

## **Germplasm and Productivity Improvement of Crops**

Increasing pressure on already scarce resources particularly land and water necessitates improved productivity per unit of land, water, labor and capital on sustainable basis. Productivity improvement underpins higher farm incomes, profitability and better wages for landless laborers. The research projects focused on resource conservation technologies such as raised bed, direct seeding in rice, zero tillage in rice-wheat system and integrated nutrient management. Investigations were directed towards orchard management, vegetable production and processing, understanding the effect of drought and heat stress in wheat, flower shedding in mungbean and nodulation capability in pulses.

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## Wheat

- November planted wheat because of better germination, tillering and grain weight, grain yield of 3690 kg/ha was obtained, whereas, wheat grain yield was 2390 kg/ha in mid December planted wheat crop. Performance of rainfed wheat varieties Wafaq-2001, Margalla 99, GA 2002 was at par at NARC for grain yield. In late planted wheat, higher seed rates did not help to control the yield losses.

## Oilseed

- Out of Three pre-emergence (Top, Dual Gold and Acetachlor @ 1.0, 0.8 and 0.7 lit/acre) and two post-emergence (Gramaxon and ISO Proturon @ 1.0 lit/acre and 0.8 kg/acre) herbicides maximum seed yield (3599 kg/ha) of sunflower was obtained in plot treated with Dual Gold.

## Sugarcane

- Application of pressmud (PM) at 5 t/ha along with recommended rate of NPK (210+125+135 kg/ha) gave maximum cane yield (72.8 t/ha) followed by half NPK + 10 t PM ha (67.9 t ha) (Figure 1).
- In balanced nutrient management trials, application of half NPK + Zn+B (7.5+1.5 kg/ha) +10 t PM ha gave maximum cane yield (84.9 t ha<sup>-1</sup>) followed by recommended rate of NPK+Zn+B (83.8 t ha<sup>-1</sup>) (Figure 2).

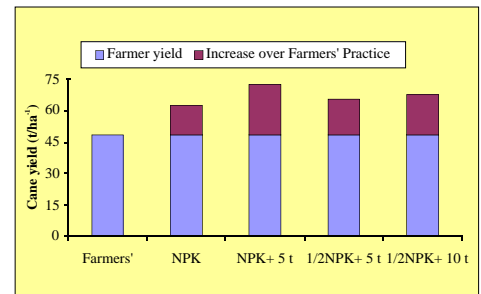


Figure 1. Effect of pressmud on sugarcane yield.

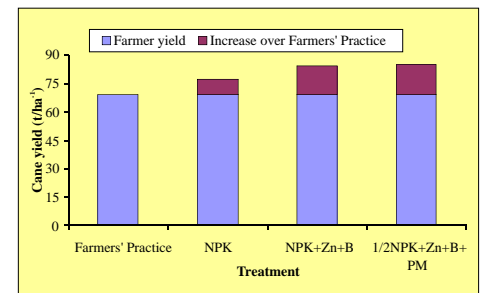


Figure 2. Effect of zinc and boron on sugarcane yield

## Maize, Sorghum and Millet

- Seed of maize variety, Islamabad Gold, Kisan & Agaiti-02992 was produced and distributed in target areas. Seed of sorghum and millet varieties was also produced and disseminated in target areas of NWFP, Punjab and Sindh. All the dissemination was done through participatory approach.

## Pulses

- In chickpea, the application of root nodulating *Rhizobium* bacteria affected nodule number and branches per plant positively. The varieties NCS 950204 and NCS 9917 performed better with respect to branches and pods per plant, 100-seed weight and yield per plant. Cultivar NCS 9917 was found more responsive to *Rhizobium* inoculation for seed yield while cultivar Pb.91xICC 13508 outperformed others in traits like branches/plant, 100-seed weight. and yield/plant.
- Cultivar NARC-02-2 with seed yield of 2384 kg/ha, notwithstanding its nodulation capability, outperformed others followed by Masoor-2004 (1975 kg/ha) and RK-2004 (1956 kg/ha).
- Seed yields of two high yielding mung genotypes, NCM-209 and Chakwal Mung-97 corresponded well with their high nodular activity producing nodule dry mass of 168 and 165 mg/plant, respectively.

