J Agric. Res., 2022, Vol. 61(2):131-137
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Agriculture Department
Government of Punjab

HORTICULTURE

INDUCTION OF VEGETATIVE GROWTH AFTER HARVESTING OF FRUITS IN MANGO CV. SAMMAR BAHISHT CHAUNSA BY USING DIFFERENT CHEMICALS

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Article received on:
05/06/2022
Accepted for publication:
03/11/2022

ABSTRACT

Mango, the king of fruits, is one of the most important fruit crops of Pakistan. In the country, Sammar Bahisht Chaunsa is a major cultivar grown for domestic as well as international markets; however, the cultivar has a strong disorder of biennial bearing. The main cause of the disorder is lack of immediate, sufficient and vigorous postharvest vegetative growth, which is essential for next year flowering/fruiting. The current study was designed to overcome this fruiting pattern by inducing postharvest vegetative growth immediately after fruit harvesting as this growth is must required for flowering. The trial was conducted in the experimental orchard of Mango Research Station, Shujabad on 25 years old trees of cultivar Sammar Bahisht Chaunsa, planted at 12m between rows and plants. The experiment was performed during the year 2015-2020. One level of Urea (2%) and two levels of KNO_3 (1 % and 2%) alone and in various combinations were applied to mango trees immediately after the fruit harvesting to recognize their effects on the induction of vegetative growth. It was found that KNO_3 at 1% ensured the maximum postharvest growth (67.11%) with maximum flowering (39.49%), and fruit yield (241 Kg/plant). However non-significant difference (25 to 26 ^{O}BRIX) in total soluble solids (TSS) and titratable acidity (TA) was noted(0.7 to 0.9 %) at all the treatments. It is concluded that application of KNO_3 twice at 10 days interval alone or in combination with Urea 2 % after the harvesting of fruits are beneficial for getting proper postharvest growth in mango trees to support subsequent fruit crop.

KEYWORDS: Mango; urea; KNO_3; flowering; vegetative growth; yield; Pakistan

INTRODUCTION

Mango (*Mangifera indica* L.), a member of genus *Mangifera* and family Anacardiaceae, is known as the king of fruits (Rajan, 2021). Mango is successful commercial fruit of tropical and subtropical regions (Hassan *et al*., 2020). Pakistan has been blessed with such agro-climatic conditions as favor the high-quality mango fruit production. Pakistan is currently producing 1.72 million tones (MT) of mango from an area of 168.6 thousand hectares with average production of 10.2 tons per hectare (GOP, 2019). The main cause of the low production is the dominance of those varieties which produce crop in alternate years like Sammar Bahisht Chaunsa and Kala Chaunsa. Both the varieties occupy a significant mango producing area in the country. In Pakistan mango is mainly grown in Punjab and Sindh provinces. Punjab holds the 77 % share in total mango production of the country by producing 1.32 million tons of mango from an area of 99 thousand hectares with average yield of 13.33 tons per hectare, while Sindh province contributes the 23 % share in mango production with an average production of 5.6 tons per hectare (MNFSR, 2021).

Almost twenty mango varieties are grown commercially in Punjab, while the 10 major varieties are occupying 87 % of total area under mango cultivation i.e. Sammar Bahisht Chaunsa (35%), Sindhri (18%), Sufaid Chaunsa (16%), Kala Chaunsa (6%), Dusehri (5%), Anwar Retaul and Late Retaul No. 12 (4%), Langra, Chenab Gold and Azeem Chaunsa (3%) and remaining 13% area is under over 10 varieties i.e. Fajri, Sensation, Sanglakhi, Lahotya, Malda, Pohilot etc.

