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Studies on influence of time of soil application of micronutrients on morpho-agronomic characters in Papaya cv. Red Lady

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Abstract
The present study was conducted to assess the influence of time of soil application of Zinc, Boron and Iron mixture on morpho agronomic characters including quality, shelf life and organoleptic parameters in papaya cv. Red Lady. The micronutrient mixture containing 3gm Boron and 10gm each of Zinc and Iron was applied to soil in twelve different treatments (T1- at planting, T2-first, T3-second, T4-third, T5-fourth, T6-fifth, T7-sixth, T8-seventh, T9-1,3,5,7^{th,} T10-1-3rd, T11-4-6th months after planting and T-12 (control; zero micronutrients/water spray). There was very little differences observed in growth parameters and however, there was positive improvement observed in reproductive, yield, quality, shelf life and organoleptic parameters compare to control. The flowering (104.00 days), fruit set (123.11 days) and fruit harvest (147.10 days) after fruit set significantly earliest in T9 compared to control (110.67, 145.33 and 160.22 days, respectively). The treatment T_9 was also the significantly best with respect to fruit weight, fruit width, and yield per plant (1.54kg, 16.20cm, 43.54kg, respectively) compared to control (1.13kg, 12.77cm, 20.70kg, respectively). Further, the plants applied with T_9 have shown significantly highest total soluble solids (11.50°Brix), highest ascorbic acid (23.03 mg/100g pulp) and lowest acidity (0.087%) compared to control. Further, the highest shelf life (8.00 days), good overall acceptability (7.53 marks), maximum score for texture (7.22), maximum score for taste (7.61), maximum score for colour (7.47) maximum score for flavour (7.48) was observed T_9 treated plants. The present study indicated that continuous application of micronutrients from planting to first harvest is very important to obtain good yield, quality, shelf and good organoleptic parameters in papaya cv. Red Lady.

Keywords: papaya, red lady, micronutrients, growth and yield, time of application

Introduction
Papaya (*Carica papaya* L.) is an important fruit crop of tropical world and has long been known as wonder fruit of the tropics. Papaya is one among the fruits, which has attained great popularity because of its quick returns, easy cultivation, adaptability to adverse soil and climatic conditions. Above all its attractive and delicious taste, wholesome fruits have multifarious uses (Reddy *et al*. 2014) [16]. The fruit contain high amount of vitamin A, vitamin C and iron (Rashid *et al*., 1987) [13]. The ripe fruit of papaya is eaten as such throughout the tropics. Ripe fruits also find its extensive uses for several preparations like jam, soft drinks, ice-cream flavoring and crystallized fruit. It is a nutritive fruit containing carbohydrates, protein and minerals mainly iron, calcium and phosphorus. It is rich source of Vitamin 'A' having 2020 I.U./100g of fruit.

The nutritional demand of papaya differs from other fruit crops because of tremendous yield potential due to precocious bearing and indeterminate flowering habit with simultaneous vegetative growth, flowering and fruiting (Bhardwaj and Bajpai, 2015). Hence, nutrient management is one of the key factor and most important cultivation practices to improve the productivity of papaya and account for 30 percent of total cost of cultivation. The productivity of papaya is adversely affected if the crop is not feed properly. For want of maximizing yield potential, continuous sole and erratic use of chemical fertilizer in imbalance ratio leads to decline in soil fertility as well as nutrient uptake efficiency of plants of papaya differ from other fruit crops because of its quick growth, continuous flowering and fruiting habit and heavy production, so plant would exhibit sensitiveness to low supply of major and minor nutrients resulting in either yield stagnation or decrease (Tandel *et al*, 2014) [22].

They play an important role in disease resistance, since they function as enzyme activators and also play a role in lignin biosynthesis. Papaya requires high amounts of nutrients for growth and fruit production, and it was estimated that papaya removes about 989 mg boron, 300 mg copper, 3364 mg iron, 1847 mg manganese, 8 mg molybdenum and 1385 mg zinc per tonne of fruit (Parmar *et al*., 2017) [12].

