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Effect of Multi-micronutrients Mixture on Fruit Yield and Soil Parameters of Sapota [*Manilkara achras* (mill.) Fosberg] cv. Kalipatti

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ABSTRACT: The present experiment entitled "Effect of multi-micronutrients mixture on fruit yield and soil parameters of sapota [*Manilkara achras* (Mill.) Fosberg] cv. Kalipatti" was carried out at Horticultural Research Farm, College of Horticulture, Anand Agricultural University, Anand during the years 2020-21 & 2021-22. The experiment was laid out in Completely Randomized Design with three repetitions and eleven treatments. Among the different treatments, T_{10}(the foliar application of multi-micronutrients mixture grade-IV @ 1% spray at flowering and pea stage with soil application of micronutrient grade-V @ 125g/tree as basal) exhibited significantly maximum fruit weight (81.53 g), fruit volume (81.77 cc), fruit length (6.06 cm), fruit diameter (6.07 cm), number of fruits per tree (1325) and yield (108.43 kg/tree and 10.84 t/ha) with highest net realization *i.e.*, Rs. 175362 with BCR (1.83) in sapota cv. Kalipatti. Micronutrients like Fe, Mn, Zn, Cu and B in soil also found significantly higher due to foliar application of multi-micronutrient mixture grade-IV @1% spray at flowering and pea stage with soil application of micronutrient grade-V @ 125 g/tree in sapota.

Keywords: Sapota, Multi-micronutrients mixture, yield, Soil micronutrient content, Economics.

INTRODUCTION

Sapota or sapodilla [*Manilkara achras* (Mill.) Fosberg] is an important tropical fruit crop grown in subtropical region of the world. It is one of the prominent dessert fruits and an economically important species of the Sapotaceae family and the order Ebenales, a long-lived evergreen tree, native to southern Mexico, central America from where it spread to other country. Sapota fruit is climacteric in nature therefore; it is harvested at matured stage and ripened at ambient temperature. The fully ripe fruits are highly delicious, with excellent sweet taste and have a pleasant aroma.

Micronutrients play an important role in crop production due to their essentiality in plant metabolism and adverse effects that manifest due to their deficiency (Bijay *et al.*, 2023). Besides affecting plant growth, micronutrients also play a major role in disease resistance in cultivated crop species. Micronutrients can tremendously boost up the crop yield and improve economy and post-harvest life of horticultural produce (Raja, 2009). The foliar application of micronutrients has a very important role in improving fruit set, productivity and economy of fruits. It has also a beneficial role in recovery of nutritional and physiological disorders in fruit trees. The nutrients required in large quantity are supplied through soil application (Fageria *et al.*, 2009) but nutrients needed in lower quantity can be better absorbed through foliar spray (Fageria *et al.*, 2009; Girma *et al.*, 2007). Thus, micronutrients like zinc, iron and boron are essentially as important as macronutrients to have better growth, yield, fruit retention and quality of fruit plants. However, meagre information is available on the effect of micronutrients on yield of sapota. Therefore, based on possible benefit of micronutrients on yield of fruit crops, the present study has been planned.

MATERIAL AND METHOD

The field experiment was carried out on 21-year-old trees planted at space of 10 × 10 m at Horticultural Research Farm, College of Horticulture, Anand Agricultural University, Anand for the years 2020-21 & 2021-22. The experiment was laid out in Completely Randomized Design having eleven treatments *viz.*, T_1: Micronutrient grade-I @ 0.5%spray at flowering and at pea stage, T_2: Micronutrient grade-I @ 1% spray at