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## Fodder

- Improved production technologies for various fodder crops have been developed and seed of oats varieties and rootstock/cuttings of Mott Grass were disseminated to various institutes, farmers and organizations throughout the country.
- Vetch, a new winter forage legume has been identified for rainfed areas.



**Mott grass grown at NARC for distribution to farmers**



**Vetch: a new winter forage legume for rainfed areas**

## Plant Physiology

- Five wheat varieties namely Chakwal-97, Inqalab-91, Margalla-99, NR-234 and Wafaq-2001 were exposed for three consecutive drought cycles at tillering, pre-anthesis and milky growth stage. 39-64% reduction in grain yield was observed when drought was imposed at pre-anthesis stage in all the tested varieties. Wafaq-2001 performed better by producing more spikelets and filled seeds per spike. The same variety accumulated highest proline and protein.
- Six wheat varieties viz., As-2002, Inqalab-91, Punjab-96, NR-234, Wafaq-2001 and SH-2002 were exposed to heat stress at milky growth stage showed 25% reduction in grain yield. Biochemical analysis showed that wheat varieties having high proline and protein contents and less relative membrane injury under heat stress seems to be heat tolerant varieties.
- Two coarse (Pakhla and KS-282) and one fine rice varieties (Bas-385) were exposed to drought stress at primordia, milky and primordial + milky growth stages. The relative decrease (39-41%) in total grain yield was greater at primordial + milky growth stages. Drought decreased protein and increased proline contents.
- Hormones GA and Kinetin alone or in combination as seed treatment were found better to control flower shedding in mungbean and thus increased the grain yield upto 33%. The hormones also increased proline and chlorophyll contents that might have contributed towards yield increase.

## Plant Genetic Resources

- Over 2000 accessions of wheat, rice, barley, maize sorghum, millet, oilseed, brassica, safflower, peas, tomato and grapes were characterized for various agro-morphological characters. Germplasm revealed a considerable level of variation for traits of economic importance. Germplasm of wheat and barley was evaluated at Pindi Bhattian (hot spot) for salinity tolerance and few accessions displayed better tolerance

## GERMPLASM AND PRODUCTIVITY IMPROVEMENT OF CROPS



Screening and evaluation of wheat landrace genotypes under field conditions at NARC

- to salinity.
- More than 1000 accessions of various underutilized and medicinal herbs were rejuvenated, multiplied
- characterized and evaluated in the field for various quantitative and qualitative traits. Few elite lines for yield and yield components were identified.
- Grapes clonal repository including 156 accessions is being
- maintained at NARC. The germplasm was characterized for 14 genetic characters.
- Seed analysis for quality traits, i.e., oil content, erucic acid and glucosinolates was carried out using oilseed brassica germplasm (*Brassica juncea*, *B. napus*, *B. campestris* and *Eruca sativa*). Results revealed that majority of brassica accessions from Pakistan have high level of erucic acid and glucosinolates in their seeds. Some of the introduced varieties and advanced breeding lines