Zinc and iron associated with various enzyme systems and boron is associated with the carbohydrate chemistry and reproductive system of the plant (Suman *et al*., 2017) [19]. Of late, horticultural crops suffer widely by zinc (Zn) deficiency followed by boron (Bo), manganese (Mn), copper (Cu), iron (Fe) and molybdenum deficiencies. Some reasons are higher crop yields which increase plant nutrient demands, use of high analyses NPK fertilizers containing lower quantities of micro-nutrient contaminants and decreased use of farmyard manure on many agricultural soils (Bhalerao and Patel, 2012) [3]. Fruit set (early fruit drop) is the most critical stage of fruit development from the grower's point of view. It is during this period that the greatest gains in fruit retention influencing final yield can be made. Events during this period also impact fruit size and quality (Lovatt, 1999) [8]. Hence, in addition to quantity, time of application of micronutrients is also a very critical event in fruit crop cultivation. In spite of several studies taken up on nutrition for papaya crop, information is meager on micro nutrient application as well as its impact. In our last study, soil application of Zinc (10gm), Boron (5gm) and Iron (10gm) showed significantly better growth, yield and quality of papaya cv. Red lady (Preethi *et. al*., 2017) [9]. In this view, the present investigation was carried out to study the influence of time of soil application of micronutrient mixture (Zinc, Boron and Iron) on morpho-agronomic characters including quality, shelf life organoleptic parameters in papaya cv. Red Lady.

Material and Methods

Pitting, planting, design for evaluation of morpho-agronomic parameters

The present research was carried out to find out best time of soil application of micronutrient mixture [Zn (10g), B (3g) and Fe (10g)] under University of Horticultural Sciences, Bagalkot. The quality seedlings of papaya cv Red Lady have been raised in portrays in polyhouse. Healthy seedling having 4-5 leaves have been selected for planting in 45cm^3 pits. Pits were dug at a distance of 6ft X 6ft between rows and plants, respectively, filled with planting mixture having top soil, FYM, 100 single super phosphate and 25 gm phorate. The supply of major nutrients was taken up (250 g N, 250 g P and 500 g K per plant) with four equal split doses at planting, at two, four and six months of transplanting into field. The Randomized Block Design (RBD) was the statistical design employed with 12 (T_1- At planting, T_2- 1st month, T_3- 2nd month, T_4- 3rd month, T_5- 4th month, T_6 -5th month, T_7- 6th month, T_8- 7th month, T_9- 1,3,5 and 7 months, T_{10}-1 to 3 months, T_{11}- 4 to 6 months, T_{12}- Control treatments) in three replications each.

Evaluation of fruits for quality parameters

The evaluation of quality of fruits of different treatment was carried out as per the procedure reported by Anon. (1960). Randomly, four fruits of all the treatments were used to assess TSS using hand refractometer (unit of expression is ° Brix). Further, The estimation of acidity (unit of expression is %) and ascorbic acid (Vitamin-C, unit of expression is mg of ascorbic acid per 100 ml of fruit juice) levels was taken up as per modified procedure of AOAC (Anon., 1960)

$$\text{Titratable acidity (\%)} = \frac{\text{TV x Normality of NaoH x Equivalent weight of acid x Volume made up x 100}}{\text{Volume of sample taken x Weight of sample x 1000}}$$

$$\text{Ascorbic acid (mg/100 ml)} = \frac{\text{Ascorbic acid (mg) in standard x TV2 x Volume made up x 100}}{\text{Standard value x Weight of sample x Aliquot taken x 1000}}$$

Evaluation of fruits for Organoleptic parameters

The fruits of various treatments were subjected to organoleptic evaluation by a team having collogues in the department of post harvest technology, fruit sciences and teachers of our college. To assess opinion of them on texture, color, taste etc., nine point hedonic rating scale (1=dislike extremely, 2= dislike very much, 3= dislike moderately, 4= dislike slightly, 5=neither like nor dislike, 6= like slightly, 7= like moderately, 8= like very much and 9 = like extremely) was followed. The fruit of various treatments and control have been marked with codes and displayed to the team of judges of sensory evaluation. Finally, the points provided by judges was averaged and compared for sensory acceptance.

