ANNUAL ABRIDGED REPORT, 2018-19

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OVERVIEW:

Mango (*Mangiferaindica* L.) is a scrumptious fruit commodity enriched with vast diversity in color, taste and aroma. It thrives in tropical to subtropical climatic region of Pakistan from Sindh province to Punjab. Mango region occupies most of the south part of Punjab province. Pakistan possesses an area 170.74 thousand hectares with annual production of 1758 thousand tons under mango but the Punjab province has 105.65 thousand hectares area that generates 1375 thousand tons production and the 61.5 thousand ton into international trade during 2016-17. Mango Research Institute, Multan is premium institute rendering its best research endeavors and working with all allied discipline i.e. Plant Pathology, Entomology, Postharvest and Nutrition under one roof. The judicious use of farm inputs and water resources to produce safe and healthy mangoes can only be possible by invigoration advanced technologies. The institute is gear up its activities into small tree system or ultra high-density plantation system in mango. After completion of research activities, its recommendation will be imparted to the farmer ends. The major challenge is climatic variability and mango is vulnerable to these events. Weather conditions drag the mango flowering into very early as manifested in the previous year but current year shift flowering mechanism too late, however, in fluctuation weather event crop resilient production technology is need of times that veto the hike of menace and bridges towards crop regularization. This institute developed strategic efforts to capacity build of agri-extension staff in various mango growing districts, pesticides companies' representatives, mango farming community and their allied farm labors, to create awareness for different phonological based operations for the betterment of mango crop. The institute empowers the mango growing stakeholders by constituting its Research and Development Board to engage them and develop problem-orientated research options. Mango Research Institute, Multan has launched SMS castor service regarding critical pest attack and farm operations as a caution to remain vigilant and stuck to their farm to enhance its performance. The print and electronic media are fully engaged for the prompt dissemination of recommendations at the grower's door step under changing weather regimes. The glance of research activities recapitulated during 2018-19.

1. HORTICULTURE SECTION

1.1. Use of interstock technique in mango to evaluate its impact on plant dwarfness and fruit maturity in mango cv. Sindhri

This research trial was performed with objective to invigorate the dwarfness character in local vigorous growing mango cultivar Sindhri. The polyembryonic mango variety 13-1 originated in Israel was used as rootstock and it possess good tolerance toward the calcareous based soil. The experiment consisted of four treatment T_1 (13-1 rootstock interstocked with Sensation and final stock with Sindhri), T_2 (13-1 rootstock interstocked with Neelum and final stock with Sindhri), T_3 (13-1 rootstock interstocked with TotaPari and final stock with Sindhri) and T_4 (13-1 rootstock interstocked and final stock with Sindhri) repeated four times under RCBD design. Our local acclimatized dwarf mango cultivars like Sensation, Neelum, TotaPari and vigorous growing cultivars Sindhri were used as interstocks. When these interstocks attained the graftable height and girths, the scion of Sindhri was final grafted on these interstocks accordingly. These plants were transferred to bigger pots for further growth in October, 2016. These plants will be transplanted in the field condition for required studies in October, 2019. The results showed that maximum plant height (130cm) and number of flushes per plants (07) were recorded in T_4 whereas minimum plant height (60cm) and number of flushes per plants (03) were recorded in T_3 (Neelum). The dwarfness character was manifested well in case of Neelum and second most was (90cm) in TotaPari interstock plants as shown in (Fig.1 and 2)

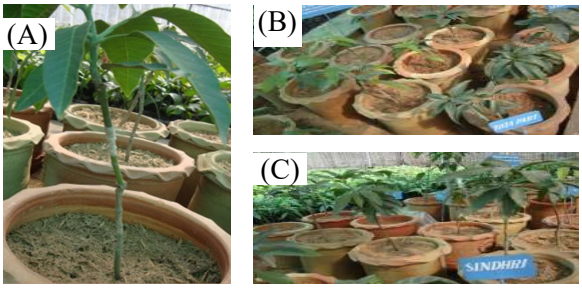


Fig. 1 Manifestation of various polyembryonic rootstocks (A) and various indigenous mango cultivars used as interstock (B) and final stock with Sindhri (C)in order to invigorate the dwarfness traits via grafting

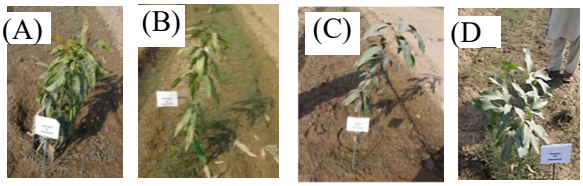


Fig.2 Left to right) Tota Pari (A) as interstock, sindhri (B) as interstock, sensation (C)as in terstock, Neelum (D) as interstok

1.2. Development of new mango varieties through hybridization

This research experiment was initiated to develop new mango varieties with better yield and quality traits through hybridization of promising mango cultivars. The varieties were selected due to salient features as Sindhri possess early season maturity, good shelf life but tapka when fruit is mature; Sufaid Chaunsa have good on tree storage, no tapka, good shelf life, but late season maturity. Sensation is red colored blush cultivar, dwarf in nature, late maturing and firm texture of pulp in fruits; SB Chaunsa have good characters of sweetness, mid-season maturity, but difficult in regular cropping behavior. The reciprocal cross strategy was adopted due to transfer of cytoplasm traits into next progeny. It comprised of three crosses T_1 (SufaidChaunsa x Sindhri),

T_2(Sindhri x SB Chaunsa), T_3(SB Chaunsa x Sensation) and reciprocated as well. These mango cultivars emerged late flowering in January and due to sudden warm weather conditions the less span was available for crossing work. The flowers according to the plan were crossed and approximately 100 crosses of each combination were made. The fruit set percentage was satisfactory and afterwards a strong series of wind storms causes fruit drop. Only cross of (Sensation x SB Chaunsa) was succeeded with two hybrid fruits paving towards its maturity.After that this fruit dropped due to wind storm and immature seed did not show germination. During the previous year three hybrid seedlings of mango were achieved and are flourishing under lath house conditions for their further studies. The hybrid plant of Sammar Bahishat Chaunsa x Sindhri attained the plant height of 160cm while Sindhri x Sufaid Chaunsa possesses 117cm and Sensation x Sammar Bahishat Chaunsa has 110cm plant height in lath house conditions under intensive care. Nonetheless, during the current year none of the crosses could manage to survive as intensity of natural calamities was much stronger this year as compared to previous years as in (Fig. 3)

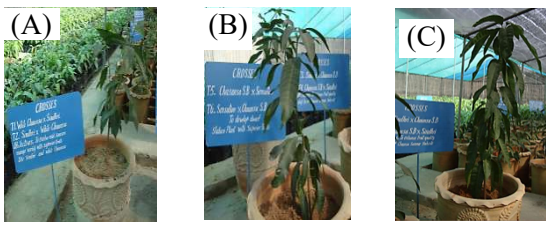


Fig.3 Hybrid plants (left to right) Sindhri x Safaid Chaunsa (A),Sufaid Chaunsa x SB Chaunsa (B), SB Chaunsa x Sindhri (C)