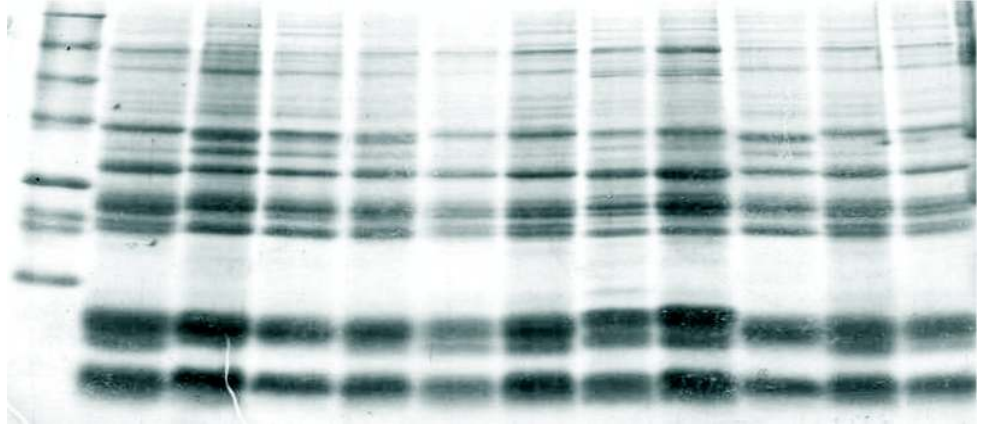
Fruit diversity in grapes germplasm



Evaluation of oilseed brassica germplasm under field conditions at NARC

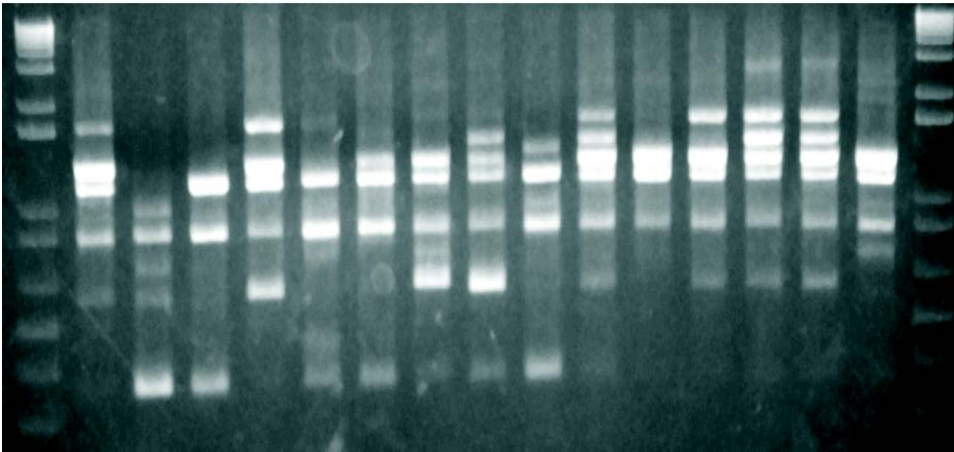
## GERMPLASM AND PRODUCTIVITY IMPROVEMENT OF CROPS

- showed low level of erucic acid and glucosinolates.
- A total of 800 accessions of various crops including peas, wheat, rice, sunflower, oilseed brassica and their wild relatives were examined for total seed proteins using SDS-PAGE analysis. Pea germplasm showed a considerable level of



Biochemical analysis of *Brassica* accessions using SDS-PAGE of total seed proteins

M 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 M

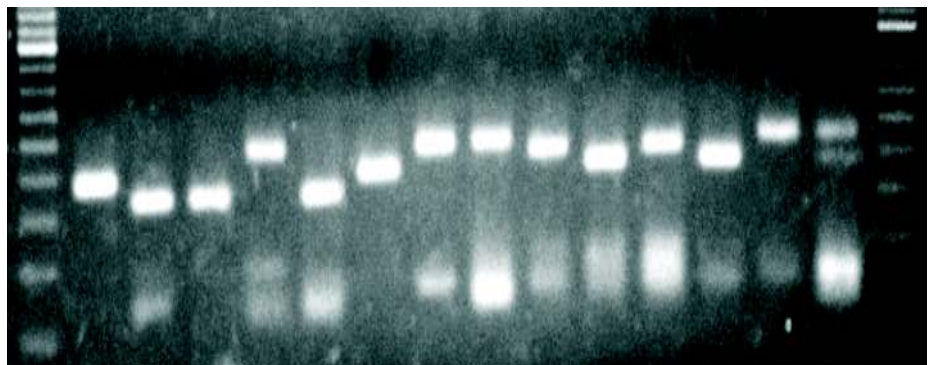


RAPD banding pattern of 15 commercial varieties and primitive cultivars of rice generated by random primer OPA-18. The lanes represent M-1Kb plus molecular marker; 1-Basmati-370, 2-Jhona-349, 3-Sathra, 4-Palman-sufaid, 5-Basmati-C622, 6-Basmati-Pak, 7-PK-177, 8-KS-282, 9-Basmati-385, 10-Super-basmati, 11-Basmati-2000, 12-Kashmir-basmati, 13-NIAB-IR9, 14-Shaheen-basmati, 15-Rachna-basmati

- variability for total seed proteins.