Evaluation of shelf life of fruits

The fruit of different treatments were subject to shelf life analysis to find out the period of acceptable appearance and marketability. When the fruits attained beyond edible ripe stage and shriveled, then those fruits were considered to have reached the end of their shelf life (Turner, 1997). The shelf life is expressed in days.

Recording observations and statistical analysis

The height of plant was recorded every month up to eight month from transplanting by using scale from the reference point made on trunk at 10 cm above ground level to shoot tip of plant and expressed in centimeters. The girth of stem was recorded every month up to eight month from transplanting at 10cm above growing level by using measuring tape and expressed in centimeters. The observation on number of leaves (upto eight months), days taken for first flowering, flowering to first harvest, flowers, fruits per plant (counted after maturity) and yield per plant was done by counting. The average fruit weight (kilo grams) was found out using five fruits selected randomly from each treatment by digital analytical balance. The observations on fruit length (cm) and width (cm) was made with scale. The shelf life and organoleptic parameters were recorded after harvesting of fruits from each treatment.

The data on all the growth, yield and quality parameters was tabulated and subjected to statistical analysis using method of analysis of variance (ANOVA) for randomized complete block design (RBD) by Fisher and Yates (1963). Whenever 'F' test was found significant, for comparing the means of two treatments, critical difference (C. D. at 5%) were worked.

Results and Discussion

Influence of time of micronutrient application on morpho-agronomic parameters

The plant height was significantly highest in the plants applied with T_9 which was on par with T_{10} (1 to 3 months) in 2nd, 3rd, 4th and 5th months after transplanting (MAT) and it was non-significant in the 1st, 6, 7 and 8th MAT (Table 1). The stem girth was significantly higher in the plants applied which were on par with T_{10} (1 to 3 months) in all the growth stages

of the plant except 1, 2, 3 and 8 MAT (Table 2). The values for number of leaves per plant were significantly higher when the plants applied with T_9 in all the growth stages of the plant except 1, 2 and 3 MAT (Table 3).

The maximum plant height (1.51 m) and stem girth (36.1 cm) and highest number of leaves (48.56) was recorded in plants applied with T_9, whereas T_{12} (control-no micronutrient/water spray) recorded minimum values for those growth parameters in papaya cv. Red Lady. Increase in the plant height and stem girth was also due to application of micronutrients, because they have important role in chlorophyll synthesis and development of cells in meristemetic tissues. The increase in number of leaves might be due to combination of zinc sulphate and boron which facilitates the transport of carbohydrates through cell membrane *i.e.* starch and sugars as well plays an important role as the activator for many enzymes which promote the growth of the plant. The beneficial effects of micronutrients on height and stem girth was might be due to zinc enhanced the synthesis of auxin in the plants as confirmed by Singh *et al.,* (2010) [17] in papaya. Similar findings were revealed by Shekar *et al.* (2010) [17] in papaya.

In the present study, there was significant effect of time of micronutrient application on reproductive and yield parameters of papaya cv. Red Lady. The days taken for flowering, fruit set and fruit harvest was less in T_9 (Table 4). The earliness in flowering also might be due to the boron, which regulates metabolism involved in translocation of carbohydrates, cell wall development, RNA synthesis and it also increased the phenolic compounds thereby regulating polar auxin transport (Ram and Bose, 2000). It also might be due to improved photosynthetic activity and respiration of plants as influenced by boron and zinc (Singh *et al*., 2010) [17]. Further, plants applied with T_9 showed higher number of flowers plant^{-1} (50.11) at 8 months after transplanting, which may be due to the positive combined effect of zinc, iron and boron on flowering. Manjunatha *et al.*, (2014) [10] have reported same type observations in papaya cv Red Lady with foliar application of micronutrients.