flowering and at pea stage, T_3: Micronutrient grade-IV @ 0.5% spray at flowering and at pea stage, T_4: Micronutrient grade-IV @ 1% spray at flowering and at pea stage, T_5: Micronutrient grade-V @ 125 g/tree soil application as basal in July, T_6: Micronutrient grade-V @ 250 g/tree soil application as basal in July, T_7: T_1 + T_6(Micronutrient grade-I @ 0.5% spray at flowering and pea stage + Micronutrient grade-V @ 250 g/tree soil application as basal in July, T_8: T_2 + T_5 (Micronutrient grade-I @ 1% spray at flowering and pea stage + Micronutrient grade-V @ 125 g/tree soil application as basal in July, T_9: T_3 + T_6 (Micronutrient grade-IV @ 0.5% spray at flowering and pea stage + Micronutrient grade-V @ 250 g/tree soil application as basal in July, T_{10}: T_4 + T_5 (Micronutrient grade-IV @ 1% spray at flowering and pea stage + Micronutrient grade-V @ 125 g/tree soil application as basal in July) and T_{11}: Control. The treatments were repeated thrice and one tree per treatment. Multi micronutrient grade I & IV were given in the form of foliar application as per treatments. First spray was given at initiation of flowering *i.e.* in August month, while second spray was given at pea stage of fruit set *i.e.*, in November month during the year 2020-21 and 2021-22. Multi-micronutrient grade V was given in a ring at two meters distance from main trunk as soil application in the July month. Besides this, 1000 g nitrogen, 500 g phosphorus and 500 g potash per tree were given as recommended dose of fertilizers in all treatments. Full dose of FYM, phosphorus and potash and half dose of nitrogen were given as basal dose in July whereas, remaining half dose of nitrogen was given in October in both the years.

RESULTAND DISCUSSION

A. Effect of multi micronutrients mixture on fruit weight (g)

The data presented in Table 1 showed that among different treatments, significantly higher fruit weight (81.41, 81.66 and 81.53g) was recorded with T_{10} in2020-21, 2021-22 and pooled, respectively and it was at par with T_4, T_7, T_8 and T_9 in 2020-21, T_3, T_4, T_7, T_8 and T_9 in 2021-22 whereas, T_8 and T_9 during pooled analysis. The interaction effect (Y× T) on fruit weight was found non- significant during the course of study. The cumulative effect of mixture of micronutrients might have resulted in higher fruit weight by the faster loading and mobilization of photo assimilates to fruit and involvement in cell division and cell expansion which ultimately reflected into more weight of fruit in treated plants. It was supported by Modi *et al*. (2021) in sapota.

B. Effect of multi micronutrients mixture on fruit volume (cc)

Maximum fruit volume (81.59, 81.95 and 81.77 cc) was registered with the same treatment T_{10} and it was significantly at par with T_9 in 2020-21 and pooled analysis while, T_8 and T_9 in 2021-22. Data revealed non-significant interaction (Y× T) effect on fruit volume. This increase in fruit volume might be due to the availability of more micronutrients which leads to more photosynthetic activity and better dry matter accumulation as the zinc plays vital role to promote starch formation, iron required to suitable cell enlargement and cell division and boron actively involved in transportation of carbon in plants. Confirmatory results were found by Modi *et al*. (2021) in sapota.

C. Effect of multi micronutrients mixture on fruit length (cm)

Data (Table 1) for both the successive years of study (2020-21 and 2021-22) as well as pooled analysis accounted significantly maximum fruit length (6.04, 6.08 and 6.06 cm) obtained with T_{10} treatment, respectively. It was at par with T_8 and T_9 in 2020-21 and T_3, T_4, T_7, T_8 and T_9 in 2021-22. In pooled analysis it was found at par with T_9. The interaction effect (Y×T) on fruit length was found non-significant during the course of study. The increase in fruit length was possibly due to boron appears to have direct role in hastening the process of cell division and cell elongation due to which length of the fruit is increased. Zinc helps in regulating the cell wall permeability, thereby allowing more mobilization of water in fruits that contributed to the greater fruit length. The present results are in conformity with the findings of Khopade *et al.* (2015); Modi *et al*. (2021) in sapota.

D. Effect of multi micronutrients mixture on fruit diameter(cm)

Among the different treatments, T_{10} (Micronutrient grade IV @ 1 % spray at flowering and pea stage + Micronutrient grade V @ 125 g/tree soil application at basal in July) had significantly higher fruit diameter (6.01, 6.13 and 6.07 cm) in 2020-21, 2021-22 and pooled, respectively, and it was at par with T_3, T_4, T_7, T_8 and T_9 in 2020-21 and 2021-22. In pooled analysis it was at par with treatments T_7, T_8 and T_9. The fruit diameter during the investigation period might be increased due to the favorable effect was attributed to the fact that the zinc is essential in the nitrogen metabolism and it also increase the synthesis of auxin which promote the cell size. These findings are in conformity with those of Khopade *et al.* (2015); Modi *et al*. (2021) in sapota.

