianum* (Tr-28) showed compatibility and can be used for combined multiplication for a period of four months through farm yard manure, poultry manure, vermin-compost and cowdung.

Planned honey bee pollination enhanced the productivity of horticultural crops. An average increase in seed yield was recorded from 11 to 38% in the planned honey bee pollinated crops over the naturally pollinated ones.

A survey of sixty farm families showed that the benefit cost ratio is the highest for tomato (6.6), followed by cauliflower and pea, whereas the total marketing cost is highest for tomato (Rs.182.4/q), followed by capsicum and bean. Marketing fee in terms of middle men's commission, market tax, etc., has the highest share in total marketing cost.

Hill farming when performed by use of improved small agriculture tools suitable for hills were very effective in improving the efficiency and reducing drudgery. A total of eight farmers' field schools and two fairs were organized for training in the use of more than 13 selected tools, which benefited a total of 1,200 farmers in the selected districts of Almora and Nainital.

AMAAS Project

Fourteen isolates were selected and designated as elite isolates based on their Tri Calcium Phosphate (TCP) solubilizing ability at 4°C. The P solubilizing ability of *Pseudomonas fragi* and *Pseudomonas lurida* under cold incubation temperatures have been reported for the first time. The isolate

Pseudomonas poae strain RT5RP2 registered the highest level of soluble P (26.64 ppm) from TCP, on the 10th day after incubation, closely followed by *Pseudomonas sp* strain RT6RP, which solubilized 26.22 ppm of soluble P on the 10th day of incubation. Multiple antibiotic resistance markers were identified for each of the isolates to facilitate their quality control during inoculant production and environmental detection when applied in soil. Apart from solubilizing P, most isolates were found to harbor more than one plant growth promoting trait at 4°C. Nine elite isolates were identified based on their 16S rRNA sequences.

Twelve cold tolerant bacterial isolates, which have ice nucleation activity in the range of -6.12 to -9.83, showed an increase in Chl a, Chl b, total chlorophyll content and physiologically available iron/ total iron content in wheat. Decrease in Na^+/ K^+ ratio was observed in wheat plants inoculated with the isolates. REP (BOX) PCR analysis revealed genetic diversity among the cold tolerant bacterial cultures isolated from Kumaon region of North Western Himalayas.

NAIP-SRLS Project

The NAIP under sustainable rural livelihood security (SRLS) for selected five districts of Kupwara, Doda, Chamba, Tehri Garhwal and Champawat was launched in January 2008. The project was undertaken with the objective of enhancement of agricultural productivity, management of natural resource base, agro-processing, value addition and improved marketing and empowerment through capacity building and employment generation. The project is being implemented in consortium mode by nine partners including SKUAST-K, SKUAST-J, ChSKHPKV, GBPUAT, CSWCRTI, GBPIHED, IIT-D, BAIF and led by VPKAS, Almora. The project has already made significant progress. This is evident in terms of 45 percent higher production of food crops, additional production of vegetables and mushrooms from the selected clusters.

KVKs

The KVK, Chinyalisaur conducted 57 training programmes (21 on campus and 36 off-campus) with the participation of 1,238 trainees including practicing farmers, farm women, rural youth and extension functionaries on various topics of Crop Improvement, Horticulture, Plant Protection, Agricultural Extension, Dairying and Home Science. Besides, Front Line Demonstration (FLDs) on oilseeds, pulses and other crops were conducted at the farmers' fields in 32.23 ha area (*kharif* – 12.22 ha and *rabi* - 20.01 ha), which benefited 876 farmers. The centre also produced and supplied 36 q of TL seed of 21 released varieties. The KVK, Bageshwar, established in 2007, conducted two training programmes in Agriculture and allied disciplines. FLDs in different crops were conducted in an area of 8 ha. The farmers were supported with high quality seed material and provided with the technological inputs through effective field oriented trainings.