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Response of preharvest foliar spray of micronutrients on physiological loss in fruit weight (PLW), fruit volume, organoleptic and shelf life of mango (*Mangifera indica* L.) cv. Langra at ambient storage conditions

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Abstract
The investigation was carried out at the Horticultural Research Centre, Patharchatta of the G.B. Pant University of Agriculture and Technology, Pantnagar (U.S. Nagar), Uttarakhand to study the effect of preharvest foliar spray of micronutrients on physiological loss in fruit weight, fruit volume, organoleptic and shelf life of mango cv. Langra. Under ambient storage conditions, preharvest foliar spray of boron, zinc, iron and copper gave minimum physiological loss in fruit weight. Organoleptic was found maximum mostly with the combination of 2, 3 or 4 micronutrients at room temperature conditions. Application of all the four micronutrients was found effective to get more shelf life of fruits.

Keywords: foliar application, langra, mango, micronutrients and shelf life

1. Introduction
Mango (*Mangifera indica* L.) the king of fruits" the main fruit of Asia and possessing own importance all over the world has been in cultivation in the Indian sub-continent for well over 4000 years (De Candolle, 1904). In India nearly 16.2 million tonnes of mangoes were produced from 2.4 million ha area. Out of the total 6.7 million hectare area, the fruit production in India is 76.4 million tonnes in 2011-12). The productivity of mango in India is low i.e. only 11.4 tonnes per hectare (Indian Horticulture Data Base, 2011-12). Mango shares 20.3 percent to total production (Indian Horticulture Data Base, 2010-11). Langra is one of the main commercial cultivars of North India. Foliar feeding is one way to achieve the goal because nutrients can be applied directly to the site of their metabolism and are, therefore, less subjected to various losses as in the case of soil application. Moreover, for rapid response and correction of deficiencies of micronutrients, foliar sprays of nutrients especially Zn, B, Cu and Fe have been used singly and in combination. Foliar feeding is beneficial for accelerating improvement in physico-chemical characters of fruits (Srivastava, 1993) [16].

2. Materials and Methods
The investigation was carried out in the two years at the Horticulture Research Centre, of the University. The experiment was conducted on 27 year old trees of mango cv. Langra planted at 12 m distance in square system and maintained under uniform cultural practices. The trees were almost uniform in growth and vigour. The soil was well drained, sandy loam having pH (6.9), Zn (0.330 ppm), Fe (23.994 ppm), Cu (2.934 ppm) and B (1.27 ppm). The treatment comprises of two levels of boron (0 and 0.4%), zinc (0 and 0.1%), iron (0 and 0.02%) and copper (0 and 0.05%). These micronutrients were sprayed through foliar application. During the month of April and May, sixteen treatment combinations were replicated thrice and laid out as per complete randomized design.

3. Results and Discussion
Results recorded on fruit weight in Table 1 indicated that the maximum physiological loss in weight was observed in treatment combination having boron + copper. Although minimum PLW was observed under the treatment combination having all the four micronutrients. Barua *et al.* (1993) [2] observed that preharvest spraying of micronutrients decreased PLW and reduced respiration rate and surface discolouration. Fruits of Khasi mandarin harvested at colour break and completely orange yellow stage of maturity and various physical characteristics were studied during transport and 9 days storage at room temperature. PLW and juice content were significantly affected by stage of maturity and application of micronutrients. Ghosh *et al.* (2001) [5] also said that $CuSO_4$ spray reduced the loss in weight i.e. approximately 3% after 15 days of storage. It was also observed in research findings in general that in all the treatment the fruit weight was less in comparision to the fruit weight in the first year because of more number of fruits and yield in comparision to previous year. It is due to the alternative bearing tendency of Langra cv. of mango. Pre-storage dip application of PAs retarded development of mean fruit softness (10.3%) and visual colour (26.3%), and reduced weight loss (6.8%) during storage without significant ($P \leq 0.05$) reductions in ethylene production and respiration rate. During ripening of 3 week-stored fruit, 0.5 mM SPM-treated fruit exhibited significantly ($P \leq 0.05$) lower mean respiration rates compared with the control. Application of PAs significantly ($P < 0.05$) increased fruit firmness and ascorbic acid content, while reducing carotenoids, total soluble solids (TSS)/acid ratio and Hue

