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Yield and quality of *Alphonso* mango as influence by foliar application of nutrients in lateritic soil

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Abstract
A field experiment was carried out in lateritic soil of coastal region in Maharashtra during the year 2016-17 to study the influence of foliar application of nutrients on yield and quality of *Alphonso* Mango at Mango Orchard of Department of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli Dist. Ratnagiri. The results of the experiment revealed that the treatment receiving foliar spray of 3 per cent Amrashakti multinutrient solution showed its superiority in respect of length and breadth of mango fruit, average weight of fruit and maximum number of fruits per tree as well as yield of mango t ha^{-1} as compared to all other treatments. However, in case of total soluble solids, ascorbic acid content, reducing sugars, total sugars as well as β-carotene content in mango fruit was improved with reducing acidity of mango pulp due to the foliar spray of 3 per cent Amrashakti multinutrient solution. In the present investigation, the foliar application of nutrients showed their beneficial effect on yield and quality of *Alphonso* mango over control treatment.

Keywords: Urea, potassium nitrate, amrashakti, yield, quality, alphonso mango

Introduction
Mango (*Mangifera indica* L.) is a major fruit crop of the tropical regions of the world. India is the largest producer of mango in the world. The fruits of mango are valued because of its excellent flavour, delicious taste, and nutritive value. It is an excellent, wonder fruit amazingly packed with a bunch of nutrients, extremely rich in minerals, antioxidants, vitamins and enzymes. It is richest source of vitamins A, C and E, minerals like potassium, calcium, iron and phosphorus. Additionally these, iron rich mangoes are high in antioxidants, low in carbohydrates and help to combat stomach acidity. It is often called "The king of the fruits" and rightly known as "National fruit of India". India has a rich wealth of mango germplasm with more than 1000 varieties grown throughout the length and breadth of the country. However, only about 21 of them like Alphonso, Banganpally, Chausa, Dashehri, Langra, Totapuri and Kesar are commercially cultivated in different mango growing regions (Yadav, 1997) [14].

Among the different varieties of mango, *Alphonso* tops the list and is used as one of the choicest and prime variety of India grown along the west coast of India viz. Gujarat, Maharashtra, Goa and Karnataka which has lone share of over 80 per cent in total mango export (Burondkar and Jadhav 2009) [4]. The Konkan region in the Maharashtra state is famous for mango production with an area of about 0.11 million ha under mango cultivation. However, the production is only 0.35 million tons with a productivity of about 3.16 tons ha^{-1}. Particularly, the two districts of the region viz. Ratnagiri and Sindhudurg are known as 'Mango baskets'. Of these, area under mango production in Ratnagiri and Sindhudurg districts is approximately 0.063 and 0.027 million ha with production of about 0.12 and 0.08 million tons having a productivity of 1.9 and 3.0 t ha^{-1}, respectively. Both districts have humid, sub-tropical climate with high rainfall. (Anonymous, 2014 b) [2].

The productivity of mango is low at national level due to various factors such as indiscriminate use of chemical fertilizers, scanty use of micronutrients, alternate bearing, fruit drop, mango malformation, spongy tissue and susceptibility to major disease and pests. An indiscriminate use of chemical fertilizers paved the way for deterioration of soil health and in turn affects trees with yield and fruit quality. The farmers are applying the nutrients mainly through soil application whereas; nutrients can also be applied directly to the site of their metabolism through foliar application (Kumar *et al*., 2017) [7]. Major elements or macronutrients are quickly taken up and utilized by the tissues of the plants by catalyzing effect of micronutrients or minor elements (Phillips, 2004) [10]. Micronutrients specially required by fruits crop for

quality improvement. According to soil scientists, only application of primary nutrients could not prove successful to produce high quality fruit in mango trees, the application of micronutrients is compulsory as well. Various characteristics like fruit size, colour, shape, taste, shelf life, processing ease etc. essentially depend on supply of micronutrients (Ganeshamurthy *et al.*, 2013) [5]. Boron, copper, zinc and ferrous are beneficial for improvement of fruit growth, retention, weight, volume, firmness and yield (Nehete *et al.*, 2011) [8]. Therefore, the present investigation was undertaken to study the influence of foliar application of nutrients on yield and quality of *Alphonso* Mango in lateritic soil.

