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Studies on chemical treatments to induce flowering in mango (*Mangifera indica* L.) cv. Kesar in Marathwada region

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Abstract
An investigation was carried to study the effect of chemical treatments for induction of flowering in mango (*Mangifera indica* L.) cv. Kesar in Marathwada region. The foliar application of KNO_3 @ 3% noted minimum number of days for panicle initiation (45.33), maximum number of panicles per tree (1208.67), maximum length of the panicle (41.11 cm), maximum fruit set (%) at pea stage (14.22%), marble stage (3.55%) and mature stage (0.87%), maximum length (9.02 cm), diameter (81.33 mm), and volume of fruit (290.42 ml), maximum number of fruits per tree (290.67), fruit weight (265.23 g), fruit yield per tree (77.26 kg/tree) fruit yield per hectare (7.73 t/ha) and TSS of the fruit (21.71%).

Keywords: Mango, Kesar, flowering, KNO_3, yield

Introduction
Mango (*Mangifera indica* L.) is one of the important tropical crops in India. It is the choicest fruit of almost all people because of its unbeatable taste, aroma, and limited season availability in a year. Mango has its origin and species richness in South-East Asia. It belongs to the family Anacardiaceae and order Sapnidales having chromosome number 2n=4x=40. Potassium nitrate (KNO_3) and potassium dihydrogen phosphate (KH_2PO_4) are commonly used as foliar fertilizers to supplement potassium and phosphorus, respectively, in mango orchards. Potassium nitrate acts as a universal bud-breaking agent which has the ability to hasten the process of initiation of flowering and induce a greater number of buds to differentiate into reproductive buds. Three months from the date of spraying of KNO_3 in a weekly induction, flowering is reported under warm temperature conditions (Davenport, 2003) [3]. Das (2001) [2] reported that the application of $Ca(NO_3)_2$ in the form of foliar application resulted in increased absorption of Ca and NO_3-N by plant canopy in which Ca synergized flowering and fruiting whereas NO_3-N enhanced fruit yield by enhancing cell division. Hence the present study was undertaken to test the best effect of the above chemicals in induction of flowering and fruiting parameters.

Materials and Methods
The research was undertaken at experimental cum research orchard located at Department of Horticulture, College of Agriculture, Latur, VNMKV, Parbhani during the year 2022-23. The foliar spray treatment of various concentration of chemicals were T_1 (KNO_3 @ 1% per tree), T_2 (KNO_3 @ 2% per tree), T_3 (KNO_3 @ 3% per tree), T_4 (KH_2PO_4 @ 0.5% per tree), T_5 (KH_2PO_4 @ 1% per tree), T_6 (KH_2PO_4 @ 1.5% per tree), T_7 ($Ca(NO_3)_2$ @ 2% per tree), T_8 ($Ca(NO_3)_2$ @ 4% per tree), T_9 ($Ca(NO_3)_2$ @ 6% per tree) and T_{10} (Control). The treatment was carried out in Randomized Block Design (RBD) and were replicated thrice. The foliar application was done twice i.e., 1st October and 1st November on 10-year-old Kesar mango orchard. There was significant difference observed in flowering, fruiting and yield parameters with the application of treatments. Number of days required for panicle initiation were counted from the date of last spray, number of panicles per tree were counted till 31st January and length of the panicle by using a measuring scale. Fruit set (%) at pea stage, marble and mature stage was calculated by using the formula.

Fruit set % at pea/marble/stage = [(Number of fruits at Sorghum stage – Number of fruits dropped at pea/marble/mature stage)/ Number of fruits at Sorghum stage] x 100

Length of the fruit was measured using standard measuring scale, diameter of the fruit at its widest cheek by using Vernier calliper and volume of the fruit by using water displacement method. Total number of fruits per tree was calculated based on the total number of fruits on every harvest and individual fruit weight was weighed using weighing scale. The statistical analysis of data was done according to the standard procedure given for RBD by Panse and Sukhatme (1985) [7].