1.3. Performance of mango cultivar Sammar Bahishat Chaunsa on various polyembryonic mango rootstocks

This trial was conducted to evaluate the response of mango cultivar Sammar Bahishat Chaunsa on various polyembryonic rootstocks viz. Carabao Super Manila, Kensington Pride and R2E2. All the mango rootstocks manifested their polyembryonic behavior after germination during previous years. The only nucellar seedlings were selected and when they attained graftable height prolific mango cultivar Sammar Bahishat Chaunsa was grafted on these nucellar seedlings. The polyembryonic mango rootstock Kensington Pride produced vigorous growth than other rootstocks. Polyembryonic plants under each treatment (05) have been transplanted in the field for further studies. Maximum plant height (155cm) was recorded in T_4 where Bullocks Hearts was used as rootstock and in T_3 R2E2 gave (108cm) but in case of T_1Carabao (Super Manila) plant height was minimal (75cm). Number of vegetative flushes per plant in T_4 was recorded (08) whereas six flushes were observed in T_1. The bud wood screening experiment concluded Carabao Lamao and Bullock Hearts manifested tolerant against mango sudden death disease after inoculation with *(Ceratocystis fimbriata)*. Hence, during the current season the seedlings of these tolerant rootstocks were included in this trial and when these seedlings shall attain the gaftable height, the scion wood of Sammar Bahishat Chaunsa would be grafted accordingly for further study as in (Fig. 4)

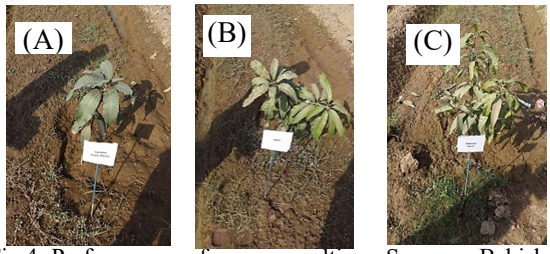


Fig.4 Performance of mango cultivar Sammar Bahishat Chaunsa on various polyembryonic mango rootstocks i.e Bullocks Hearts (A), Kensington Pride (B) and Carabao Lamao (C)

1.4. Survey for the selection of new promising mango varieties

The experiment was long term nature to isolate the chance seedling mango tree having better traits. Survey was carried out in different mango regions and fruits of promising varieties were collected and evaluated for quality attributes. The varieties showed significant behavior were remained under close observation of researchers to explore its characteristics and bud wood was also collected and multiplied in sectional mango nursery for further evaluation. Newly identified mango selections are given as in (Table 1) as well as (Fig. 5 and 6)

Selection Identified	Fruit weight (g)	Peel weight (g)	Stone weight (g)	Pulp weight (g)	TSS Brix)
PREVIOUS SELECTIONS					
Sajjan	320	55	73	192	24.5
FK-2017	470	65	84	321	22.3
NEW SELECTIONS					
Sandeela (Summer)	296	45	54	197	19
Sandeela (Winter)	292	49	56	187	22.5
Haseen	375	46	54	275	23

Table 1. Data profile of promising mango varieties

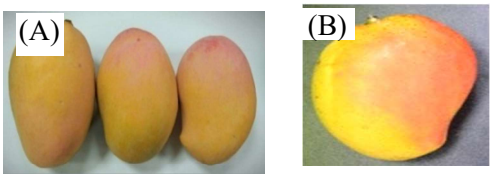


Fig. 5 Fruits of Sandeela crop in summer (A) and winter (B)(above and below)

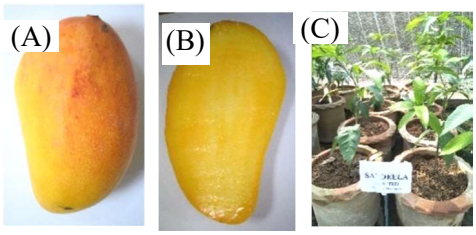


Fig.6 (left to right) Haseen fruit (A) transverse (B) and grafted plants (C) in MRI nursery

1.5. Effect of different chemicals to protect mango seedlings from frost and cold weather injuries

The experiment was scheduled to study the effective treatment against the prevailing frost/cold weather injuries on mango seedlings. Six foliar sprays of different chemicals were applied after fortnight interval starting from 15th November to 15thFebruary. These include control (T_o), H_2O_2 (T_1), Ascorbic Acid (T_2), Salicylic Acid (T_3), and three commercial products Wet-Cit (T_4), Megafol (T_5) and AF-6 (T_6). The data for number of frosty nights was recorded from monthly meteorological data. The performance of T_6 gave good results among all treatments as damage bud sign (01), leaf damage (03) and no bark damage symptoms while second option provide (02) bud damage sign, (04) leaves damage and (01) bark damage sign recorded in the experiment as shown in (Fig. 7)

Fig.7 Effect of different chemicals to protect mango seedlings from frost and cold weather injuries.

1.6. Identification and evaluation of various available pot media ingredients for clean mango nursery plants

The experiment was planned in order to identify the various crop residues to be utilized as potential pot media ingredients. Pot media play an important role in success of mango nursery. Local available and cheap source was identified which has potential for utilization in as source of pot media ingredients. The crop residues were identified as T_1 Sugarcane baggase, T_2 Sunflower heads, T_3 Leaf litter, T_4 FYM, T_5 Corn cob, T_6 Wheat straw and T_7 Rice straw. These media ingredients were grinded and divided into three categories as coarse particles (>5mm) after sieving, medium particle (>5 and <3mm) while fine particles (<3mm). The pot media physical and chemical properties depend on particle size of the ingredients. Maximum electrical conductivity was recorded in Sunflower head of all particles size as 13.76dSm^{-1} while minimum was recorded in Sugarcane baggase in all particles size <1.21dSm^{-1}. Every media ingredient has advantage and disadvantage over other in some physical and chemical properties. The future prospects of this experiment will be utilization of these ingredients in various proportions to search our suitable combination of mango nursery plants as (Fig.8)

Fig. 8 Different potting media showing different particle size categorized as coarse (A), medium (B) and fine (C)

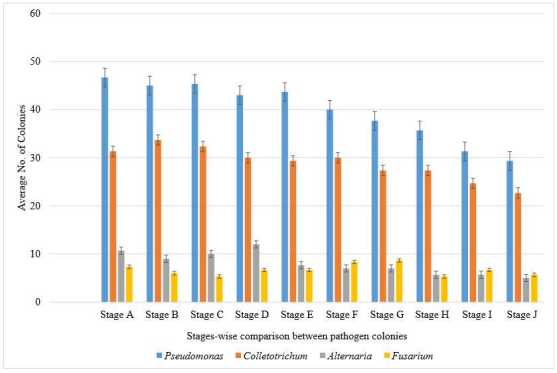
2. PLANT PATHOLOGY SECTION

2.1 Investigation and management of apical necrosis as new bacterial threat to mango orchards

The study was conducted to survey and collect diseased floral buds from tree orchards. Symptomatic buds were exercised in small pieces and cultured on PDA and Kings's Agar B media. Associated pathogens were identified as *Pseudomonas syringae* Pv *syringae*, *Fusarium mangiferae*, *Colletotrichum gloeosporoides* and A*lternaria* spp. Identification was carried out on the basis of morphological characteristics and standardized protocols. Infection frequency of associated pathogens was calculated. *Pseudomonas syringae*pv. *syringae* was the most frequently isolated pathogen at each flowering stage. Infection frequency of *Pseudomonas syringae*pv. *syringae* was maximum 93.33% at stage A(Fig 9(A). Confirmation of the capability of the *Pseudomonas syringae*pv. *syringa*e to cause the disease was done following the Koch's postulates in both the conditions *in-vitro* and *in-vivo*. Infection frequency of each isolated pathogen was correlated with environmental factors. In case of *Pseudomonas syringae*pv. *syringae* ,it was concluded that pathogen infestation was highly favored by high humidity and low temperature. It was also noticed that rain fall also highly correlated with pathogen infestation. It was also observed that correlation between infection frequencies of *Pseudomonas syringae*pv. *syringae* and relative humidity was positive maximum while the correlation was negative maximum with temperature (Fig.9