Significantly highest number of fruits were recorded in the plants applied with T_9 (28.33), whereas least number of fruits in T_{12} (Control) (Table 5). Such increase in number of fruits per tree due to combined application of micronutrients either through foliar or soil application might be due to production of auxins which were probably helpful for retention of fruits by reducing flower drops thereby increasing number of fruits and similar results were reported by Preethi *et al*. (2017) [9] in papaya cv. Red Lady with soil application of different quantity of micronutrients. In this study, weight of fruits (1.54 kg) and fruit width (16.20 cm) was significantly highest in the plants applied with T_9 and the lowest values were observed in control. Further, the highest fruits per plant and hectare at 8th MAT was 43.55 kg and 125.03 t/ha in the plants applied with T_9, respectively, while the lowest of it was 22.71 kg and 70.08 t in T_{12} (Control), respectively. Similarly, Bhalerao and Patel (2015) [4] reported that with foliar application of combination of micronutrients (calcium nitrate 1000 mg/l + borax 30 mg/l + zinc sulphate 200 mg/l + ferrous sulphate 200 mg/l) at 60,90 and 120 days after planting has resulted in a highest weight, length, fruits per plant and hectare of 1.37kg, 25.39cm 32.31kg and 80.76kg compared to 1.03kg, 19.12cm, 19.63 49.07kgs, respectively in control in papaya cv. Red Lady. In another study in papaya cv. Red Lady by Manjunath *et al.*, (2014) [10] with foliar application of micronutrients at 3rd, 5th and 7th MAT, the fruit weight, length, fruits per plant and hectare at nine months was highest of 1.73kg, 21.17cm, 38.57kg and 119.04kgs, respectively in combination of Zn (0.25%), Fe (0.5%) and Bo (0.1%) compared to 1.13kg, 17.60cm, 19.97kg and 61.62kgs, respectively in control. Suman *et al.* (2016) [20] reported that increased fruit set and reduced fruit drop as a result of boron, iron, magnesium, manganese, zinc and copper spray could give higher number of fruits and consequently the yield. Hence, it appears, continues supply of micronutrients in soil helps in obtaining high yield in papaya cv. Red Lady.

Table 1: Effect of time of soil application of Zinc, Boron and Iron mixture on plant height (m) of papaya cv. Red Lady

Treatment [Zn(10g), B(3g) and Fe(10g)]	Months after transplanting							
	1	2	3	4	5	6	7	8
T_1-At planting	0.41	0.65	0.88	1.05	1.18	1.32	1.35	1.49
T_2-1st month	0.40	0.71	0.92	1.09	1.18	1.35	1.41	1.48
T_3-2nd month	0.37	0.64	0.92	1.12	1.15	1.33	1.38	1.43
T_4-3rd month	0.38	0.64	0.89	1.10	1.23	1.35	1.40	1.47
T_5-4th month	0.33	0.61	0.83	1.09	1.19	1.31	1.37	1.43
T_6-5th month	0.43	0.64	0.81	1.09	1.13	1.29	1.35	1.41
T_7-6th month	0.39	0.62	0.80	1.02	1.13	1.28	1.33	1.39
T_8-7th month	0.37	0.60	0.84	1.01	1.14	1.25	1.30	1.37
T_9-1,3,5,7 months	0.37	0.76	0.96	1.22	1.30	1.40	1.47	1.51
T_{10}-1 to 3 months	0.42	0.72	0.98	1.18	1.29	1.39	1.44	1.50
T_{11}-4 to 6 months	0.38	0.67	0.85	1.10	1.21	1.31	1.37	1.43
T_{12}-Control	0.35	0.61	0.80	1.00	1.14	1.25	1.33	1.36
S Em+_	0.02	0.02	0.04	0.04	0.04	0.05	0.05	0.05
CD@5%	NS	0.07	0.11	0.13	0.11	NS	NS	NS