Besides facing the number of biotic and abiotic stresses, one of the major problems faced by the mango growers is biennial or alternate bearing. It is characterized by production of heavy crop in one year termed as "on year" followed by less crop in the next year known as "off year" (Shirvan *et al*., 2020). There are various factors which are responsible for the biennial bearing disorder of mango such as age and size of shoots,

irregular or delayed pruning, delayed harvesting, imbalanced nutrition application and fertilization, climatological factors and hormonal imbalance (Kumar *et al*., 2021). Early initiation of postharvest vegetative growth is essential to conquer the shoots' proper physiological maturity, which is mandatory for flower initiation. The delay in the emergence of postharvest vegetative growth causes definite reduction in yield in the forthcoming year. Mango plant bears flowering on mature vegetative flushes of five to six months of age. Proper physiological maturity of vegetative flushes is essential for the induction of flowering; therefore its age is the dominant factor in regulating the flowering pattern of mango (Davenport, 2003). Moreover, proper and judicious pruning is also an effective tool for inducing uniform postharvest vegetative flushes, along with reducing variation in the flowering. Mango cv. Chuansa Sammar Bahisht, Pakistan's leading exportable variety (Malik *et al*., 2015), mainly flowers on new mature shoots; hence, the timely initiation of vegetative growth immediately after the fruit harvesting is essential to avoid alternate bearing. There are certain chemicals which enhance the induction of vegetative growth in mango. Ataide and Jose (2000) reported that application of KNO_3 and Urea together with pruning at 4-meter height produced the maximum vegetative growth, highest shoot length, shoot girth, number of leaves per shoot and canopy spread of mango. Kumar *et al.,* (2005) illustrated that spraying inductive chemicals on mango trees enhanced the vegetative flushes of mango after the harvesting phase and increased the number of perfect flowers /panicles, fruit set %, flowering and fruiting characters as well as mango fruit yield.

This experiment was designed keeping in view the importance of instant, sufficient and vigorous postharvest vegetative growth to overcome the problem of alternate bearing. The assurance of postharvest vegetative growth immediately after harvesting is being used as tool to regulate the production cycle of mango cultivar Sammar Bahisht Chaunsa.

MATERIALS AND METHODS

The trial was conducted in the experimental orchard of Mango Research Station Shujabad, on 25 year old trees of mango cultivar Sammar Bahisht Chaunsa, planted at a distance of 12m (40 feet) between rows and plants. The experiment was performed during the year 2015-20. The fruits under experimental plants were harvested at physiological maturity. Immediately after harvest in July-August, the standard practices of pruning and application of fungicide and nutrition were carried out. After the crop harvest every year, the required pruning of the 60 trees under experiment was conducted and all the plants were initially reduced to 6-meter height and 5.3-meter canopy radius. The effect of different chemicals on post-harvest vegetative growth, flowering and fruit yield of mango was evaluated. All the chemicals were sprayed twice after the standard nutrition application i.e. N, P_2O_5 and K_2O @ 1 Kg/plant each. The 1st spray was applied immediately after the harvesting, and the post-harvest nutrition application in all the plants under the experiment was ensured followed by the 2nd spray after ten days interval. The detail of the chemicals applied is as following.

Treatments	Detail
T_0	Control
T_1	Urea 2 %
T_2	KNO_3 1%
T_3	KNO_3 2%
T_4	Urea2%+$KNO_3$1%
T_5	Urea2%+ KNO_3 2%

Performance of different treatments was evaluated on the basis of vegetative parameters such as postharvest vegetative growth flush and April vegetative flushes, while reproductive parameters such as flowering terminals and fruit yield were also evaluated.

Vegetative growth: The post-harvest growth was measured after the complete harvesting of fruits in last week of October by using ring method. A wooden ring of known diameter (approximately 1.5 meter) was used for measuring growth intensity, the ring was placed all around the plant randomly on plant canopy at variable height at 20 different locations and vegetative growing/ grown and non-growing terminals were counted inside the ring. The total terminals inside the ring were calculated and the growing terminals were expressed in percentage by using the following formula.

$$\text{Growing terminals (\%)} = \frac{\text{Growing terminals inside the ring}}{\text{Total terminals inside the ring}} \times 100$$

Similar method was also used for measuring the April growth and flowering terminals at their respective times.

Reproductive growth (Flowering): All the fruits on a tree were harvested and counted and the yield was taken by exact weighing of all fruits (UWE-ESP 5). The average fruit weight was calculated accordingly. Total number of fruits per tree were recorded at the

time of harvest and final yield per plant was calculated by weighing the harvested fruits and expressed in kilograms.