(B&C). Evaluation of six bactericides viz: Copper hydroxide, Copper oxy-chloride, Streptomycin, Streptomycin sulphae, Kasugamysin and elemental /sulphur + Copper sulphate*in –vitro* through food poisoning technique was done as chemical management of this menace and concluded that Copper hydroxide was most effective at 200 ug/ml concentration . Experiment was conducted under completely randomized design (CRD) with five replications for each treatment. It was concluded that *Pseudomonas syringae*pv. *syringae* bacterium was isolated from each flowering stage A to J. The predominant bacteria was tested as Gram negative. This bacterium was found pathogenic tested through Pathogenicity test. Copper hydroxide was evaluated as best bactericide to control it as shown (Graph .1 A-D

A



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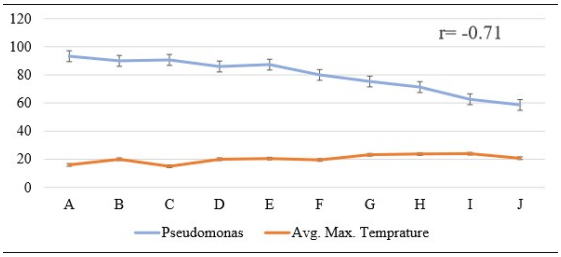
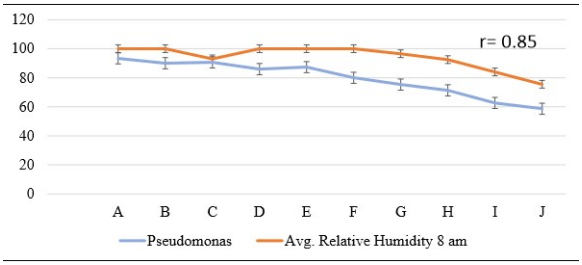
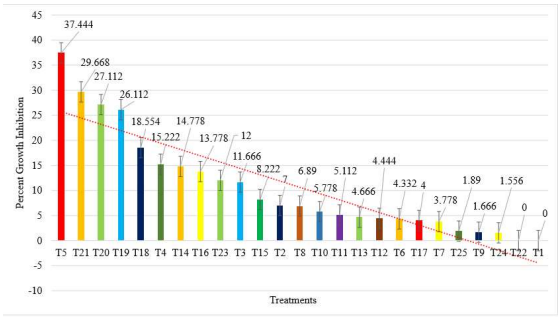


C



D



Graph 1. (**A**) Various pathogens isolated from mango flowers at different stages from A to J.(**B**) Indicates negative correlation between infection frequency of bacterium Pseudomonas and Temperature.(**C**) Indicates positive correlation between infection of Pseudomonas and Relative Humidity. (**D**) Inhibition of bacterial growth using various chemicals

2.2 Impact of environmental variables on floral diseases of commercial mango varieties.

This study was initiated during the current spring season to check the effect of environmental variables such as temperature, humidity, rain fall on floral disease development of mango. The study was conducted in Multan and Vehari districts. Varieties such as Langhra, Doshari, Ratol, Sindhri and Sufaid Chaunsa were included in study. The metrological data were recorded on daily basis from Central Cotton Research

Institute, Multan, websites and weather stations installed in respective district. The data related to diseases incidence of Blossom Blight, Apical necrosis and powdery mildew were recording after fifteen days as (Fig. 9)

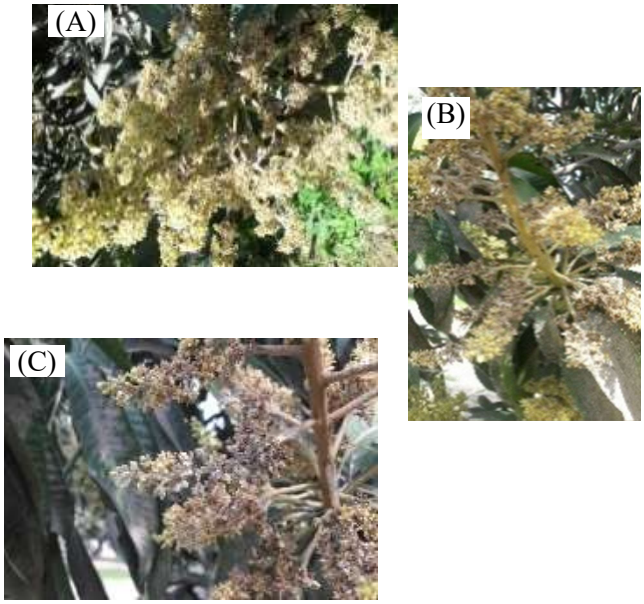


Fig. 9(**A**) Attack of Powdery Mildew on Sufaid Chaunsa (**B**) Disease severity of Powdery mildew on Sindhri cultivar(**C**) Attack of Powdery mildew on Doshari mango variety

2.3 Mango floral disease detection using image processing technique.

The study was designed to devise a quick disease diagnosis system by using image of diseased plant parts. The images of diseased plant parts showing unique/ distinguishing symptoms were taken for incorporation into a database for analysis MAT Lab.

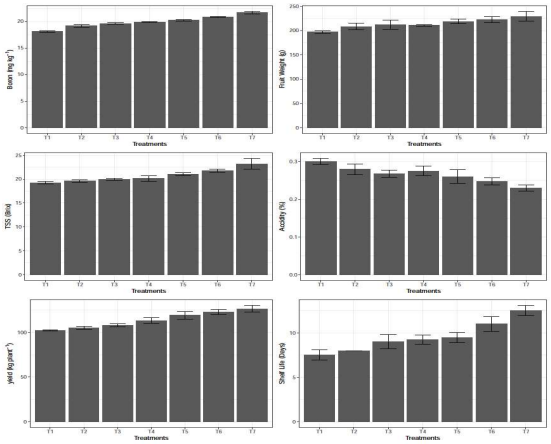
The branches on mango trees were tagged and Image of floral diseases such as powdery mildew and blossom blight and mango malformation were collected from various orchards at various development stages of disease. The said study was also started during the current spring season.

3. PLANT NUTRITION SECTION

3.1 Effect of pre flowering and pre harvest foliar spraying of some macro and micro nutrients on mango cv. Sammer Bahisht Chaunsa

The study was initiated to compare the effect of foliar applied Calcium Nitrite, Potassium Nitrate and Potassium Citrate alone and in combination with Boric Acid on fruit retention, ripening, shelf-life and yield of mango Cv. Chaunsa SB. Generally, it is believed that K and Ca sources play a significant role in enhancing fruit setting, retention, reducing SER, and increasing shelf life of mango fruit and Nitrogen use efficiency respectively. Therefore, to achieve the above mentioned targets, treatment combinations were set as: Control (T_1), Foliar application of Boric Acid 0.2% (T_2), Foliar application of $Ca(NO_3)_2$1.0% + Boric Acid 0.2% (T_3), Foliar application of $CaCl_2$1.0% + Boric Acid 0.2% (T_4), Foliar application of K-Citrate1.0% + Boric Acid 0.2% (T_5), Foliar application of K_2SO_4 1.0% + Boric Acid 0.2% (T_6), Foliar application of KNO_3 1.0% + Boric Acid 0.2% (T_7). The treatments were applied at pre flowering (during the month of March) and pre harvest stage of fruit with the help of tractor mounted Jecto Sprayer. The results indicated that No. of fruit set (47 fruit/panicle), average fruit weight (229g), retention (0.52%) were found significantly high in treatment where KNO_3 1.0% + Boric Acid were applied. Effect of foliar application of variable sources of Ca and K with B remained significant for shelf life, acidity of juice and total soluble solids. Maximum increase of 28 % was

recorded in TSS with the application of KNO_3 1.0% + Boric Acid. The decrease in acidity (0.23 %) of juice and increase in shelf life (13 days) of mangoes was also observed with application of KNO_3 1.0% + Boric Acid followed by K_2SO_4 1.00% +Boric Acid as shown in (Graph 2 and Fig 10-11)