- Total genomic DNA of 75 landraces/cultivars of rice, 70 genotypes of peas and 32 accessions of Kalonji were isolated, quantified for DNA fingerprinting using RAPD/SSR analysis. Most of the commercial varieties and old cultivars clustered into distinct groups, corresponding to basmati, coarse and japonica type of rice.

M 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 M



Microsatellite banding pattern of 14 commercial cultivars of rice generated by SSR primer pairs RM-310. The lanes represent M-20bp molecular marker; 1~14 name of rice cultivar given in above figure

## GERMPLASM AND PRODUCTIVITY IMPROVEMENT OF CROPS

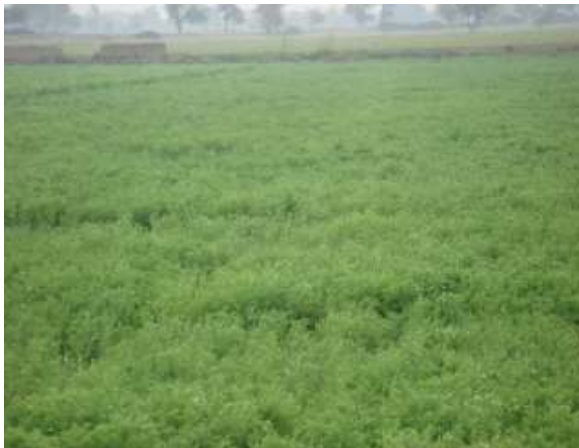
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- Germplasm of vegetatively propagated plant species including potato, peach, grapes, pear, sugarcane, etc. were rejuvenated for extending the longevity of cultures, in-vitro conservation and future utilization.
- Twenty-five demonstration plots (1~2 acres each) of medicinal herbs including kalonji, ispaghol, gul-e-baboona, tukhme-balungoo and fennel were sown at farmers' fields in the districts of Bhakkar, Leyyah, Bahawalpur, Vehari, Okara and Kasur.



**In vitro established culture of pear**



**Field evaluation of medicinal herbs at farmer's field (left) Kalonji (right) Ispaghool**

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### **Land Resources**

- Abscisic acid (ABA) and benzyladenine (BA) treatments had a significant ameliorative effect against
- NaCl salinity stress on wheat varieties Inqalab-91 and SAARC-1. Salt treatment increased the concentration of Na<sup>+</sup> and Cl<sup>-</sup> in flag leaf of both the cultivars. However, ABA and BA treated plants showed significant decrease in Na<sup>+</sup> content and increased K<sup>+</sup> content in flag leaf of both the cultivars. ABA and BA increased number of grains per spike, grain yield and proline accumulation.
- Shoot and root dry weight of three rice cultivars, Super Basmati, Shaheen Basmati and cv.IR-6 was
- decreased by salinity stress. However abscisic acid (ABA), benzyladenine (BA) and cycocel (CCC) treatment increased shoot and root dry weight over that of salt alone and decreased Na<sup>+</sup> content in flag leaves as well as in roots. The ranking of growth regulators for their effects on grain yield and 1000-grain weight was ABA>BA>CCC. Higher grain yield and 1000-grain weight was recorded in cv.IR-6.
- Increase in NaCl salinity decreased shoot dry weight of all 15 *Brassica* genotypes tested. Genotype

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Sultan Raya produced the maximum shoot and root dry weight followed by BARD-1, 19-H, Toria, 85-5001, BSA, Shiralle, Con-1, 85-497, Dunkled, 85-508, 85-499, Jewel and 85-500.