Material and Methods

An experiment was conducted during 2016-17 at Mango Orchard of Department of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth with mango cv. Alphonso. The experimental soil observed from the data, was moderately acidic (5.43) in reaction with low (0.113 dSm^{-1}) electrical conductivity, very high in organic carbon (9.96 g kg^{-1}), medium in available nitrogen (302.43 kg ha^{-1}), low in available phosphorus (9.70 kg ha^{-1}) and high in available potassium (286.34 kg ha^{-1}) content. However, the experimental soil was very low in exchangeable calcium (3.01 Cmol (p+) kg^{-1}) and magnesium (6.01 Cmol (p+) kg^{-1}), low in sulphur (12.87 kg ha^{-1}) content. The DTPA extractable micronutrients were i.e. high in iron (37.39 mg kg^{-1}) and zinc (1.37 mg kg^{-1}) while, optimum in manganese (27.08 mg kg^{-1}) and copper (2.57 mg kg^{-1}) content in soil. In general, soil properties of experimental site showed a typical lateritic soil of Konkan region.

The experiment was conducted in randomized block design with seven treatments which were replicated thrice. The treatments were T_1- control, T_2- 1 per cent urea, T_3- 1 per cent potassium nitrate, T_4- 1 per cent Amrashakti, T_5- 3 per cent urea, T_6- 3 per cent potassium nitrate and T_7- 3 per cent Amrashakti multinutrient solution. Urea, single super phosphate, muriate of potash were obtained from the licensed fertilizer supplier to meet the requirement of nitrogen, phosphorus and potassium fertilizes, were applied on 18th June 2016 @ 3 kg urea, 3 kg SSP and 1 kg MOP at fertilizer ring periphery to all experimental trees, respectively. The foliar spray of urea, potassium nitrate and amrashakti nutrient solution were applied on 16th May 2016 as per the treatment details.

The green fresh fruits weight was taken immediately after harvest of fruits. The fruits from observational tree were picked and counted at each picking. Numbers of harvested fruits $trees^{-1}$ were counted and their total weight in kilograms (kg) per tree was recorded and calculated on the basis of yield ha^{-1}. T.S.S. was determined by Hand Refractometer and Titratable acidity was estimated by Titration with NaOH as per the procedure given by A.O.A.C. (1975) [1]. Ascorbic acid in mango fruit was determined by 2, 6, dichlorophenol indophenol dye method while, Reducing and Non reducing sugar was estimated by Lane and Eynon method and Beta-carotene was determined colorimetrically as described by Ranganna (1997) [11].

Results and Discussion

Effect of foliar application of nutrients on yield attributing characters and yield of mango

Yield attributing characters and the yield of mango are presented in Table 1.

Length of fruit

The data pertaining to the effect of foliar application of nutrients showed significant effect on length of fruit with different treatments. The length of mango fruit varied from 8.12 to 10.02 cm with a mean value of 9.19 cm. The treatment T_7 receiving foliar spray of 3 per cent Amrashakti recorded significantly maximum length of fruit over all other treatments. It was followed by treatment T_6 (9.38 cm), T_4 (9.28 cm), T_5 (9.22 cm), T_3 (9.21 cm) and T_2 (8.12) treatments which were at par with each other. The treatment T_1 i.e. control treatment recorded minimum length of fruit (8.12 cm). Bansode (2012) [3] reported that the treatment receiving foliar spray of 1 per cent potassium nitrate and 0.5 per cent mono-potassium phosphate recorded maximum fruit length (10.43 cm) of mango.

Breadth of fruit

From the data presented in Table 1, it was revealed that the breadth of mango fruit varied significantly from 5.83 to 7.12 cm with a mean value of 6.43 cm. The treatment T_7 receiving foliar spray of 3 per cent Amrashakti recorded significantly maximum breadth of mango (7.12 cm) as compared to all other treatments. It was followed by T_6 treatment consisting 3 per cent potassium nitrate and T_4 treatment consisting 1 per cent Amrashakti nutrient solution. Both the treatments were at par with each other. However, treatment T_1 i.e. control treatment recorded minimum breadth of fruit (5.83 cm). Bansode (2012) [3] reported that the treatment receiving foliar spray of 1 per cent potassium nitrate and 0.5 per cent mono-potassium phosphate recorded maximum fruit breadth (7.77 cm) of mango.