Biochemical Analysis: TSS of mango juice taken from individual ripe fruits from each replication was detected by using a digital refractometer (ATAGO, RS- 5000) and the average value was expressed in ^{O}BRIX. To estimate TA, 5 ml mango juice separately squeezed from each of 20 fruit per replication was taken in a 10-ml flask and the volume was made up to the mark by adding distilled water. 2-3 drops of phenolphthalein were added to the juice. The juice was titrated against 0.1 N NaOH till the development of pink color. TA of mango juice expressed in percentage (%) was calculated using the following formulae (Qureshi *et al*., 2021).

$$TA\ (\%) = \frac{0.1\ N\ NaOH \times 0.0064}{Volume\ of\ juice\ used} \times 100$$

Statistical Analysis: The experiment was laid out according to Randomized Complete Block Design under factorial arrangement. There were six treatments with five years and five replications keeping two plants in each replication as an experimental unit. The collected data was analyzed statistically by analysis of variance over the year technique (Steel *et al.,* 1997). Comparison among the means was made by Tuckey test ($P<0.05$).

RESULTS AND DISCUSSION

Post-harvest growth (%): The efficacy of different chemicals on post-harvest vegetative growth of mango trees was recorded for five successive years (2015-2019) in the present investigation **(Table 1).** A significant effect of different chemicals was recorded. KNO_3 1% was found to be the most effective chemical in inducing maximum postharvest vegetative growth (67.11%) throughout the experimental duration and statistically similar results (63.66 %) were also recorded when Urea 2% was applied in combination with KNO_3 1%. These treatments were found decisive in inducing postharvest vegetative growth which is an important aspect in deciding the fate of next year's crop. Postharvest growth has been found an important utensil in deciding the fate of the next year's fruiting. More postharvest growth in Sammar Bahisht Chaunsa results in better flowering and fruiting in the upcoming flowering season because flowering in Sammar Bahisht Chaunsa occurs mainly on new shoots, while delayed or poor postharvest growth causes less fruiting in the next year. Therefore, proper and timely induction of postharvest growth is mandatory to achieve regular crop. In this study, maximum postharvest growth and flowering terminals were recorded from the trees which were treated with KNO_3 (1%) in mango cultivar Sammar Bahisht Chaunsa. The role of nitrogen and KNO_3 in improving the vegetative and reproductive performance of mango has also been documented earlier by Corbesier *et al*., (2002); Kumar *et al*., (2013) and Geetha *et al*., (2016). Moreover, it is also reported that potassium is a fundamental nutrient element for vegetative growth and flowering (Marschner, 2002), and it also stimulates the floral initiation and increases the number of perfect flowers. Potassium from KNO_3 could stimulate photosynthesis, which is very important for the formation of flowers (Swietlik, 2003). In addition, N containing compounds as urea increase levels of arginine which promotes the flowering and enhances the vegetative growth (George *et al.,* 2003).

April Growth (%): An antagonistic interaction between postharvest vegetative growth and April vegetative growth was observed during the present investigation **(Table 2).** The mango plants which attained the maximum postharvest vegetative growth, induced minimal April growth. The maximum April growth (12.66 %) was recorded under the control treatment and these plants induced the minimum postharvest vegetative growth. The April growth was minimum (8.37 %) on the mango plants on which Urea 2% +KNO_3 1% were applied, but the mango plants under these treatments exhibited excellent post-harvest growth.

Generally, a healthy and non-flowering mango shoot completes four to five flushing episodes per year, while blooming occurs on a few of them during the following year. Flowering occurs on the shoots having the age of five to six months at the time of flowering (Davenport 2003). As a result of postharvest application of KNO_3, mango plant induces vegetative growth early and shoots become mature prior to flowering which results in heavy flower induction which leads to profuse flowering. Davie *et al*., (2000) presented the similar idea that the older and more mature flushes accumulate sufficient reserves of carbohydrates to attain physiological maturity required for fruit bud differentiation and flowering.