Results and Discussion

The results from Table 1 shows that the foliar spray of various chemicals has significantly influenced the flower parameters. The treatment T_3 (KNO_3 @ 3% per tree) advanced the days of panicle initiation i.e., 45.33 days. The earliness in panicle emergence influenced by potassium nitrate was due to the breaking dormancy of flower buds by the nitrates (Trewavas, 1983) [15]. The KNO_3 involves in the formation of increased concentrations of amino acids responsible for dormancy break and flowering initiation due to trigger response from the formation of nitrogen reductase. The treatment T_3 (KNO_3 @ 3% per tree) showed maximum number of panicles per tree (1208.67) and maximum length of the panicle (41.11 cm). According to Valmayor (1962) [16], the internal ethylene concentrations were increased in shoots due to the increase of ethylene forming enzyme (EFE) in leaves mainly due to application of KNO_3. The activation of quiescent buds' results in panicle initiation mediated by an increase in the amount of endogenous ethylene. The number of flowers that successfully develop into fruits depends on factors like pollination, weather conditions, and overall tree health (Singh *et al.*, 2014) [13]. The results obtained were similar to Sudha *et al.* (2012) [14] in Alphonso mango, Patel *et al*. (2016) [8] in Kesar mango, Nahar *et al*. (2010) [6], Sarker and Rahim (2013) [11], and Amarchouli *et al*. (2016) [1]. At the same time, unfavourable environmental conditions of temperature, humidity, and water availability during the flowering and fruit-setting period can lead to flower drop and poor fruit set regardless of panicle length.

The parameters like fruit set (%) at pea stage, marble stage and mature stage were high in the treatment T_3 (KNO_3 @ 3% per tree) i.e., 14.22%, 3.55%, 0.87% respectively.

Table 1: Effect of chemical treatments on flower and fruit parameters

Treatment Details	Days of panicle emergence	No. of panicles per tree	Length of the panicle (cm)	Fruit set (%)			Length of the fruits (cm)	Diameter of the fruits (mm)	Volume of the fruits (ml)
				Pea stage	Marble stage	Mature stage			
KNO_3 (1%)	68.00	865.33	29.22	9.07	2.23	0.57	7.55	66.80	234.20
KNO_3 (2%)	52.33	1017.33	37.52	12.40	3.00	0.79	8.44	72.99	258.73
KNO_3 (3%)	45.33	1208.67	41.11	14.22	3.55	0.87	9.02	81.33	290.42
KH_2PO_4 (0.5%)	69.67	817.33	29.21	8.42	2.18	0.42	7.34	66.29	233.00
KH_2PO_4 (1%)	63.67	958.33	34.37	10.18	2.53	0.68	7.84	70.87	248.13
KH_2PO_4 (1.5%)	47.00	1046.00	39.33	13.23	3.18	0.81	8.77	76.60	271.83
$Ca(NO_3)_2$ (2%)	64.67	925.00	31.85	9.57	2.30	0.60	7.81	69.83	238.52
$Ca(NO_3)_2$ (4%)	58.33	974.00	35.37	10.73	2.61	0.73	7.88	71.29	250.83
$Ca(NO_3)_2$ (6%)	76.00	708.67	28.72	8.02	2.01	0.33	7.15	63.54	228.85
Control	79.33	641.67	25.66	7.38	1.93	0.12	6.79	60.70	225.56
SE (m) ±	2.63	65.72	1.93	0.67	0.26	0.05	0.39	3.45	12.34
C.D. at 5%	7.59	190.08	5.58	1.95	0.74	0.14	1.12	9.99	35.70

Table 2: Effect of chemical treatments on yield parameters

Treatment Details	No. of fruits per tree	Average fruit weight (g)	Fruit yield per tree (kg)	Fruit yield per hectare (t/ha)	Total Soluble Solids (T.S.S.) (%)
KNO_3 (1%)	210.00	206.07	43.31	4.33	17.36
KNO_3 (2%)	266.00	237.11	63.10	6.31	19.20
KNO_3 (3%)	290.67	265.23	77.26	7.73	21.71
KH_2PO_4 (0.5%)	202.67	198.08	40.27	4.03	17.31
KH_2PO_4 (1%)	239.00	217.87	51.79	5.18	18.02
KH_2PO_4 (1.5%)	281.00	246.77	69.02	6.90	19.98
$Ca(NO_3)_2$ (2%)	223.67	214.08	47.87	4.79	17.75
$Ca(NO_3)_2$ (4%)	254.00	224.08	57.20	5.72	18.36
$Ca(NO_3)_2$ (6%)	192.33	181.87	34.99	3.50	16.96
Control	175.33	177.41	31.08	3.11	15.65
SE (m) ±	11.59	12.23	3.88	0.39	1.05
C.D. at 5%	33.52	35.38	11.23	1.12	3.05