Graph 2. Impacts of calcium nitrate, potassium nitrate, potassium citrate, in combination alone and in combination with boric acid on yield and quality parameters of mango fruit. Figure (a) shows the treatments effects on the boron concentration in mango fruit, b) effect of treatments on Total salts in mango fruit, c) effect of treatments on yield of mango, d) effect on fruit weight, e) effect on acidity in fruit, f) effect on shelf life of mango fruit. The values of all parameters reflect the mean of three replications while bars represent the standard deviation. Treatment were: Control (T1), Foliar application of Boric Acid 0.2% (T2), Foliar application of Ca(NO3)21.0% + Boric Acid 0.2% (T3), Foliar application of CaCl21.0% + Boric Acid 0.2% (T4), Foliar application of K-Citrate1.0% + Boric Acid 0.2% (T5), Foliar application of K2SO4 1.0% + Boric Acid 0.2% (T6), Foliar application of KNO3 1.0% + Boric Acid 0.2% (T7).

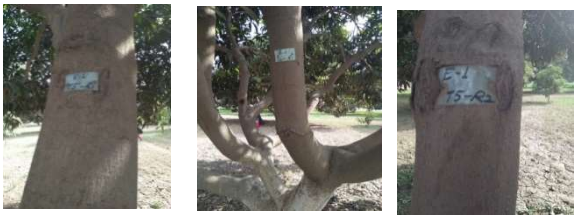


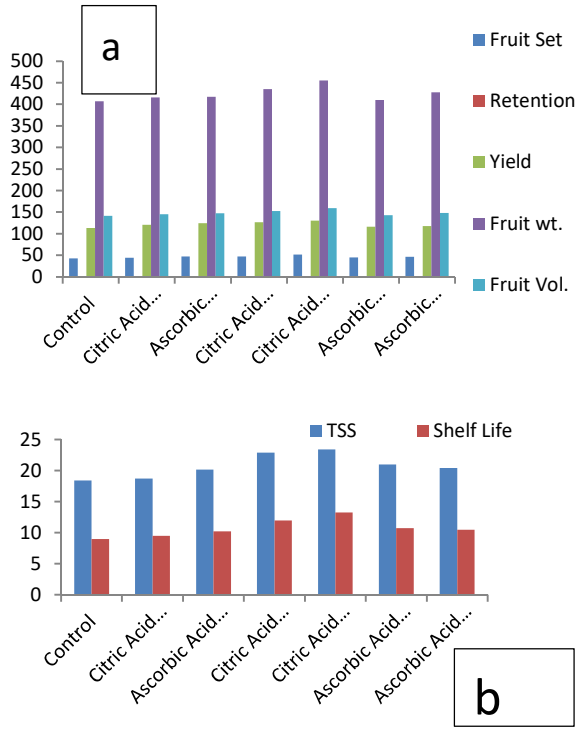
Fig. 10 This show the tagging of mango fruit trees before the application of treatments. Three plants (replications) were tagged for each treatment. There were total seven treatments in this experiment. Therefore, total 21 mango treats of Sammer Bahist were tagged.

Fig. 11 Shows the different steps of organic matter determination: a) After soil samplings from the experimental field, the soils were dried for about two days. After drying, the samples were grinded, b) After grinding the samples, the soil was passed through 2mm sieve, c) Organic matter in the soil was determined by Potassium dichromate method.

3.2 Effect of pre-harvest spray of antioxidants along with micronutrients on post-harvest shelf life and quality of mango cv. Sufaid Chaunsa

A study was carried out to evaluate the effect of some antioxidants (Ascorbic acid and Citric acid) alone and in combination with micronutrients mixture (Zn, Cu, Fe and Mn) as foliar application on fruit retention, yield and fruit quality of mango Cv. Chaunsa White. Treatment combinations applied were: Control(T_1), Foliar application of Citric Acid @1000ppm(T_2), Foliar application of Ascorbic Acid @1000ppm(T_3), Foliar application of Citric Acid @1000ppm + (Zn, Cu ,Fe and Mn) @0.15%(T_4), Foliar application of Citric Acid @1000ppm + (Zn, Cu ,Fe and Mn) @ 0.30%(T_5), Foliar application of Ascorbic Acid @1000ppm + (Zn, Cu, Fe and Mn) @ 0.15%(T_6),

Foliar application of Ascorbic Acid @1000ppm + (Zn, Cu, Fe and Mn) @ 0.30%(T_7). The results revealed that the foliar application of Citric Acid @1000ppm + (Zn, Cu, Fe and Mn) @ 0.30% was found favorable in improving quantitative parameters of fruit with maximum results obtained regarding fruit set/panicle (52), fruit retention (0.53%). Moreover, significantly higher N (0.95%), P (0.15%), K (0.49%) were found with the application of Citric Acid @1000ppm + (Zn, Cu ,Fe and Mn) @ 0.30%. Biochemical analyses of the mango fruit reported the significantly high concentration of TSS (23.5) and low acidity (0.22 %) of juice under the treatment effect of foliar application of Citric Acid @1000ppm + (Zn,Cu,Fe and Mn) @ 0.30% as compared to control and other treatment effects as in (Graph 3-4) and (Fig. 12).



Graph 3-4 a) The Ascorbic acid and citric acid effect alone and in combination on the fruit quality and yield on Mango cv. Sufaid Chaunsa.8). Treatment combinations applied were: Control(T1), Foliar application of Citric Acid @1000ppm(T2), Foliar application of Ascorbic Acid @1000ppm(T3), Foliar application of Citric Acid @1000ppm + (Zn, Cu ,Fe and Mn) @0.15%(T4), Foliar application of Citric Acid @1000ppm + (Zn, Cu ,Fe and Mn) @ 0.30%(T5), Foliar application of Ascorbic Acid @1000ppm + (Zn, Cu, Fe and Mn) @ 0.15%(T6), Foliar application of Ascorbic Acid @1000ppm + (Zn, Cu, Fe and Mn) @ 0.30%(T7). Figure b shows the effect of treatments on TSS and shelf Life of Mango Cv. Sufaid Chaunsa. The values presented in both figures are mean of three replications.