Flowering terminals (%): The percentage of flowering terminals on experimental mango trees was recorded for five consecutive years (2016-2020) by the 'Ring' method **(Table 3).** A significant effect of different chemicals on emergence of flowering terminals was

Table 1. Effect of different chemicals on post-harvest vegetative growth of mango

Treatments	2015	2016	2017	2018	2019	Average
Control	21.14^{d} ±2.13	39.15^{d} ±3.34	27.21^{d} ±1.43	45.12^{d} ±2.44	31.18^{c} ±2.14	32.76^{d}±2.43
Urea 2 %	40.76^{c} ±3.14	55.67^{c} ±4.53	41.33^{c} ±2.45	61.21^{c} ±3.34	47.65^{c} ±3.25	49.32^{c}±3.44
KNO_3 1%	61.43^{a} ±5.63	70.54^{a} ±5.63	64.54 ^{ab} ±4.54	71.43^{ab}±3.34	67.65 ±4.35	67.11^{a}±4.32
KNO_3 2%	51.23^{b} ±4.32	63.87^{b} ±4.97	51.34^{bc} ±2.84	63.41^{b}±3.34	58.33^{b}±3.14	57.63^{b}±4.44
Urea2%+ $KNO_3$1%	59.78^{a} ±4.53	67.65^{ab}±4.33	60.11^{a} ±2.87	68.43^{a}±3.34	62.35^{a}±4.53	63.66^{ab}±4.64
Urea2%+ KNO_3 2%	53.13^{b} ±4.63	64.54^{b} ±3.57	56.45^{b} ±3.74	63.32^{b}±3.34	59.15^{b}±3.24	59.31^{b}±3.44
Average	47.91^{d} ±3.17	60.24^{a} ±3.61	50.16^{c}±2.83	62.15^{a}±3.31	54.39^{b} ±3.21	

The values followed by different letters in the same column indicate significant differences, while ± indicates the standard error of means (Tukey test, *P* value 0.03).

Table 2. Effect of different chemicals on April Growth (%) of mango

Treatments	2016	2017	2018	2019	2020	Average
Control	14.02^{a}±1.37	10.46^{a}±1.16	13.27^{a} ±1.23	11.32^{a}±1.14	14.23^{a}±1.21	12.66^{a}±1.14
Urea 2 %	13.14^{ab}±1.2	9.59^{c}±1.03	11.68^{b}±1.01	10.33^{b}±1.11	12.11^{b}±1.13	11.37^{b}±1.16
KNO_3 1%	10.35^{c}±1.01	7.57^{d}±0.97	8.35^{c}±1.13	8.34 ^{c}±1.02	9.26^{c}±1.01	8.77^{d}±1.03
KNO_3 2%	11.57^{b}±1.23	10.57^{b}±1.12	10.13^{d} ±1.06	12.37^{a}±1.11	11.37^{b}±1.14	11.20^{e}±1.12
Urea2%+ $KNO_3$1%	10.67^{d}±1.44	7.46^{d}±1.05	8.26^{c}±1.14	8.15^{c}±1.0	7.34^{d}±1.02	8.37^{d}±1.02
Urea2%+ KNO_3 2%	12.78^{b}±1.37	9.13^{c}±1.14	11.35^{b}±1.15	10.17^{b}±1.12	10.32^{c}±1.12	10.75^{c}±1.1
Average	12.09^{a}±1.31	9.13^{c} ±1.14	10.51^{b} ±1.06	10.11^{b} ±1.11	10.77^{b}±1.16	

The values followed by different letters in the same column indicate significant differences (Tukey test, *P* value 0.04).

Table 3. Effect of different chemicals on flowering terminals (%) of mango

Treatments	2016	2017	2018	2019	2020	Average
Control	18.42^{e} ±1.57	24.56^{e}±2.27	19.33^{f}±1.58	23.41^{e}±1.89	17.53^{f}±1.68	20.65^{f}±1.60
Urea 2 %	22.43^{d} ±1.19	26.54^{e}±2.31	27.43^{d}±1.70	23.67^{e}±1.78	27.43^{e}±1.87	25.50^{e}±1.78
KNO_3 1%	35.49^{a} ±2.12	42.75^{a}±3.43	36.43 ^{a}±2.55	45.32^{a}±3.58	37.48^{a}±2.90	39.49^{a}±1.89
KNO_3 2%	27.11^{b}±2.31	37.83^{b}±3.10	29.54 ^{c}±1.47	43.31^{b}±3.68	28.14^{c}±1.88	33.18^{b}±1.70
Urea2%+$KNO_3$1%	26.1^{c}±2.30	33.43^{c}±3.11	30.41^{b}±1.68	38.54^{c}±2.88	31.13^{b}±3.80	31.92^{c}±1.68
Urea2%+KNO_3 2%	27.09^{b}±2.40	31.17^{d}±3.01	25.78^{e}±1.77	33.1^{d}±2.56	24.09^{d}±2.68	28.24^{d}±1.75
Average	26.11^{c}±2.38	32.71^{b}±3.12	28.93^{c}±1.45	34.56^{a}±2.58	27.63^{c}±2.71	

The values followed by different letters in the same column indicate significant differences, while ± indicates the standard error of means (Tukey test, *P* value 0.03).