Table 2: Effect of time of soil application of Zinc, Boron and Iron mixture on stem girth (cm) of papaya cv. Red Lady

Treatment [Zn(10g), B(3g) and Fe(10g)]	Months after transplanting							
	1	2	3	4	5	6	7	8
T_1-At planting	11.1	18.0	23.9	28.8	30.7	31.6	33.1	35.5
T_2-1st month	11.0	17.8	23.8	28.8	30.3	31.9	32.9	35.3
T_3-2nd month	10.7	15.6	23.2	28.6	31.1	32.1	34.1	35.3
T_4-3rd month	11.2	15.6	22.2	29.1	31.2	33.0	34.1	35.1
T_5-4th month	9.6	17.0	22.6	28.7	31.6	32.0	33.4	34.4
T_6-5th month	10.8	16.5	22.6	27.6	29.2	31.4	33.0	34.4

T_7-6th month	10.7	17.5	23.0	28.9	30.2	31.5	32.8	34.3
T_8-7th month	10.5	17.2	22.3	27.5	28.6	31.7	32.7	34.3
T_9-1,3,5,7 months	10.9	18.6	24.2	31.3	33.6	34.5	36.0	36.1
T_{10}-1 to 3 months	10.8	18.1	24.1	30.4	32.6	34.1	34.8	35.7
T_{11}-4 to 6 months	10.7	15.8	22.5	28.8	32.0	32.9	33.8	34.5
T_{12}-Control	11.1	17.0	22.8	27.5	28.7	31.9	32.7	33.6
S Em+_	0.44	0.69	0.73	0.72	0.91	0.69	0.62	0.76
CD@5%	NS	NS	NS	2.12	2.67	2.02	1.81	NS

Table 3: Effect of time of soil application of Zinc, Boron and Iron mixture on number of leaves of papaya cv. Red Lady

Treatment [Zn(10g), B(3g) and Fe(10g)]	Months after transplanting							
	1	2	3	4	5	6	7	8
T_1-At planting	9.56	13.11	24.00	30.00	33.68	35.67	38.11	41.56
T_2-1st month	11.00	13.89	23.56	30.77	33.56	35.55	38.44	42.22
T_3-2nd month	9.89	13.44	23.00	32.01	36.78	36.78	39.67	43.56
T_4-3rd month	9.22	12.56	23.56	31.78	37.44	40.00	42.11	43.78
T_5-4th month	9.56	12.33	23.00	31.32	37.11	39.78	41.33	43.33
T_6-5th month	12.00	14.89	22.67	31.56	34.01	37.00	40.78	43.33
T_7-6th month	11.22	13.56	22.56	30.89	32.68	36.89	38.45	41.44
T_8-7th month	11.00	13.56	22.56	30.23	32.89	35.33	38.00	41.11
T_9-1,3,5,7 months	9.67	11.78	24.44	37.33	39.11	42.68	45.45	48.56
T_{10}-1 to 3 months	10.67	13.67	24.33	36.43	38.22	41.78	43.00	44.22
T_{11}-4 to 6 months	10.67	13.78	23.44	33.55	38.00	39.78	41.78	43.44
T_{12}-Control	10.44	13.67	22.44	29.89	32.89	35.33	38.00	40.33
S Em+_	0.57	0.63	0.67	1.60	1.62	1.70	1.58	1.03
CD@5%	NS	NS	NS	4.70	4.76	4.98	4.62	3.01

Table 4: Effect of time of soil application of micronutrients on reproductive parameters in Papaya cv. Red Lady