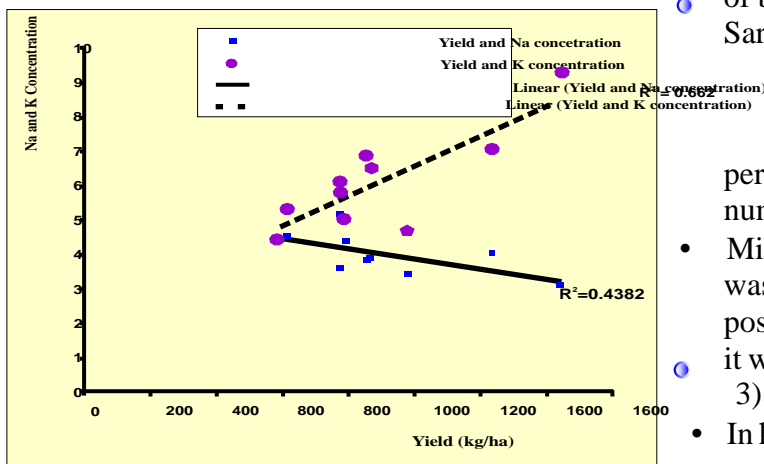
- Sodium content (%) in shoot and root of different *Brassica* genotypes increased with increase in salinity. Sultan Raya had minimum Na content. There was a strong negative correlation between shoot Na<sup>+</sup> content and shoot/root dry weights in all *Brassica* genotypes (R = -0.42 and -0.38, respectively). Potassium content of shoot and root in *Brassica* genotypes decreased with increase in salinity. *Brassica* genotypes differed significantly with respect to shoot/root potassium content. Genotype BSA contained more potassium than the rest of genotypes.
- Salinity also affected calcium uptake and Sultan Raya had the maximum Ca. Positive correlation between shoot Ca<sup>2+</sup> contents and shoot/root dry weights was observed. High Ca<sup>2+</sup> and low Na<sup>+</sup> contents in shoots of *Brassica* can be used as selection criteria under salt stress conditions (Table).

**Table. Correlation coefficients for different growth and ionic content variables recorded in *Brassica* cultivars**

	Root Ca <sup>2+</sup>	Shoot Ca <sup>2+</sup>	Root K <sup>+</sup>	Shoot K <sup>+</sup>	Root Na <sup>+</sup>	Shoot Na <sup>+</sup>	RDW	SDW
<b>Root Ca<sup>2+</sup></b>	1							
<b>Shoot Ca<sup>2+</sup></b>	-0.083	1						
<b>Root K<sup>+</sup></b>	0.439**	0.002	1					
<b>Shoot K<sup>+</sup></b>	0.187	-0.014	0.243	1				
<b>Root Na<sup>+</sup></b>	0.326*	-0.224	0.13	0.357*	1			
<b>Shoot Na<sup>+</sup></b>	0.154	-0.325*	-0.266	-0.017	-0.067	1		
<b>RDW</b>	-0.284*	0.306*	0.174	0.24	0.151	-0.382**	1	
<b>SDW</b>	-0.4**	0.288*	0.198	0.227	0.036	-0.423**	0.97***	1

\* Significant at 0.05, \*\* Significant at 0.01 and \*\*\* Significant at 0.001

- Cultivar Rainbow had the maximum plant height closely followed by Dunkled at two salt affected sites;
- Soil Salinity Research Institute, Pindi Bhattian and at a farmer's field in Sarghoda; Sultan Raya and BRS-II produced more number of branches per plant. Comparatively a stunted growth and less number of branches were observed in the farmer's field in Sarghoda possibly because of high salinity. Numbers of pods per plant were different at both of the sites. Cultivar Dunkled produced the maximum number of pods per plant at SSRI, Pindi Bhattian while pod number was higher with Rainbow at Sargodha.
- Minimum Na<sup>+</sup> and maximum K<sup>+</sup> concentration was observed in tissues of Sultan Raya. Yield was positively correlated with tissue K<sup>+</sup> content while it was negatively correlated to Na<sup>+</sup> content (Figure 3).
- In hydroponics *Brassica campestris* and *B. juncea* responded significantly (P < 0.01) to graded levels of Ca<sup>2+</sup> in the root medium for growth and ions