Table 4. Effect of different chemicals on yield (Kg) of mango

Treatments	2016	2017	2018	2019	2020	Average
Control	120^{f}±4.17	155^{f}±4.73	125^{f}±4.75	151^{f}±4.62	124^{f}±4.61	135^{f}±4.35
Urea 2 %	155^{e}±4.73	185^{e}±6.72	151^{e}±4.62	187^{e}±6.64	153 ^{e}±4.72	166.2^{e}±4.62
KNO_3 1%	231^{a} ±7.85	247^{a}±7.92	235^{a}±7.53	251^{a}±7.51	241^{a}±5.63	241^{a}±5.50
KNO_3 2%	190^{c}±6.32	235^{c}±7.53	195^{c}±5.78	234^{c}±6.67	197 ^{c}±5.05	210.2^{c}±5.13
Urea2%+$KNO_3$1%	197^{b}±6.57	242^{b}±7.71	201^{b}±6.72	259^{b}±7.12	208 ^{b}±5.12	221.4^{b}±5.75
Urea2%+KNO_3 2%	181^{d}±6.35	223^{d}±7.58	185^{d}±6.72	227^{d}±7.18	187 ^{d}±4.93	200.6^{d}±5.10
Average	179^{d}±6.32	205.5^{b}±7.01	182^{c}±6.68	218.16^{a}±6.85	185^{c}±4.83	

The values followed by different letters in the same column indicate significant differences, while ± indicates the standard error of means (Tukey test, *P* value 0.02).

recorded throughout the experimental span. The flowering terminals were maximum (39.49 %) on the plants treated with KNO_3 1%, while emergence of flowering terminals was also high (33.18 %) on the plants under the treatment KNO_3 2%. It is quite important to mention and synchronize that postharvest vegetative growth of mango was also higher under the control treatment. The lowest flowering terminals (20.65 %) were recorded under control treatment.

Abd El–Razek *et al.,* (2013) found that spraying mango trees with potassium nitrate improved the tree vegetative growth (as leaf area) and flowering percentage.

Fruit Yield (Kg): Fruit yield is an ultimate goal of every orchardist. In present study, A significant effect of different chemicals on yield of mango was recorded **(Table 4)**. A positive correlation between post-harvest vegetative growth and fruit yield of mango plants is evident from **Table 1** and **Table 4**. A vigorous postharvest vegetative growth safeguards the maximum fruit yield in subsequent season. The yield was the highest (241 Kg) on mango plants treated with KNO_3 1%, followed by Urea 2 % and KNO_3 1% (221.4 Kg) and these treatments were statistically significant from each other. Lowest yield (135 Kg) was recorded from the control treatment.

Abd El-Razek *et al*. (2013) and Ebeed and El-Migeed (2005) found that mango yield as number of fruits/tree or as weight (kg/tree) were increased and reached to maximum by spraying with potassium. Ataide *et al.* (2000) found that productivity of several mango cultivars as well as physical and chemical properties are enhanced by the foliar application of potassium nitrate. This is due to beneficial effects on increasing fruit set and supporting fruit retention via improving nutritional status of trees.

TSS (°BRIX) and TA (%)

Non-significant difference in TSS of mango fruits under different treatments was noted. The slight variation in TSS was noted from sample to sample and year to year as evident from the results mango fruits ranged between 25 to 26 °BRIX %, regardless of the treatments and years **(Fig. 1).** A similar trend of variation in TA of mango fruits was also observed as evident from **Fig. 2.** Hassan *et al*., (2020) reported that total solube solid contents of mango cv. Sammar Bahisht Chaunsa ranges from 25 to 26 °BRIX. Similar results regarding TSS of mango cv. S.B Chaunsa were also reported by Jabbar *et al*., (2012).