angle of ripe fruit compared with the no-PA treatment. In conclusion, pre-storage dip application of PAs improved the shelf-life of mango fruit without impairing fruit quality (Malik and Singh, 2005) [11]. Calcium application (0.5-1.0% $CaCl_2$/Ca $(NO_3)_2$) reduced physiological weight loss and spoilage in fruits. The deficiency of zinc and iron on young foliage can easily be controlled by spraying 0.4-0.5% zinc sulphate and ferrous sulphate, respectively, during April (2003).

In the first year percentage change in fruit volume was maximum in treatment combination having iron and copper while it was minimum in treatment combinations having boron, zinc and copper. Although in the second year minimum change (13.74%) in fruit volume was observed in the treatment having all four micronutrients while it was maximum in treatment having iron application only (Table 2). Overall result showed that iron alone and in combination with copper gave maximum fruit volume because iron and copper act catalyst in metabolic reactions of carbohydrate metabolism by seeing the result it is observed that boron, zinc and copper gave minimum percentage change in fruit volume. It means this combination is good for having more fruit volume after 8 days of storage under ambient conditions. Singh and Khan (1990) supported the findings. They observed that trace micronutrients (Zn, Cu and B) significantly increased the tree volume of mango cv. Dashehari (Table 2).

Data presented in Figure 3 revealed that organoleptic rating increased from 4th day onwards and declined on the 8th day of storage in both the years. Maximum organoleptic rating was observed for the fruits harvested from trees treated mostly with combinations of 2, 3 or 4 micronutrients. Kapse *et al.* (1989) [10] carried out storage studies in Mulgoa and Malda varieties of mango. Organoleptic evaluation, physiological and bio-chemical changes were studied. In fruits stored at ambient temperature, the proper development of sugar acid blind and carotenoids was accounting for the highest organoleptic rating on tenth day. Organoleptic evaluation data was in conformity with bio-chemical assessment. Score for cold stored fruit was comparatively less than the fruits stored at ambient temperature. Syed and Haq (1993) [17] also studied the organoleptic evaluation of mango fruit and showed that its fragrance and taste were best for 7th days (scoring 4.52 and 4.50, respectively).

Data revealed that after 2 days of storage of fruits number of marketable fruits reduced in some treatments (T_1, T_2, T_4, T_5, T_7, T_9, T_{10}, in first year and T_2, T_6 and T_9 in second year). After 4th day of storage all 5 fruits remained marketable under T_{16}. After 6th days of storage period number of marketable fruits decreased upto 3.33 (T_1, T_2 and T_3) to 4.33 (T_{15} and T_{16}) in the previous year while reduction in number of fruits was much less in the treatment T_{15} and T_{16} in comparision to control treatment (3.33). So results indicated that there was minimum (T_{16}) reduction upto 4th days of storage and maximum (T_1) reduction was recorded after 8th day of storage in both the years (Figure 4). It means combination of all the four micronutrients play vital role in increasing the shelf life of fruit as compare to fruits of control trees. Moreover Sanches *et al.* (2005) [13] found that the fruits of Gola and Kaithli cvs. of ber became unfit for consumption by the 8th day of ambient room storage after transportation. Research finding is also similar to the findings of Singh and Chauhan (1993) [14] who observed that the preharvest spray of calcium nitrate, calcium nitrate + zinc chloride and cycocel increased the shelf life of guava fruits. Treated fruits did not show any rotting for upto 18 days storage and even after 24 days rotting of fruits was less than in the control. Dipasupil (1984) [4] recorded that mangoes stored at ambient condition throughout the storage period exhibited significantly the shortest storage life of 12.67 days. While Ahmed *et al.* (1997) [1] also confirmed that foliar sprays of Zn, Cu, B and Fe alone or in combination improve the growth nutritional status and shelf life of fruit of Red Roomy grapevines (*Vitis vinifera* L.). Litchi (*Litchi chinensis*) fruits were dipped in 50 ppm aqueous solution of $Cacl_2$, $CuSO_4$ and borax for 30 minutes. These treatments greatly prolonged the shelf life of litchi (Ghosh *et al.*, 2003) [6], Raina *et al.* (1993) [12] observed minimum spoilage (20.5%) in fruits of peach cv. Sharbati Safeda from trees receiving 1 spray of $ZnSO_4$, 2 sprays of Ca $(NO_3)_2$ and 1 spray of malefic hydrazine in sequential order. Fruits were marketable after 6th days of storage compared with 2nd days for fruits from untreated trees.The results suggested that treatment with chitosan coating exhibited a potential for shelf life extension at ambient temperature when litchi fruit were removed from cold storage (Yueming *et.al.*, 2005) [9] (Figure 4).