**Figure 3. Correlation between Na and K concentration of different *Brassica* cultivars and yield**

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concentrations. Fresh mass of both species increased as compared to control at 4 to 10 mM  $\text{Ca}^{2+}$  application. In shoot of *B. campestris* and *B. juncea*,  $\text{Ca}^{2+}$  had synergistic relation with S and  $\text{K}^+$ . In *B. campestris* K and S had linear relations with  $\text{Ca}^{2+}$ . Sodium ion had negative relationship with  $\text{Ca}^{2+}$ .

- Application of Rhizobium and fertilizer P increased chickpea yield in two fields NARC, Islamabad and at a farmer's field, Fatehjang. Phosphorus solubilizing microorganisms (PSM) were effective at Fatehjang but not at NARC. Even  $\frac{1}{2}$  P (i.e., 40kg  $\text{P}_2\text{O}_5 \text{ ha}^{-1}$ ) was sufficient at NARC but at Fatehjang full dose of P (i.e., 80kg  $\text{P}_2\text{O}_5 \text{ ha}^{-1}$ ) was more effective (Figure 4).

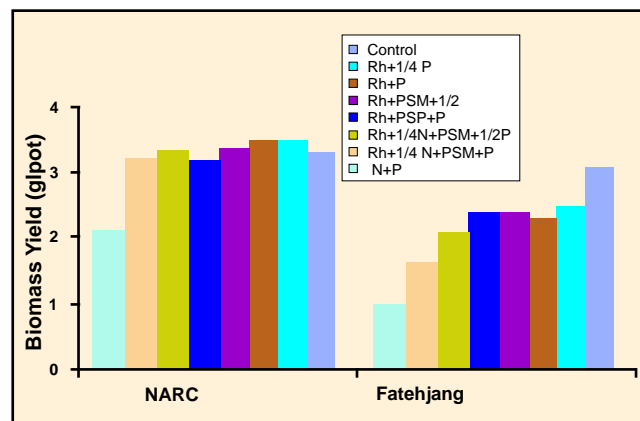


Figure 4. Integrated use of Rhizobium, PSM and fertilizer-P Increases grain yield of chickpea

### Plant Growth Promoting Rhizobacteria Increase Rice Yield

- Plant growth promoting Rhizobacteria (PGPR) isolates significantly increased rice biomass. Among the isolates RPR-51 was more effective that increased rice biomass yield over fertilizer control by 46%. However, mixture of all three isolates was even more effective that had 66% increase in yield over control (Figure 5).
- Three hundred (300) bags of Biozote (Rhizobium based bio-fertilizer) (one bag/acre) were produced and distributed among farmers for legume crops, chickpea, mung/mash, lentil, soybean and groundnut. Fifty (50) bags of Biozote were given to researchers and students of different universities e.g., UAAR, QAU and other research/ educational institutions.

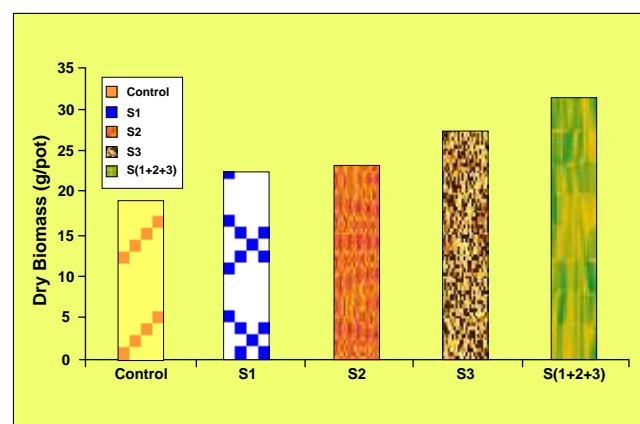


Figure 5. Plant growth promoting rhizobacteria (PGPR) increase rice biomass yield