Average weight of fruit

The data regarding the effect of foliar application of nutrients on average weight of fruit are presented in table 1. It was revealed from the data that the average weight of fruit varied significantly from 247 to 266 g with a mean value of 255 g. The treatment T_7 receiving foliar spray of 3 per cent Amrashakti recorded significantly highest average weight of fruit (266 g) of mango. The increase in fruit weight by foliar spray of nutrients may be due to involvement of nutrient in cell division and cell elongation which ultimately increase the weight of mango. It was followed by treatment T_6 (256 g), T_4 (256 g), T_5 (255 g) and T_3 (254 g) treatments which were at par with each other. The minimum average weight of fruit (247 g) was recorded with treatment T_1 i.e. control treatment and it was at par with treatment T_2 receiving foliar spray of 1 per cent urea (249 g). Gurjar *et al.* (2015) [6] reported the average weight of fruit by treatment receiving foliar spray of 1 per cent $ZnSO_4$ and $FeSO_4$ each + 0.5 per cent Borax (314.69 g) as compared to control treatment (182.72 g).

Number of fruits per tree

The number of fruits varied significantly from 115.00 to 209.00 with a mean value of 153.23. The treatment T_7 receiving foliar spray of 3 per cent Amrashakti multinutrient solution recorded significantly maximum number of fruits (209.00) per tree and showed its superiority over all other treatments. The application of multinutrient solution balances the auxin in plant which regulates fruit retention in mango and therefore, increased the number of fruits per tree. It was followed by treatment T_6 (178.33) and T_4 (177.00) treatments which were at par with each other. The Treatment T_1 i.e. control treatment recorded minimum number of fruits per tree

(115.00). Gurjar *et al.* (2015) [6] reported that the treatment receiving foliar spray of 1 per cent $ZnSO_4$ and $FeSO_4$ each + 0.5 per cent Borax recorded maximum number of fruit per tree.

Yield

The data pertaining to the effect of foliar application of nutrient on fruits per kg and yield in t ha^{-1} are presented in Table 1. It was revealed from the data that the application of manures, fertilizers and foliar spray showed significant effect on yield with different treatments. The treatment T_7 receiving foliar spray of 3 per cent Amrashakti multinutrient solution recorded significantly maximum fruits (53.30 kg $tree^{-1}$) and it was at par with treatment T_6 receiving foliar spray of 3 per cent potassium nitrate (46.97 kg $tree^{-1}$). The minimum mango fruits kg per tree were observed by treatment T_1 i.e. control treatment (29.45 kg $tree^{-1}$). The increase in fruit yield (kg $tree^{-1}$) is a cumulative effect of increase in number of fruits due to combined application of nutrients on mango. The yield t ha^{-1} was computed and it was observed that the treatment T_7 receiving foliar spray of 3 per cent Amrashakti multinutrient solution recorded significantly maximum fruit yield (5.39 t ha^{-1}) and showed its superiority over all other treatments. It was followed by treatment T_6 receiving foliar spray of 3 per cent potassium nitrate (4.59 t ha^{-1}), treatment T_4 consisting foliar spray of 1 per cent Amrashakti (4.44 t ha^{-1}) and treatment T_5 receiving foliar spray of 3 per cent urea (3.77 t ha^{-1}) showed an individual effect of treatments on mango yield. The minimum yield of mango was recorded with treatment T_1 i.e. control treatment (2.93 t ha^{-1}). This indicated the single chemical or combination of low dose of chemical nutrient did not influence the fruit yield in mango. Patil *et al.* (2010) [9] also reported the increase in the yield of mango due to increasing doses of foliar nutrient spray on Alphonso.

Effect of foliar application of nutrients on quality of mango

The data pertaining to the quality parameters of mango i.e. TSS, acidity, ascorbic acid, reducing sugars, total sugars and β-carotene content are presented in Table 2.