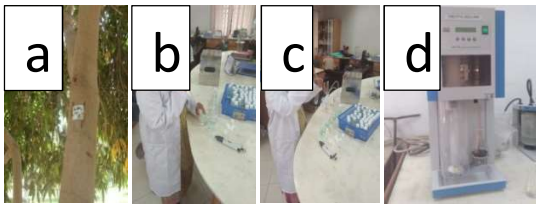


Fig. 12 Shows the different steps of nitrogen determination in the leaf samples of Sufaid Chaunsa. a) The leaf samples were collected from Mango trees. b) Then the leaf samples were oven dried for 3-4 days. Then samples were digested in digestion block with sulfuric acid. c) Then volume of samples was made with distilled water, d) Then distillation of these samples was done and then titrated with 0.1 N H_2SO_4 to determine the N contents in leaf

3.3 Impact of boron application times on mango fruit setting, retention and fruit quality in mango cv. Sufaid Chaunsa

A study was planned to evaluate the effect of B application times, on fruit setting per panicle, fruit retention percentage and fruit quality in mango plants. Three different times of Boron application evaluated were: Before bud initiation, fruit setting and pre harvest stage of fruit. Two application methods (soil and foliar) were adopted to test the difference (if found) with four repeats and RCBD statistical design on cv Chaunsa White. The treatment plan was as following: Control (T_1), Foliar spray of Boric Acid 0.08 % before bud initiation (T_2), Foliar spray of Boric Acid 0.08 % before fruit setting (T_3), Foliar spray of Boric Acid 0.08 % pre harvest of fruit (T_4), Soil application of Boric

Acid 60g/plant before bud initiation (T_5), Soil application of Boric Acid 60g/plant before fruit setting (T_6) and Soil application of Boric Acid 60g/plant pre harvest of fruit (T_7). Before application of treatments, basic analysis of soil samples conducted. Loam textured soil was free from salinity and sodicity hazards (EC 2.40 dSm^{-1} and pH 8.05) hazards with optimum P (8.12ppm), K (190ppm) and B (0.51ppm) contents and low in organic matter (0.55%). Pre-treatment application data of leaves indicated the deficient concentration of B (17ppm). The results after treatment application revealed that maximum number of fruit set per panicle (44), fruit retention (0.48 %), fruit weight (395g), and Yield (131kg/plant) was recorded in treatment where soil application of boric acid 60g/plant before bud initiation was carried out following, soil application of boric acid 60g/plant before fruit setting respectively. Moreover highest value of TSS (23.1Brix^{o}) and shelf life (14 days) was found in the same treatment where boricacid @ 60g/plant before bud initiation applied as (Fig. 13)

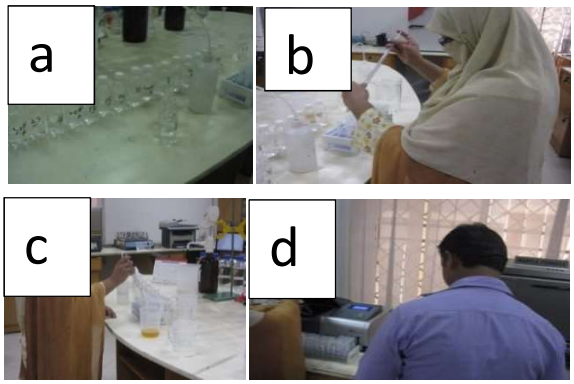


Fig. 13 Leaf extract for determination, Azomethine-H in propylene tubes and reading on spectrophotometer at 420nm wavelength to test the effects of treatments; Control (T_1), Foliar spray of Boric Acid 0.08 % before bud initiation (T_2), Foliar spray of Boric Acid 0.08 % before fruit setting (T_3), Foliar spray of Boric Acid 0.08 % pre harvest of fruit (T_4), Soil application of Boric Acid 60g/plant before bud initiation (T_5), Soil application of Boric Acid 60g/plant before fruit setting (T_6) and Soil application of Boric Acid 60g/plant pre harvest of fruit (T_7).

3.4 Standardization of nutritional requirements of die back affected plants in Sammer Bahisht Chaunsa with integrated approach

An experiment was planned to rehabilitate the diseased plants (dieback affected) with chemical fertilizer as well as organic manures through improving nutrient use efficiency and standardize the nutritional requirements of these plants in cv. Chaunsa SB to set a yardstick for further application. Four types of organic sources viz; FYM, City Waste, Poultry Manure, Press Mud and elemental Sulfur were applied with recommended doses of NPK with three replications and RCBD statistical design. Treatments were: Recommended dose of NPK (T_1), RD of NPK + FYM (T_2), recommended dose of NPK + City Waste (T_3), recommended dose of NPK + Poultry Manure (T_4), recommended dose of NPK + Press Mud (T_5), recommended dose of NPK + Sulfur (T_6). NPK were be applied according to the recommendations during the months of July-August and Feb-March and in the subsequent years the fertilizers will be applied according to soil and leaf analysis report. Organic sources were added on the basis of organic matter contents during the month of December, while the micronutrients were supplied to all treatment plants as foliar spray at recommended time of application. Plants of same age were selected. All the cultural practices required for mango were

maintained. Basic analysis of soil samples was conducted. Loam textured soil was marginally saline and sodic (EC 2.99 dSm-1 and pH 8.59) with slightly deficient P (7.91ppm), K (190ppm) and organic matter (0.61%). Before application of treatments leaves were analyzed for NP and K. Low level of N, P and K was observed (0.58, 0.11, 0.38 %) respectively. After application of treatments, significantly lowest disease intensity (0.12%) was observed where recommended dose of NPK + Poultry Manure (T_4) were applied, followed by recommended dose of NPK + Sulfur (0. s (Fig 14)

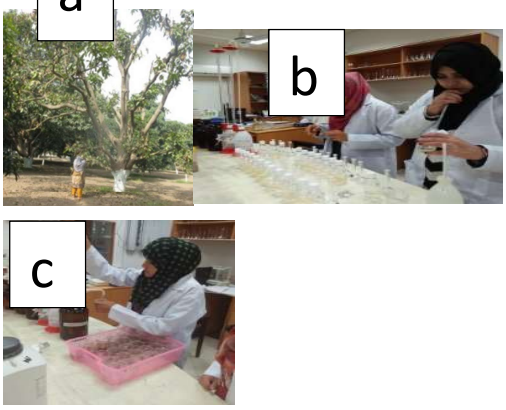


Fig. 14 Shows the different steps of determination of phosphorus and potassium. a) Ammonium Acetate was used for potassium extraction of soil samples. b) The samples were filtered after centrifuging at 1500-2000 rpm for 5 minutes. c) Potassium was determined by Flame Photo Meter

Projects: PARB-904

Title: Nutrition enhancement of crops, fruits, vegetables and their products under climate change scenario

Mango fruit is a rich source of energy, vitamins and minerals but due to unbalanced use of fertilizers and mineral deficiency in our country under current climate change scenario, we have not been able to accomplish the required nutritional values and yield of mango fruit. Therefore, to ensure the availability of all the essential nutrients in fruit, it is required to improve the supply of all essential nutritive elements from soil to fruit by applying the organic and inorganic sources of nutrients in different combinations. The increase in yield and improvement in nutritional value of the mango fruit are the main objectives of this project. Five orchards from each top mango producing districts (Multan, Muzaffargarh, Bahawalpur, Khanewal and Rahim Yar Khan) in Punjab were selected to collect the soil, leaf, and fruit samples. In these districts, some of the popular commercially grown varieties are Sufaid Chaunsa, Sammar Bahisht Chaunsa, Sindhri, Dusehri, Langra, Anwar Retaul. The current nutrient status in soil, leaf and fruit samples in existing nutrient management system of the farmer orchards were tested to draw the baseline of nutrients in soil, leaf and fruit samples in selected mango farms during year I. The collected 543 samples of soil samples were analysed for EC, pH, Olsen P, K, OM, Zn, and Fe while leaf and fruit samples (192) were analysed for N, P, K, Zn, and Fe to determine mineral composition. Fruit samples were also analysed for biochemical parameters (TSS, Acidity, and Beta Carotene). 3 experiments are initiated for biofortifiction technology development at Mango Research Institute Multan and Mango Research Station Shujaabad on Sammer Bahisht Chaunsa, Sufaid Chaunsa and Sindhri, respectively. Leaf and soil samples ground and analyses of 72 soil samples for EC and pH done. Second dose of Nitrogen and Potash fertilizer is applied to experimental trees. Zn and

Fe application according to treatment plane is done as shown in (Fig. 15, 16 and 17).