E. Effect of multi micronutrients mixture on number of fruits per tree

A perusal of data presented in Table 2 observed significantly maximum number of fruits per tree (1318, 1333 and 1325) with treatment T_{10} (Micronutrient grade IV@ 1 % spray at flowering and pea stage + Micronutrient grade V 125 g/tree soil application at basal inJuly) in 2020-21, 2021-22 and pooled, respectively, which was at par with T_4, T_7, $T_8$and T_9in 2020-21, 2021-22 and in pooled analysis. The minimum number of fruits per tree (1122, 1131 and 1127) was recorded in 2020-21, 2021-22 and pooled data, respectively with treatment T_{11}(control). Whereas, an interaction effect (Y × T) on number of fruits per tree was found non- significant. Different grades of micronutrients when applied to tree alone or in

combination involved directly in various physiological processes and enzymatic activity. This might have resulted into better photosynthesis, greater accumulation of starch in fruit and involvement of zinc in auxin synthesis and B in translocation of starch to fruit. The balance of auxin in plant regulates the fruit drop or retention in plants, which altered the control of fruit drop and increased the total number of fruits per tree. Moreover, boron plays a part in fruit setting, which ultimately leads to an increase in the number of fruits produced per tree (Thompson and Batjer 1950). These findings are in agreement with Khopade *et al.* (2015); Modi *et al*. (2021) in sapota.

F. Effect of multi micronutrients mixture on yield (kg/tree and t/ha)

It was found that among different treatments, T_{10} (Micronutrient grade IV@1% spray at flowering and pea stage + Micronutrient grade V@ 125 g/tree soil application at basal *i.e.*, in July) resulted in significantly maximum fruit yield (107.18, 109.68, 108.43 kg/tree and 10.72, 10.97 and 10.84 t/ha) in 2020-21, 2021-22 and pooled, respectively, which was at par with T_7, T_8 and T_9 during 2020-21 and 2021-22. In pooled analysis it was at par with T_9. The minimum fruit yield (77.95,78.75 and 78.35kg/tree and 7.80,7.87 and 7.84t/ha) was recorded in 2020-21, 2021-22 and pooled data, respectively with treatment T_{11}(control). The interaction (Y × T) and year effects on fruit yield was found significant.

This influence might be due to fact that micronutrients like boron, zinc and iron helped in increase in chlorophyll content and leaf area which together have accelerate the photosynthesis rate that increase in supply of carbohydrates to the plant and finally increase the yield of plant. Spray of boron increase the pollen tube germination and elongation as a result of higher fruit set percent and ultimately yield. Application of treatment T_{10} resulted higher number of fruits per tree, higher fruit weight and higher fruit volume which eventually observed in terms of higher fruit volume which eventually observed in terms of higher fruit yield per tree. Micronutrients helps in reduce flower drop and increase the fruit retention Corresponding results were found by Khopade *et al*. (2015); Modi *et al*. (2021) in sapota.

Table 1: Effect of multi-micronutrients mixture on different yield parameters of sapota.