CONCLUSION

From the above findings it is concluded that the induction of postharvest growth immediately after fruit harvesting is useful for getting maximum flowering and fruiting in the subsequent year. The intensity of immediate postharvest growth is directly proportional to the next year fruiting. The KNO_3 has the potential to improve the induction of postharvest growth in mango trees when used instantaneously after fruit harvesting. The application of KNO_3 (1%) twice at 10 days interval after the harvesting of fruits is recommended for getting proper postharvest growth in mango cv. Chaunsa Sammar Bahisht to support subsequent fruit crop.

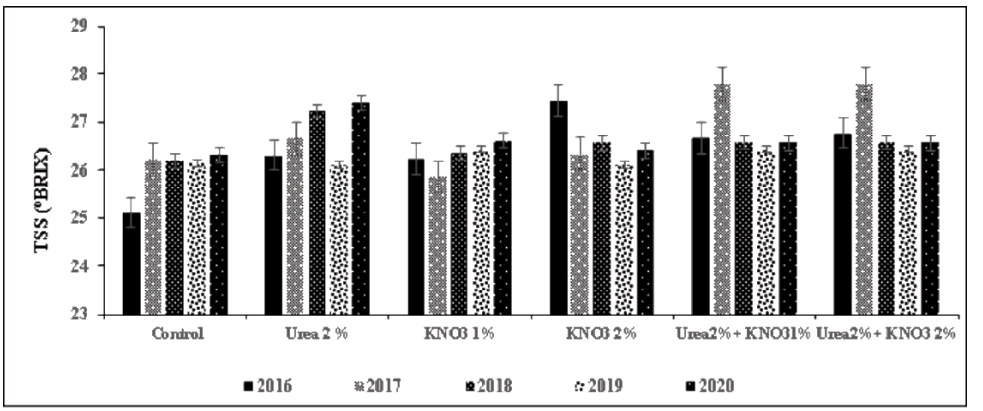

Fig. 1. TSS (°BRIX) of mango under different treatments

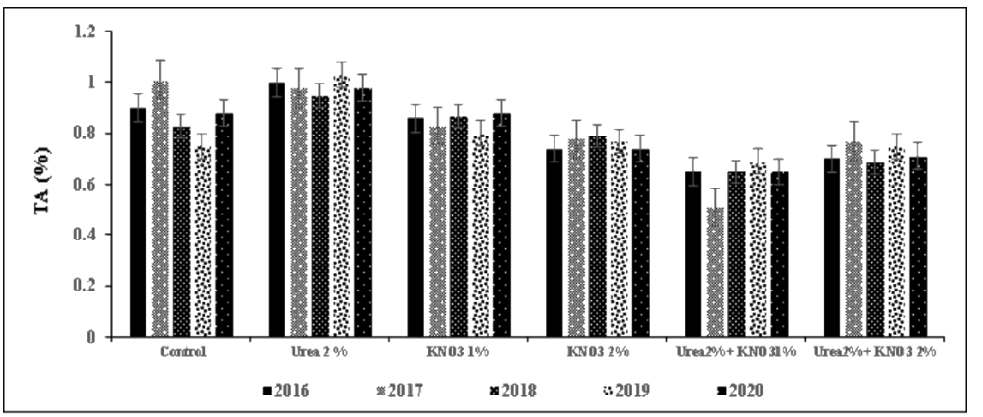

Fig. 2. TA (%) of mango under different treatments

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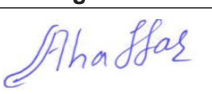
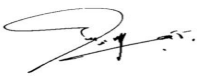
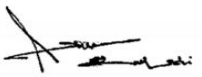
CONTRIBUTION OF AUTHORS

Sr. No.	Author's name	Contribution	Signature
1.	Abdul Ghaffar Grewal	Conducted the research and wrote up the manuscript	
2.	Maqbool Ahmad	Helped in collection of data	
3.	Muhammad Shahzad Zafar	Helped in manuscript write up	
4.	Samad Raza	Collected review of literature	
5.	Ghulam Mustafa	Tabulated the data	
6.	Muhammad Ahsan Qureshi	Statistically analyzed the data and proof read the manuscript	
7.	Atif Iqbal	Assisted in data compilation for statistical analysis