Total soluble solids

The data regarding the effect of foliar application of nutrients on total soluble solids revealed that the application of manures, fertilizers and foliar spray showed significant effect on total soluble solids with different treatments, ranged from 17.97 ^{0}Brix to 20.57 ^{0}Brix with a mean value of 19.32 ^{0}Brix. The treatment T_7 receiving foliar spray of 3 per cent Amrashakti recorded maximum total soluble solids (20.57 ^{0}Brix) and it was at par with T_6, T_4, and T_5 treatments. The increase in TSS may be due to the combine effect of nutrients that enhanced the conversion of complex polysaccharides into simple sugar through translocation of sugars from leaves to developing fruits. The minimum total soluble solids were recorded with treatment T_1 i.e. control treatment. Patil *et al.* (2010) [9] reported that the treatment receiving foliar spray of 2 per cent urea, sulphate of potash and single super phosphate each + 0.25 per cent $ZnSO_4$, $CuSO_4$ and borax each + 0.01 per cent ammonium molybdate recorded maximum TSS (21.13 ^{0}Brix) as compared with control treatment (17.83 ^{0}Brix) in Alphonso mango.

Titratable acidity

The data pertaining to titratable acidity as influenced by foliar application of nutrients are presented in Table 2. The titratable acidity significantly varied from 0.25 to 0.33 per cent with a mean value of 0.29 per cent. It was observed from the data that Treatment T_7 receiving foliar spray of 3 per cent Amrashakti recorded significantly minimum titratable acidity (0.25 %) as compared to other treatments and it was at par with treatment T_6 and T_4 receiving foliar spray of 3 per cent potassium nitrate and 1 per cent Amrashakti, respectively. The lowest acidity by application of nutrients combination may be due to conversion of acid into sugar and their derivatives by the reaction involving reversal glycolytic pathway. Significantly maximum titratable acidity 0.33 per cent was recorded with treatment T_1 i.e. control treatment that was significantly inferior over rest of the treatments. Similar values of titratable acidity were reported by Patil *et al.* (2010) [9] who reported the treatment receiving foliar spray of 0.5 per cent urea, sulphate of potash and single super phosphate each + 0.25 per cent zinc sulphate, copper sulphate and borax each + 0.01 per cent ammonium molybdate recorded significantly minimum titratable acidity in Alphonso mango.

Ascorbic acid content

From the data presented in Table 2, it was evident that ascorbic acid content varied significantly from 41.44 to 58.43 mg 100 g^{-1} with a mean value 49.46 mg 100 g^{-1}. The treatment T_7 comprising foliar spray of 3 per cent Amrashakti recorded significantly maximum ascorbic acid content of 58.43 mg 100 g^{-1}. The higher value of ascorbic acid content might be due to higher level of sugar by foliar spray of nutrients since ascorbic acid is synthesized from sugar. The treatment T_7 showed its superiority over all other treatments. It was followed by treatment T_6 (54.98 mg 100 g^{-1}) and T_4 (54.51 mg 100 g^{-1}) and both the treatments were at par with each other. The Treatment T_1 i.e. control treatment recorded minimum 41.44 mg 100 g^{-1} ascorbic acid content. The similar findings were obtained by Thakre (2016) [13] in Alphonso mango.

Reducing sugars

The data pertaining to reducing sugars as affected by different treatment are presented in table 2. The data revealed that reducing sugars in mango fruit was significantly influenced from 3.05 to 4.46 per cent with a mean value 3.94 per cent. Significantly, maximum reducing sugars 4.46 per cent was recorded with treatment T_7 receiving foliar spray of 3 per cent Amrashakti but it was at par with treatment T_6 and T_4 treatments. However, minimum reducing sugars 3.05 per cent was recorded with treatment T_1 i.e. control treatment. These finding are in conformity with the results reported by Bansode (2012) [3] who reported that the treatment consisting foliar spray of 2 per cent urea and 0.5 per cent mono-potassium phosphate recorded maximum reducing sugars (4.06 %) in Alphonso mango.