Fig. 15 The figures shows the preparation of biochar on locally manufactured furnace; a) The cotton sticks and dried banana leaves were used as feed stock. The materials were grinded first before to put in furnace. b) The grinded material was put into furnace for about 45 minutes. c, d) the prepared biochar

Fig. 16 The Fertilizers application process a) The weighing and preparing of treatments wise b) The application of fertilizer under the canopy of tree.

Fig. 17 $NaHCO_3$ preparation for soil P determination, P standards preparation, sample preparation for Soil K extraction

4. ENTOMOLOGY SECTION

4.1 Off season chemical management of mango hoppers (*Idioscopus* sp.) and its ultimate impact during flowering season.

The experiment was conducted at two different locations i.e. Mango Research Institute and farmer field, Mouzagaraywala, Tehsil and District Multan. The orchard of Mango Research Institute, Multan was sprayed regularly to overcome hopper population whereas the farmer did not spray the orchard during non-flowering stage. The results reported that MRI orchard has zero population of mango hoppers on inflorescence during whole March, 2019. The farmer orchard has mango hoppers population ranging from 3.29 to 11.32 individuals per inflorescence during the month of March 2019 and sprayed (Fig. 18)

Table 2. Data regarding population of mango hoppers during flowering and non-flowering stage of mango

Date of observation	Location-1 Mango Research Institute, Multan		Location-2 Farmers field garaywala orchard, Multan	
	Av. population of MH per ft branch/ inflor	Av. population of MH per sq. ft on trunk	Av. population of MH per ft branch/ inflor	Av. population of MH per sq. ft on trunk
5.10.18	0.00	1.45	0.00	10.23
12.10.18	0.00	1.20	0.00	5.12
19.10.18	0.00	0.80	0.00	8.61
26.10.18	0.00	1.12	0.00	6.29
02.11.18	0.00	0.55	0.00	4.32
07.11.18	0.00	0.75	0.00	5.28
13.11.18	0.00	0.30	0.00	3.26
21.11.18	0.00	0.20	0.00	2.10
27.11.18	0.00	0.15	0.00	2.29
3.12.18	0.00	0.25	0.00	1.56
10.12.18	0.00	0.25	0.00	2.19
17.12.18	0.00	0.10	0.00	2.12
23.12.18	0.00	0.05	0.00	2.18
31.12.18	0.00	0.05	0.00	1.55
07.01.19	0.00	0.00	0.00	0.75
14.01.19	0.00	0.00	0.00	0.50
21.01.19	0.00	0.00	0.00	0.25
28.01.19	0.00	0.00	0.00	0.19
4.2.19	0.00	0.05	0.00	0.01
11.2.19	0.00	0.00	0.00	0.00
18.2.19	0.00	0.00	0.00	0.02

25.2.19	0.00	0.00	0.00	0.00
4.3.19	0.00	0.00	3.29	0.00
11.3.19	0.00	0.00	5.70	0.00
18.3.19	0.00	0.00	8.11	0.00
25.3.19	0.00	0.00	11.32	0.00
1.4.19	0.00	0.00	0.00	0.00

Fig.18. Data regarding population of mango hoppers during flowering and non-flowering stage of mango

4.2 Evaluation of different insecticides for management of leaf blotch miner (LBM) (*Acrocercopessyngramma*) on mango plants.

The experiment was conducted at Mango Research Institute, Multan during the peak activity of leaf blotch miner in October, 2018. The results reported that maximum mortality of LBM was recorded by the applications of insecticides Belt and Boltan having 72.73 and 70.59 percent mortality 3 days after spray. Whereas, 5 days after spray Belt, Coragen and Rashim gave maximum mortality of LBM i.e. 87.11, 81.29 and 80.19 percent mortality. After 7 days of spray Belt, Coragen and Rashim gave good mortality 89.79, 83.12 and 81.23 percent.

Table 3. Data regarding mean percent mortality of leaf blotch miner

Treatments		Dose/ 100 L	Mean population/ leaf of LBM	Mean % mortality of LBM after		
Trade Name	Common name			3 days	5 days	7 days
Karate 2.5EC	lambdacy	100ml	23	60.87	67.12	71.23
	halothrin					
Match 50EC	lufenuron	100ml	25	48.00	52.34	55.43
Belt 480SC	flubendiamide	25ml	11	72.73	87.11	89.79
Coragen 20SC	chlotranilprole	50ml	16	62.50	81.29	83.12
Boltan 31EC	gammacyhalothrin+chlopyrifos	300ml	34	70.59	73.24	79.83
Decis super 100Ec	deltamethrin	50ml	10	60.00	62.38	68.21
Rashim	bifenthrin	100ml	44	65.90	80.19	81.23
Emamectin 1.9EC	emamectin benzoate	100ml	18	66.67	73.28	74.14
Nitenpyram	nitenpyram	150ml	14	21.42	24.53	25.11
Control		-	22	0.00	0.00	0.00

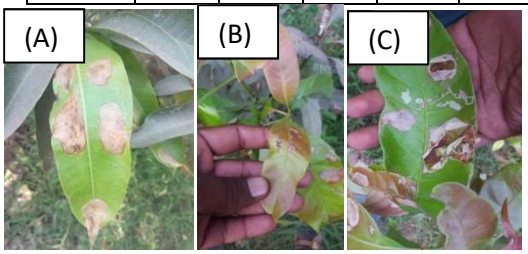


Fig. 19 Evaluation of different insecticides for management of leaf blotch miner (LBM) (*Acrocercopessyngramma*) on mango plants. **(A)** Damage of LBM **(B)** Blotch of LBM **(C)** Larvae of LBM (*Acrocercopes syngramma*) on mango plants

4.3 Exploitation of quantitative studies pertaining to mango fruit fly

This study was conducted to assess the infestation and species occurrence. The fallen fruits under each experimental plant were also collected on daily basis for the same purpose. Susceptibility level for each variety was examined with the keen

observation of apparently infested fruits on the tree followed by the dissection and rearing in the laboratory. It was found that 45-70% fruit drop in these varieties at maturity stage was only due to attack of fruit fly. Cv. Sindhri was observed more prone to fruit fly with the highest larval infestation percentage by 18.75 followed by 10.52 and 8.34 percent in cultivars Chaunsa (SB) and SufaidChaunsa respectively. Two species named *Bactrocerazonata* and *Bactroceradorsalis* were predominantly prevalent in experimental orchard by 93.38 and 6.62 percent respectively with sex ratio of 3:1 for both species. The new inquiry in hand will be useful to stream line the management strategy against this challenging insect pest in Pakistan in (Tab. 4-5-6)

Tab. 4 On-tree inspection

Variety	No. of inspected fruits	No. of suspected fruits	No. of fruits cut	Fruits attacked		%age attack
				Yes	No	
Sindhri	300	32	32	6	26	18.75%
Chaunsa	400	57	57	6	51	10.52%
ChaunsaSufaid	400	63	63	4	59	8.34%