Treatment [Zn(10g), B(3g) and Fe(10g)]			Days taken for first flowering	Days taken to first fruit set	Days to fruit harvest after fruit set	Flowers plant^{-1}	Fruits plant^{-1}
T_1	105.44	130.44	152.22	130.44	152.22	40.44	22.00
T_2	105.44	132.33	156.22	132.33	156.22	40.22	22.33
T_3	109.66	138.89	156.89	138.89	156.89	40.22	22.44
T_4	109.44	144.88	155.56	144.88	155.56	41.22	22.67
T_5	109.33	145.33	156.89	145.33	156.89	42.89	22.78
T_6	109.55	143.78	157.11	143.78	157.11	44.55	22.78
T_7	109.44	142.42	156.43	142.42	156.43	41.67	22.00
T_8	109.89	144.63	160.10	144.63	160.10	40.22	22.33
T_9	104.00	123.11	147.10	123.11	147.10	50.11	28.33
T_{10}	104.78	129.00	150.22	129.00	150.22	48.00	24.00
T_{11}	108.67	145.10	155.78	145.10	155.78	47.00	23.33
T_{12}	110.67	145.33	160.22	145.33	160.22	39.89	20.00
S.Em ±			1.11	1.17	1.12	1.85	1.08
CD @ 5%			3.26	3.43	3.30	5.42	3.17

Table 5: Effect of time of soil application of micronutrients on yield parameters in papaya cv. Red Lady

Treatment [Zn(10g), B(3g) and Fe(10g)]			Fruit weight(kg)	Fruit length (cm)	Fruit width (cm)	Yield (kg plant^{-1})	Yield (t ha^{-1})
T_1	-	At planting	1.15	16.93	11.80	25.36	78.26
T_2	-	1st month	1.16	16.32	11.88	25.91	79.97
T_3	-	2nd month	1.18	16.77	12.18	26.46	81.67
T_4	-	3rd month	1.20	16.38	12.30	27.20	83.95
T_5	-	4th month	1.25	16.70	12.48	28.45	87.81
T_6	-	5th month	1.28	17.20	12.55	29.22	90.16
T_7	-	6th month	1.23	16.87	12.83	27.13	83.71
T_8	-	7th month	1.20	16.02	12.93	26.85	82.86
T_9	-	1,3,5,7 months	1.54	18.40	16.20	43.54	134.37
T_{10}	-	1 to 3 months	1.38	17.62	14.15	33.19	102.44
T_{11}	-	4 to 6 months	1.41	20.13	14.50	32.90	101.51
T_{12}	-	Control	1.13	15.90	12.77	22.70	70.05
S Em ±			0.02	0.51	0.55	1.61	4.98
CD @ 5%			0.06	1.49	1.62	4.74	14.61

Influence of time of micronutrient application on quality parameters

There was significant effect of time of micronutrients application on total soluble solids (TSS), acidity and ascorbic acid of fruits. The highest total soluble solids (TSS) and ascorbic acid of 11.50˚ Brix and 23.03 mg/100g pulp, respectively was recorded in fruits of plants applied with T_9 while the lowest of 9.45˚ Brix and 18.98 mg/100g pulp,

respectively was recorded in T_{12} (Control). The lowest and highest acidity was observed in T_9 (0.087%) and T_{12} (Control; 0.168%), respectively (Table 6). Similar findings were recorded in the studies conducted by Bhalerao and Patel (2015) [4] in papaya cv. Red Lady, with foliar sprays of micronutrient combination at 60, 90 and 120 days of planting, highest TSS and ascorbic acid content was obtained i.e 7.49˚Brix and 23.23 mg/100 g. Similarly, Modi *et al*. (2012) [11] with foliar sprays of micronutrients, highest TSS of 11.44 ˚Brix compared to control (9.82˚Brix) in cv. Madhu Bindu. High TSS content in micronutrients applied fruits was may be attributed to an increased photosynthetic activities and production of more sugars. Similarly, in guava, Rawat *et al*. (2010) [14] reported increase in TSS and decrease in acidity upon application of micronutrients. An increase in ascorbic acid content was due to catalytic activity of zinc, iron and boron on its bio-synthesis from its precursor glucose-6-phosphate or inhibition of its conversation into dehydro ascorbic acid by enzyme and oxidation or both. Similar trend was also observed by Dutta *et al.* (2000) [6] in litchi. The reduction in acidity might be due to conversion of acids into sugar and their derivatives by reaction involving reversal of glyconic pathway (Tamboli *et al*., 2015) [21].