Total sugars

The data in respect of total sugars as affected by different treatment are presented in table 2. It was revealed that the total sugars content in mango fruit varied from 12.13 to 13.99 per cent with a mean value of 13.22 per cent. Maximum total sugars (13.99 %) was observed in case of treatment T_7 consisting foliar spray of 3 per cent Amrashakti but it was at par with treatment T_6, T_4 and T_5 treatments. The increase in sugars and different fractions of sugars might be due to applications of nutrient these augmented the conversion of

starch to sugar and it has also been increases transportation of sugars, synthesis of metabolites and rapid translocation of photosynthates and minerals from other parts of the plant to developing fruits. Minimum total sugars (12.13 %) was observed with treatment T_1 i.e. control treatment. Nehete *et al.* (2011) [8] reported that the treatment receiving foliar spray of 1 per cent $ZnSO_4$ and $FeSO_4$ each + 1 per cent Borax recorded maximum total sugar (16.67 %) as compared to control treatment (13.10 %) in mango cv. *Kesar*.

β-carotene

The data regarding β-carotene content in mango fruit as affected by foliar spray are presented in Table 2. It was observed from the data that the treatment T_7 receiving foliar spray of 3 per cent Amrashakti recorded maximum β-carotene content in mango but it was at par with T_6, T_4 and T_5 treatments. The increase in the β-carotene content may be due to accelerated biosynthesis during ripening process. The β-carotene content in mango ranged from 8.14 to 11.57 mg 100 g^{-1} with a mean value of 10.06 mg 100 g^{-1}. The minimum β-carotene content was recorded with treatment T_1 i.e. control treatment. Sankar *et al.* (2013) [12] also reported significantly maximum β-carotene content (12.34 mg 100 g^{-1}) as compared to control treatment (9.66 mg 100 g^{-1}) in mango due to foliar spray of nutrients.

Table 1: Effect of foliar application of nutrients on yield attributing characters and yield of mango

Tr. No.	Treatments	Yield attributing characters				Fruits (kg tree^{-1})	Yield (t ha^{-1})
		Length of fruit (cm)	Breadth of fruit (cm)	Average weight of fruit (g)	No. of fruits (tree^{-1})		
T_1	Control	8.12	5.83	247	115.00	29.45	2.93
T_2	Urea 1%	9.08	5.95	249	119.28	30.37	3.10
T_3	Potassium nitrate 1%	9.21	6.01	254	123.00	31.52	3.13
T_4	Amrashakti 1%	9.28	6.72	256	177.00	44.13	4.44
T_5	Urea 3%	9.22	6.57	255	151.00	40.24	3.77
T_6	Potassium nitrate 3%	9.38	6.84	256	178.33	46.97	4.59
T_7	Amrashakti 3%	10.02	7.12	266	209.00	53.30	5.39
	Mean	9.19	6.43	255	153.23	39.43	3.91
	S.E.±	0.188	0.084	1.44	4.72	2.68	0.03
	C.D. (P=0.05)	0.581	0.258	4.46	14.56	8.26	0.10

Table 2: Effect of foliar application of nutrients on quality of mango

Tr. No.	Treatments	TSS (^{0}Brix)	Titratable Acidity (%)	Ascorbic acid content (mg 100g^{-1})	Reducing Sugars (%)	Total sugars (%)	β-carotene (mg 100g^{-1})
T_1	Control	17.97	0.33	41.44	3.05	12.13	8.14
T_2	Urea 1%	18.40	0.30	43.52	3.49	12.73	9.06
T_3	Potassium nitrate 1%	18.76	0.29	43.54	3.77	13.04	9.33
T_4	Amrashakti 1%	19.73	0.26	54.51	4.28	13.61	10.76
T_5	Urea 3%	19.60	0.28	48.81	4.11	13.34	10.58
T_6	Potassium nitrate 3%	20.20	0.26	54.98	4.43	13.68	11.00
T_7	Amrashakti 3%	20.57	0.25	58.43	4.46	13.99	11.57
	Mean	19.32	0.29	49.46	3.94	13.22	10.06
	S.E.±	0.458	0.009	1.091	0.060	0.224	0.635
	CD at 5%	1.413	0.028	3.363	0.185	0.690	1.957

Conclusion

From the present investigation, it can be concluded that the application of 3 per cent Amrashakti multinutrient solution through foliar spray is essential for increasing yield attributing characters and yield as well as quality of *Alphonso* mango in lateritic soil of Konkan region of Maharashtra.

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