The above was followed by of KH_2PO_4 @ 1.5% per tree and KNO_3 @ 2% per tree. Potassium supports the synthesis of proteins and enzymes crucial for pollen germination and tube growth, which are prerequisites for successful fertilization and fruit setting. The fruit retention on the tree till the harvest stage is boosted by the foliar spray of potassium-containing chemicals. Inside the cell, K ions contribute to the osmotic potential, affecting water movement and turgor pressure. Maintaining appropriate turgor pressure is crucial for cell expansion and division, factors that influence flower development and fruit retention. Insufficient potassium can disrupt the cell's ability to maintain turgor pressure, leading to fruit abscission. The maximum length, breadth and volume of the fruit were observed from the treatment T_3 (KNO_3 @ 3% per tree) i.e., 9.02 cm, 81.33 mm, and 290.42 ml respectively which were at par with the treatment T_6 (KH_2PO_4 @ 1.5%) and T_2 KNO_3 @ 2% per tree and followed by the treatment T_8 ($Ca(NO_3)_2$ @ 4% per tree and T_5 (KH_2PO_4 @ 1% per tree).

Potassium is necessary to keep the turgor pressure in plant cells at a healthy level. It was involved in the translocation of sugars and nutrients from source to sink (e.g., leaves to fruits), which can contribute to better fruit growth. Potassium itself doesn't directly "inflate" the fruit like a balloon, it influences factors that contribute to larger fruit size. Proper osmotic regulation supports the uptake of water and nutrients, leading to cell expansion and enlargement. This can result in larger fruit cells and overall increased fruit size. The above-obtained results are in accordance with Patoliya *et al*. (2017) [9], Sharma *et al*. (2016) [12] in guava, and Mahorkar *et al*. (2022) [5] in custard apple.

The highest number of fruits per tree (290.67, 65.78% increase over control), maximum fruit weight (265.23 g, 49.50% increase over control), maximum fruit yield per tree (77.26 kg/tree, 148.57% increase over control), maximum fruit yield per hectare (7.73 t/ha, 148.57% increase over control), and maximum TSS of the fruit (21.71%, 38.72% increase over control) were observed from the treatment T_3 (KNO_3 @ 3% per tree). In order to have good productivity in mango, it is necessary to have leaf nitrogen levels in the range of 1.1-1.4% at the time of synchronization of flowering (Davenport, 2007) [4] whereas in case of low nitrogen levels (<1.1%), the impact is negatively reflected on the productivity (Ramirez and Davenport, 2010) [10]. The nitrogen residuals present in the tree are utilized in the vegetative flush and get dropped down in the nitrogen levels. The necessity of potassium also gets increased at the time of flowering and plays a crucial role in the retention of fruit through various stages of fruit development (Patel *et al*., 2016) [8]. The above demand in the shoots was being compensated through the foliar application of potassium nitrate which has positively impacted the all-over yield from the Kesar mango tree. The increased TSS from the treatment T_3 (KNO_3 @ 3% per tree) might be driven by potassium, which plays a key part in the translocation of sugars, photo assimilates, hydrolysis of polysaccharides, conversion of organic acid in soluble sugars and other soluble solids along with improved solubilization of insoluble starch and pectin the present in the cell wall and middle lamella.

Conclusion

Hence, it can be concluded that the foliar spray of KNO_3 @ 3% per tree twice during pre-flowering stage i.e., 1st October and 1st November on 10-year-old tree on mango tree in Marathwada region found to be beneficial and superior over various other chemical sprays. It also improved fruit quality and overall health of the mango tree other than flower, fruit and yield attributes. Further, various other factors like adequate pollinators, weather conditions, sufficient nutrient and irrigation, and environmental conditions *viz*., temperature, humidity, and water availability during the flowering and fruit-setting period etc. plays major role in flowering and proper development of fruits during the growth phase.

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