Table 6: Effect of suitable period of soil application of Zinc, Boron and Iron mixture on quality, shelf life and organoleptic parameters of papaya cv. Red Lady

Treatment [Zn(10g), B(3g) and Fe(10g)]	TSS(˚Brix)	Ascorbic acid (mg/100 g pulp)	Acidity (%)	Flavour	Taste	Texture/ Consistency	Overall acceptability	Shelf life (days)	Colour
T_1-At planting	9.58	19.39	0.167	5.20	5.16	5.31	6.20	6.33	6.51
T_2-1st month	9.88	21.00	0.160	5.21	5.41	7.03	6.50	6.83	7.27
T_3-2nd month	9.62	21.00	0.147	6.02	6.05	6.27	6.39	6.83	6.51
T_4-3rd month	10.58	21.00	0.147	6.20	6.18	6.36	6.44	6.33	6.55
T_5-4th month	10.52	21.81	0.134	6.05	6.27	6.05	6.18	6.17	6.41
T_6-5th month	10.78	21.81	0.134	6.27	6.42	5.81	5.98	6.00	6.39
T_7-6th month	10.68	22.22	0.147	6.06	6.51	7.08	5.09	5.83	5.27
T_8-7th month	10.78	22.22	0.161	6.41	6.71	5.14	5.08	6.00	5.05
T_9-1,3,5, 7 months	11.50	23.03	0.087	7.45	7.61	7.22	7.53	8.00	7.47
T_{10}-1 to 3 months	10.72	21.81	0.121	7.18	7.05	6.07	7.18	7.67	7.40
T_{11}-4 to 6 months	11.18	22.62	0.087	7.48	7.51	7.14	7.50	7.83	7.45
T_{12}-Control	9.45	18.98	0.168	5.18	4.39	5.14	4.98	5.50	5.02
S. Em+_	0.23	0.06	0.05	0.31	0.07	0.03	0.29	0.01	0.56
CD@5%	0.67	0.18	0.16	0.90	0.19	0.09	0.84	0.03	1.65

Influence of time of micronutrient application on organoleptic parameters and shelf life

In the present study, the time of micronutrient application had significant influence on fruit colour (7.47), flavour (7.48), taste (7.61), texture (7.22) and overall acceptability (7.53) compared to control (Table 6). There are no reports on impact of mocronutrients on organoleptic tests in papaya. However, there is possibility in enhancement of organoleptic qualities by application of micronutrients in papaya and other fruits as these involved in photosynthesis, enzyme activities, etc. Further, the time of application of micronutrients had significant effect on shelf life. The maximum shelf life was observed in fruits of plants applied with T_9 (8.00 days) and minimum of it was in fruits of T_{12} (Control; 5.50 days). Similarly, Bhalerao and Patel (2015) [4] found that with foliar application of micronutrients enhanced shelf life to 6.95 days compared 3.86 days in fruits of control in papaya cv. Red Lady. Bhagwan *et al.* (2000) [2] reported that polyamines play a role in extension of shelf life of fruits by affecting the permeability of cell membranes along with their opposing effects on the action of ethylene. Nevertheless, in papaya extension of shelf life could be ascribed to the beneficial effect of zinc and boron on hormonal metabolism, photosynthesis and water relations in plants. Further, it may be due to slower conversion of starch to sugars and also less and delayed incidence of papaya ring spot virus, which deteriorates the fruit quality. Appreciable improvement in shelf life by Zinc and boron application has also been reported by Singh *et al.* (2010) [17] in papaya cv. Ranchi.

Comprehensively, the present study concludes that both micronutrients and time of its application was found to have little influence on vegetative but they have prominent impact on other morpho-agronomic characters such as flowering, fruit characters, yield including quality, shelf life and organoleptic parameters in papaya cv. Red Lady.

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