Treatment No.		Av. fruit weight(g)			Av. Fruit volume (cc)			Fruit Length(cm)			Fruit diameter (cm)			Number of fruits/tree			Fruit yield (Kg/tree)			Fruit yield(t/ha)		
		2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1		71.78	72.31	72.04	71.11	71.67	71.39	5.26	5.46	5.36	5.45	5.47	5.46	1172	1179	1175	83.21	84.65	83.93	8.32	8.47	8.39
T_2		72.79	73.16	72.97	72.18	72.45	72.32	5.31	5.52	5.41	5.50	5.53	5.52	1193	1120	1156	85.09	86.72	85.91	8.51	8.67	8.59
T_3		73.49	73.86	73.68	73.07	73.25	73.16	5.47	5.60	5.53	5.60	5.66	5.63	1212	1217	1215	88.03	90.10	89.06	8.80	9.01	8.91
T_4		74.93	75.22	75.07	73.31	73.74	73.52	5.53	5.67	5.60	5.61	5.71	5.66	1258	1274	1266	93.49	93.90	93.70	9.35	9.39	9.37
T_5		70.71	71.05	70.88	70.08	70.15	70.12	5.03	5.31	5.17	5.46	5.27	5.37	1132	1159	1145	79.80	80.78	80.29	7.98	8.08	8.03
T_6		71.63	71.87	71.75	71.44	71.01	71.22	5.19	5.39	5.29	5.36	5.44	5.40	1156	1184	1170	81.57	82.91	82.24	8.16	8.29	8.22
T_7		75.03	75.13	75.08	74.47	74.75	74.61	5.59	5.77	5.68	5.76	5.80	5.78	1270	1276	1273	95.45	97.15	96.30	9.55	9.72	9.63
T_8		76.44	76.62	76.53	75.96	76.23	76.10	5.62	5.81	5.71	5.84	5.90	5.87	1281	1284	1283	97.06	99.05	98.05	9.71	9.90	9.81
T_9		78.92	79.26	79.09	78.53	78.75	78.64	5.69	5.88	5.79	5.95	5.99	5.97	1299	1315	1307	103.18	105.75	104.46	10.32	10.58	10.45
T_{10}		81.41	81.66	81.53	81.59	81.95	81.77	6.04	6.08	6.06	6.01	6.13	6.07	1318	1333	1325	107.18	109.68	108.43	10.72	10.97	10.84
T_{11}		70.09	70.66	70.38	70.26	70.32	70.29	4.90	5.13	5.01	5.08	5.14	5.11	1122	1131	1127	77.95	78.75	78.35	7.80	7.87	7.84
T	S.Em ±	2.63	2.66	1.76	1.74	2.23	1.33	0.15	0.16	0.10	0.15	0.17	0.11	32.6	36.4	23.7	4.45	4.34	3.11	0.44	0.43	0.31
	C.D. (P=0.05)	7.77	7.84	5.34	5.10	6.53	3.77	0.43	0.48	0.29	0.43	0.50	0.30	95.7	106.8	67.4	13.12	12.80	8.88	1.31	1.28	0.89
Y	S.Em ±	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.39	-	-	0.13
	C.D. (P=0.05)	-	-	NS	-	-	NS	-	-	NS	-	-	NS	-	-	NS	-	-	3.97	-	-	0.40
Y x T	S.Em ±	-	-	2.65	-	-	2.00	-	-	0.15	-		0.16	-	-	34.6	-	-	4.39	-	-	0.43
	C.D.(P=0.05)	-	-	NS	-	-	NS	-	-	NS	-		NS	-	-	NS	-	-	12.55	-	-	1.26
C.V.%		6.14	6.17	6.16	4.08	5.21	4.68	4.67	5.00	4.84	4.49	5.20	4.86	4.63	5.15	4.90	8.54	8.19	8.36	8.54	8.19	8.36

Table 2: Effect of multi-micronutrients mixture on micronutrient content in soil after two years of experiment in sapota.

Treatment No.	Treatment Details	Nutrient content(mg/kg)				
		Fe	Mn	Zn	Cu	B
		Initial status				
		5.68	6.63	0.73	1.00	0.13
		After two years of experiment				
T_1	Micronutrient grade I@0.5% spray at Flowering and at pea stage	6.24	6.63	0.80	1.07	0.15
T_2	Micronutrient grade I@1% spray at Flowering and at pea stage	6.36	6.77	0.83	1.10	0.15
T_3	Micronutrient grade IV@0.5% spray at Flowering and at pea stage	6.43	6.85	0.85	1.12	0.16
T_4	Micronutrient grade IV@1%spray at Flowering and at pea stage	6.51	6.98	0.88	1.11	0.17
T_5	Micronutrient gradeV@125g/tree soil Application at basal *i.e.* in July	5.91	6.47	0.76	1.04	0.13
T_6	Micronutrient gradeV@250g/tree soil Application at basal *i.e.*in July	6.13	6.54	0.77	1.06	0.14
T_7	Micronutrient grade-I @ 0.5% spray at flowering and pea stage + Micronutrient grade-V@250g/tree soil application *i.e*. in July	6.63	7.05	0.91	1.13	0.18
T_8	Micronutrient grade-I @1% spray at flowering and pea stage + Micronutrient grade–V@125g/tree soil application at basal *i.e.* in July	6.78	7.11	0.94	1.12	0.19
T_9	Micronutrient grade IV @ 0.5% spray at flowering and at pea stage + Micronutrient grade V @ 250 g/tree soil application at basal *i.e*. in July	6.83	7.18	0.96	1.14	0.19
T_{10}	Micronutrient grade IV@1% spray at flowering and at pea stage + Micronutrient grade V @ 125 g/tree soil application at basal *i.e*.in July	6.91	7.30	0.97	1.15	0.20
T_{11}	Control	5.70	6.42	0.73	1.02	0.13
S.Em +		0.153	0.17	0.025	0.013	0.06
C.D.(P=0.05)		0.449	0.507	0.075	0.039	0.017
CV%		4.14	4.38	5.14	2.08	6.17