### ΔZRI, Umerkot

- Out of 12 varieties of Sorghum, MR BURSTER produced highest yield (4163) kg  $\text{ha}^{-1}$  followed by PARC SS-2 and CSV-13 (2618 and 2439 kg/ $\text{ha}^{-1}$  respectively), whereas RS-29 provided lowest grain yield (1186 kg  $\text{ha}^{-1}$ ).
- Two varieties, Johar (sorghum) and Bajra super-1 (millet) of PARC were selected and introduced among farmers of both irrigated (Umerkot) and rainfed areas of Thar desert.

### AZRI, D.I. Khan

- Effect of various inputs i.e. fertilizer (@ 20:50 kg NP  $\text{ha}^{-1}$ ), insecticide (Methamedophos @ 1000 ml  $\text{ha}^{-1}$ ) and hand weeding, alone and in different combinations, tested for grain yield showed significant variation among the treatments. The highest grain yield was obtained in the treatment receiving all the three inputs.

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- Significant effect of Methamedophos on the grain yield and yield component of mungbean against grasshopper attack was noticed.. The grain yield ranged from 487 to 708 kg ha<sup>-1</sup>. The highest yield was obtained @ 1000 ml ha<sup>-1</sup> Methamedophos spraying showing 45 % increase over control.

### Tea

- Tea (*Camellia sinensis* L.) plants once established require 5-6 years to come into economical production and remain productive, thereafter for 90-100 years. Thus the use of inferior planting material would
- certainly affect the productivity and profitability of crop for years. After nursery performance, the germplasm was transplanted in the field in 24 lines. Out of these plants of 10 lines showed the same characters as of their parents in terms of yield and quality of made tea.

### Citrus

- Nutrient uptake and tolerance to cold weather was better on Troyer citrange in Salustiana orange whereas for these factors Kinnow mandarin performed better on Sweet lime.
- Nursery of citrus rootstocks have been raised to check by challenging these at early stage of growth with
- biotic stress factors (nematodes and soil borne fungi) in collaboration with Crop Diseases Research Programme.

### Peach

- Plant height, stem girth and canopy of cv. Florida King budded on GF 677 was more (3.51m, 26.21 cm, 6.38m respectively) compared to Peshawar local (2.43m, 21.07cm, 5.35m) and Swat local (2.20m, 17.5cm, 4.25m). Leaf samples for nutritional uptake capability analysis were collected.
- Rooting of dormant Hardwood cuttings of three peach varieties and peach rootstock GF 677 under field
- conditions.
- Self rooted nursery plants of peach cultivars (Florida King 33%, Early Grand 40%, Maravillah 23% and GF 677 23%) were growing well, no mortality was observed in the rooted plantlets. Moreover, the plants have attained the field transplantable height within a year.

### Potato

- Foliar application of K superimposition enhanced tuber yield from 1.3 to 2.1 t ha<sup>-1</sup>.
- At 85 day after planting the maximum yield of 22.5 t ha<sup>-1</sup> was obtained by TPS 9813 which was followed by TPS 9802 (21.10 t ha<sup>-1</sup>). These two TPS progenies also performed better at 55 and 75 days after planting.

### KARINA, Juglote

- The nitrogen and phosphorus level of 110 kg ha<sup>-1</sup> and 100 kg ha<sup>-1</sup> gave the highest yield of 43.95 t ha<sup>-1</sup> of tomato whereas control gave the lowest of 16.48 t/ha<sup>-1</sup>.
- The plant to plant spacing of 75 cm x 60 cm with an average NPK dose of 75, 50, 30 kg/ha<sup>-1</sup> gave the highest yield of 9.83 t ha<sup>-1</sup> sweet pepper whereas the control gave the lowest yield of 7.51 t ha<sup>-1</sup>.