Tab. 5 Inspection of dropped fruits

Variety	No. of Dropped fruits	No. of suspected fruits	No. of fruits cut	Fruits attacked		%age attack from total dropped fruits
				Yes	No	
Sindhri	47	47	47	25	22	53.19%
Chaunsa(	73	73	73	55	18	79.34%
ChaunsaSufaid	66	66	66	43	23	69.15%

Tab. 6. Rearing of fruit fly in laboratory

Variety	No. of Pupae placed in cage	Adult emergence					
		B. zonata			B. dorsalis		
		M	F	Total	M	F	Total
Sindhri	168	07	50	57	06	01	07
Chaunsa (SB)	413	111	235	346	03	09	12
Chaunsa Sufaid	328	21	112	133	06	13	19
Total	909	139	397	536	15	23	38

(1) Adult emergence from Pupae after rearing in Laboratory:
57/909 X100 = 63.14%

(2) Sex Ratio

Female	:	Male
420/574 X100	:	154/574 X 100
73.17%	:	26.83%
3	:	1

(3) Ratio of different species in newly emerged adult Flies

B. zonata	:	***B. dorsalis***
536/574 x 100	:	38/574 x 100
93.38%	:	6.62%

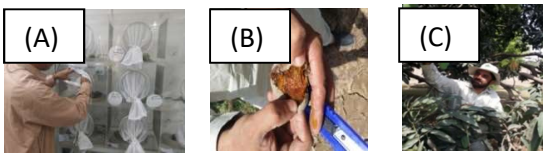


Fig. 20. Exploitation of quantitative studies pertaining to mango fruit fly. A) Fruit samples in cages (B) Larvae of fruit flies (C) Checking hanging infested fruits by fruit flies Exploitation of quantitative studies pertaining to mango fruit fly

5. POST-HARVEST SECTION

5.1. Standardization of maturity indices of promising mango varieties

The study was carried out to find out the most suitable time of harvesting of promising varieties of mango viz. Aalishan, Late Sindhri and Azeem Chaunsa. Aalishan was harvested after 80, 90, 100 and 110 days of fruit setting while the

harvesting days of Late Sindhri were kept as 100, 110, 120 and 130 days. . The color development, TSS, acidity and shelf life were the main quality attributes in this study to see the effects of harvesting time. Resultantly, Aalishan after 90 days, late Sindhri after 120 days and Azeem Chaunsa after 140 days of harvest showed best performance regarding the above-mentioned quality parameters.

Figure.21. Mango fruits glimpse at maturity stage a) Aalishan b) New Sinhari & c) Azeem Chaunsa

5.2. Effect of pedicle removal at different length with reference to anthracnose and stem end rot development in mango cv. S.B. Chaunsa

The research trial was conducted to study the effect of pedicle removal with different lengths during harvest. The mature fruit was harvested, and pedicle removed with 0cm, 01 cm, 02 cm, 03cm & 04 cm lengths. After ripening, fruit was placed in ambient temperature. The severity of stem end rot & anthracnose was measured on daily basis. The results showed that fruit with ≥ 02 cm pedicle was more resistant to both diseases (stem end rot & anthracnose) as (Fig. 22)

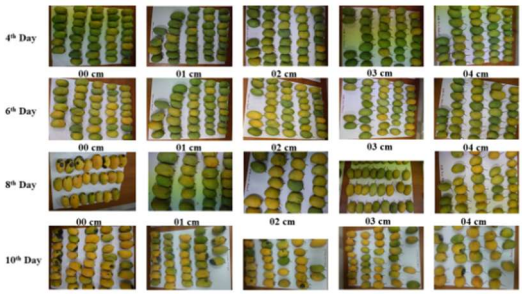


Fig.22 The severity of anthracnose & stem end rot on pedicle removal at different length with two days interval after harvest

ANNUAL ABRIDGED REPORT, 2018-19

MANGO RESEARCH STATION, SHUJABAD"

OVERVIEW:

Mango (*Mangiferaindica*L.) is the most important fruit grown in more than 110 tropical and subtropical countries in the world. In Pakistan it is being grown on 174 thousand hectares with annual production of 1716 thousand tons of fruit. Over 300 mango varieties are being cultivated in Pakistan and among these 30 are well known in local markets and 10 varieties are grown at commercial level. In Pakistan this fruit is mainly grown in provinces of Punjab and Sindh. Mango in Sindh matures almost one month earlier than Punjab, which is quite helpful to extend the marketing span of mango fruit. Pakistan falls in top five major

mango producing countries but so far export is less than 7 percent of total produce. The export needs to be extended up to 20% of total crop to fetch maximum foreign exchange and to stable the fruit prices in local markets. Similarly, the pulp industry may also be strengthened to absorb 20% of total produce, which is capable to utilize less than 3 % mango fruit at this stage. The weaknesses in basic infrastructure, unavailability of healthy nursery plants and lack of capacity at farm level are the major hurdles in quality fruit production. While gaps of information regarding foreign market standards and trade linkages deficits are the other hurdles which needs to be addressed to enhance the mango export to high end markets of the world.

The industry is showing concerns and hopefully the ongoing efforts may develop the enough opportunities for export in coming few years and mango industry of Pakistan will flourish significantly in next decade.

1. **Documentation and study of different traits of mango germplasm**

In the fruit plants, three conventional methods, i.e. Selection, introduction and breeding are adopted for the evolution of new varieties. Selection and introduction are more victorious and creative methods as all the commercial cultivars of the country have come into existence from selection of the naturally available material. During survey and selection of promising mango strains, one mid-season variety "Late Sindhri" was identified five years ago in Jalalpur and one late season variety Azeem Chaunsa was also identified from Uch Sharif in the same year. Behavior of plants and characteristics of fruits were studied for 3-4 years and later on fruit and plant characteristics were recorded as per requirement of Federal Seed Certification & Registration Department for DUS test and registration. The two-year data recorded from the selected plants at grower's field and have been submitted to FSC & RD for DUS test. The verification of data by FSC&RD is in progress. The floral, vegetative and plant related characteristics have been verified by the representative of FSC & RD in current flowering season and fruit characteristics will be verified during current fruiting season in July-August at proper fruit maturity.

Late Sindhri: The Fruit size is large i.e.400-750 gm, flesh firm with deep yellow and shining color. The skin is shining and attractive, mature in mid-July and can be kept on tree till 1st week of August (Fig.1). The plant is regular in fruiting with good average yield (350kg per plant). The fruit has extended shelf life, so highly suitable for export to high end markets of the world (Fig.2)

Variety	**T_1** (Control)	**T_2** (10 minutes)	**T_3** (20 minutes)	**T_4** (30 minutes)	**T_5** (40 minutes)	**T_6** (50 minutes)	**T_7** (60 minutes)	**T_8** (70 minutes)
Sindhri	100 % contamination	1	0	0	0	0	0	0
Chaunsa S.B.	100 % contamination	0	0	0	0	0	0	0
Chaunsa white	100 % contamination	1	0	0	0	0	0	0

Fig.1 Late Sindhri-Fruit on plant Fig.2Late Sindhri-ripened Fruit

Azeem Chaunsa: is another variety late in season with medium fruit size which has extended shelf life. It matures during last week of August with average yield of 550 kg fruit per plant (Fig.3).

Fig .3 Azeem Chaunsa-Ripened Fruit

Varieties have well on tree storage ability, compact flesh and extended shelf life and growers are taking lot of interest in these varieties and both verities have great export potential. The blocks of these varieties have been planted at this research station for further experimentation in future.