Effect of multi micronutrients mixture on soil parameters

Available iron content in soil. The result showed that among the different treatments, T_{10} recorded significantly highest iron content (6.91 mg/kg) in soil after completion of two years of experiment and it was found at par with T_4, T_7, T_8 and T_9. The initial value before starting of experiment was recorded 5.68 mg/kg.

Available manganese content in soil. The result showed that among the different treatments, T_{10} recorded significantly higher manganese content (7.30 mg/kg) in soil after completion of two years of experiment and it was found at par with T_3, T_4, T_7, T_8 and T_9. The initial value before starting of experiment was recorded 6.63 mg/kg.

Available zinc content in soil. The result indicate that among the different treatments, T_{10} recorded significantly higher zinc content (0.97 mg/kg) in soil after completion of two years of experiment and it was found at par with T_7, T_8 and T_9. The available zinc content in soil was increased with treatment T_{10}might be due to soil application of zinc and other micronutrients mixture as grade V in soil. The initial value before starting of experiment was recorded 0.73 mg/kg.

Available copper content in soil. The result showed that among the different treatments, T_{10} recorded significantly higher copper content (1.15 mg/kg) in soil after completion of two years of experiment and it was found at par with T_3, T_4, T_7, T_8 and T_9. The initial value before starting of experiment was recorded 1.00 mg/kg.

Available boron content in soil. The result showed that among the different treatments, T_{10} recorded significantly higher boron content (0.20 mg/kg) in soil after completion of two years of experiment and it was found at par with T_7, T_8 and T_9. The initial value before starting of experiment was recorded 0.13 mg/kg.

Table 3: Economics of different multi-micronutrients mixture grades treatment in sapota cv. *Kalipatti.*

Treat. No.	Fruit yield (t/ha)	Gross realization (Rs. /ha)	Common cost of cultivation (Rs/ha)	Treatment cost (Rs./ha)	Total cost of cultivation (Rs. /ha)	Net realization (Rs. /ha)	Benefit cost ratio
T_1	8.39	209750	82323	5660	87983	121767	1.38
T_2	8.59	214750	82323	5960	88283	126467	1.43
T_3	8.91	222750	82323	7560	89883	132867	1.48
T_4	9.37	234250	82323	9760	92083	142167	1.54
T_5	8.03	200750	82323	3555	85878	114872	1.34
T_6	8.22	205500	82323	4430	86753	118747	1.36
T_7	9.63	240750	82323	10090	92413	148337	1.60
T_8	9.81	245250	82323	9515	91838	153412	1.67
T_9	10.45	261250	82323	11990	94313	166937	1.77
T_{10}	10.84	271000	82323	13315	95638	175362	1.83
T_{11}	7.84	196000	82323	0	82323	113677	1.38

Selling price of sapota fruit: Rs. 25/kg

Effect on economics. The data revealed that among the different treatments, T_{10}(Micronutrient grade IV @ 1% spray at flowering and pea stage + Micronutrient grade V@125g/trees oil application at basal in July) has the highest net realization *i.e.*, Rs. 175362 with BCR (1.83).

CONCLUSIONS

From the foregoing investigation of two years, it can be concluded that the application of micronutrient grade IV @ 1% spray at flowering and pea stage with micronutrient grade - V 125 g/tree soil application as basal in July was found effective in increasing yield and net profit in sapota cv. Kalipatti. Moreover it also increased micronutrients like Fe, Mn, Zn, Cu and B contents in soil.

FUTURE SCOPE

The foliar application of multi-micronutrients mixture grade-IV @ 1% spray at flowering and pea stage with soil application of micronutrient grade-V @ (125g/tree as basal can be used to increase fruit weight, fruit volume, fruit length, fruit diameter, number of fruits per tree and yield with highest net realization in sapota cv. Kalipatti.

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