2 Standardization of hot water dip duration to check infestation of fruit fly in mango fruit.

This experiment was designed to find out the appropriate duration for hot water dip of mango fruit to kill fruit fly eggs and maggots in different varieties of mango. 50 fruits were harvested at proper maturity for each variety. Harvested fruits were handed over to Professor Dr. ShafqatSaeed at MNSUA, Multan wherefruits remained under fruit fly egg laying process for 24 hours. The fruit was collected back immediately at MRS, Shujabad for HWT without delay. The temperature of Hot Water was maintained at 48°C for each variety before putting mango in it, in the presence of Professor Dr. Shafqat Saeed or his representative. After hot water dip the fruits were placed at ambient temperature to settle down the fruit temperature. Then fruits were allowed to ripen in traditional packing (7-9 days). The infestation of fruit fly was checked at the time of ripening of the fruit and infected fruits were counted accordingly. While the fruits under T_1 were remained at MNSAU, Multan for inspection at ripening and again jointly inspected by the research workers (Table.1).

Table. 1Standardization of hot water dip duration to check infestation of fruit fly in mango fruit

The results recorded reflect that fruit fly infestation in fruits for all varieties after ripening has been observed 100 % under T_1. While in Sindhri&Chaunsa White fruit fly infestation was observed in T_2 only and fruits under the remaining treatments for all varieties remained free from infestation of fruit fly while Chaunsa S.B. remain clean even under T_2. Therefore, it can be concluded that the hot water dip duration of 20 minutes is equally safe (as 60 minutes) and fruit fly maggots were killed in all varieties when kept at 48° C for the said period.

3 Efficacy of different bagging materials for the control of mango fruit fly in cv. chaunsa white.

Primary objective of this experiment was to find out a suitable physical barrier on the fruit to protect them against the egg laying of fruit fly and bruising by different sources (wind / collision etc.) in mango. In this experiment four different types of fruit bagging materials (Common newspaper, Chines newspaper, Brown Paper and White paper) were used to wrap the mango fruit cv. Chaunsa White (Fig. 4) and practice was carried out in the month of May when fruit was hard green and achieved the good size. All the fruits were wrapped on each plant under different treatments and fruits on the control plants were also counted but remained unwrapped. During last week of August 2018, the following data were recorded at the time of harvesting for further evaluation (Table. 2).

Fig. 4 Fruit wrapped with Brown Paper

Table.2 Efficacy of different bagging materials for the control of mango fruit fly in cv. chaunsa white.

Bagging Material	**No. of fruits wrapped**	**% of damaged bags**	**%age of harvested fruits**	**%age of fruit fly affected fruits**
T_1 (Control) (No wrapping)	1259	-	-	7%
T_2 (Common newspaper)	460	49%	51%	-
T_3 (Chinese newspaper)	605	56%	44%	-
T_4 (Brown paper bags)	365	42%	58%	2%
T_5 (White paper)	510	57%	43%	-

High percentage of bags were damaged under different treatments White paper bags (57%) were damaged under T_5 followed by T_3 (56%) due to wind storm / rain while minimum damaged bags i.e. 42% were recorded in T_4 (brown paper bags) and remaining treatments fall between these two extremes. From these results it may be concluded that common newspaper and brown paper bags survive comparatively for longer period and have no bad impact on fruit size and quality. Further, it is added that both these paper bags are cost effective. All the wrapped fruit under T_2 were clean and without contamination while under T_4 some fruit (2%) were found

contaminated with fruit fly indicating that insect can attack through brown paper bags.

4 Evaluation of polyembryonic root stock for commercial mango cultivars of punjab.

The bud woods of 46 polyembryony mango varieties were imported during March 2009-10 and out of these 27 varieties are growing successfully.From the data regarding health and vigor of the plants (height, spread and stem girth), out of 27 cultivars 06 varieties are vigorous and 05 are dwarf in nature while remaining 16 showed medium or weak growth. 24 varieties have produced the crop this year. The stone of these 24 varietieswere sown to check their behavior. Out of 24 varieties, 17 varieties including Kaew, Banana Long, Xoai Cat Hoaloc, Brown seedling, Olour, Carabao Super manila, Xoaitoung, indo Chinese late, Kensington Pride, Kuru, Bullocks Heart, Austarlian Common, Kastori, XoaiBoui, Rosa, Rockdale Siagon and 13-1 were found polyembryonic while 07 varieties including Pirie, Rupee, Crimson Blush, KeowSavoey, Palmer, Elephant Tusk and R_2E_2 were found Monoembyonic. The plant behavior of these polyembryonic varieties will be tested against salinity, drought, high & low temperature when used as rootstock for local commercial varieties in future.

Fig. 5 All plants have independent root system

5 Factors involved in the development of viviparity phenomenon in late maturing mango cultivar chaunsa white.

Vivipary is the phenomenon whereby the embryo grows from the mango stone (Fig.6) when fruit is on the tree or ripe and this disorder is common in cv Chaunsa White. This experiment was designed to find out the time period (week) when vivipary disorder initiate and also find the major factors which facilitate and encourage this disorder.For this purpose,fruits were collected (50% normal size & 50% large size) and allowed to ripen according to standard procedure (wrapping in newspaper and keeping at ambient temperature) (Fig.7).

Fig. 6 Stone showing embryo growth Fig. 7 Prominent root growth

At fruit ripening each fruit was checked for embryo growth or root development. The management practices regarding nutrition (Post

harvest & flowering) and irrigation of selected orchards was also recorded w.e.f. February to last harvest to establish linkage with the disorder if any (Table.3).

Table. 3 Factors involved in the development of viviparity phenomenon in late maturing mango cultivar chaunsa white

Treatments	Time of Harvesting	Fruit Checking (date)	Ave Fr. Wt. (gm)	Fruit showing root growth
T_1	August 3rd Week	27.08.2018	499	3
T_2	August 4th Week	31.08.2018	487	2
T_3	September 1st Week	14.09.2018	600	12
T_4	September 2nd Week	22.09.2018	547	15
T_5	September 3rd Week	30.09.2018	481	22
T_6	September 4th Week	04.10.2018	478	31
T_7	October 1st Week	-	-	-

The results reflect that the intensity of disorder increase with time and when fruit is kept on tree for longer period the issue becomes more severe. Minimum disorder was observed in T1 & T2 while maximum under T6. The irrigation has the strong relationship with the disorder, the over irrigation promotes the disorder strongly. The quantity of Nitrogen application has no impact on the occurrence and intensity of the disorder.

OTHER DEVELOPMENT ACTIVITIES

Radio Talks	15
TV Talks	02
Capacity Building Program	16
Seminar	06
Urdu/English Articles	10
Farmer Gathering	12
Conferences	02
Class Visited	10
Internee/M.Sc.	15
Special Meetings	05
Grower Visited	211
Orchard Visited	35
Mango nursery plants sold	2245

Other activities (MRS, Shujabad)

Participation in mango exhibitions	2
Seed production (true to type and clean grafted mango plant)	4626
Urdu articles	1
Trainings	2

RESEARCH PUBLICATIONS

Full length Papers

1. Kiran, S., Iqbal, J, Bakhsh, A, Asif-ur-Rehman, H, Ullah, H, Ahmad, I., Bibi, F, Raza, S, Iqbal, A, Bukhari, S.I.U.S. and Danish, S. (2018). Effect of grafting season, rootstocks and seedling age on success of stone grafting and pigments synthesis in Sindhri leaves. J. Biodivers. Environ. Sci., 13, 63–72.
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