Table 1: Effect of pre-harvest foliar spray of micronutrients on fruit weight at ambient storage conditions in mango cv. Langra.

Treatments	Fruit weight (g)											
	First Year						Second Year					
	0 day	2 days	4 days	6 days	8 days	% PLW*	0 day	2 days	4 days	6 days	8 days	% PLW*
$B_0Zn_0Fe_0Cu_0$	274.17	249.16	234.17	224.16	219.15	20.06	254.15	236.81	221.50	210.83	205.83	19.02
$B_0Zn_0Fe_0Cu_1$	285.83	260.83	245.82	235.81	230.80	19.24	265.81	240.83	225.83	215.80	210.82	20.69
$B_0Zn_0Fe_1Cu_0$	298.50	273.51	258.51	248.52	243.51	18.43	278.52	253.50	238.51	228.51	223.50	19.75
$B_0Zn_0Fe_1Cu_1$	309.30	284.31	269.32	259.32	254.30	17.78	289.17	264.16	249.16	239.16	234.17	19.02
$B_0Zn_1Fe_0Cu_0$	314.41	287.42	272.43	262.43	257.41	18.13	292.98	267.97	252.96	242.98	237.97	18.76
$B_0Zn_1Fe_0Cu_1$	316.30	291.10	276.29	266.31	261.31	17.39	294.42	269.42	254.41	244.44	239.43	18.68
$B_0Zn_1Fe_1Cu_0$	317.76	292.77	274.43	264.43	259.42	18.36	297.76	272.78	257.75	247.76	242.77	18.45
$B_0Zn_1Fe_1Cu_1$	319.21	294.22	279.22	269.21	264.24	17.23	299.17	274.17	259.15	249.17	244.50	18.27
$B_1Zn_0Fe_0Cu_0$	353.57	328.57	313.56	303.56	298.58	15.55	333.57	308.56	293.59	283.59	278.57	16.50
$B_1Zn_0Fe_0Cu_1$	369.13	344.02	329.00	319.03	280.70	23.96	349.11	324.12	309.13	299.11	294.13	15.75
$B_1Zn_0Fe_1Cu_0$	375.53	342.20	327.20	315.10	312.20	16.86	355.53	330.52	315.91	305.53	287.20	19.22
$B_1Zn_0Fe_1Cu_1$	381.90	356.90	336.00	325.23	310.23	18.77	361.90	336.93	321.91	311.92	306.93	15.18

$B_1Zn_1Fe_0Cu_0$	392.40	334.00	319.00	309.00	304.00	22.53	372.40	347.41	332.42	322.33	317.40	14.77
$B_1Zn_1Fe_0Cu_1$	411.20	386.21	371.22	361.20	356.23	13.38	391.21	366.20	351.21	341.20	336.21	14.06
$B_1Zn_1Fe_1Cu_0$	425.63	400.62	385.64	375.63	370.64	12.92	405.63	380.62	365.65	355.64	350.63	13.56
$B_1Zn_1Fe_1Cu_1$	463.37	438.36	426.70	416.70	411.71	11.15	443.37	418.57	400.23	390.24	385.25	13.11
S.Em. ±	6.09	7.62	8.02	8.29	9.69		6.49	7.11	7.48	7.77	6.01	
C.D. at 5 %	7.94	8.53	8.53	8.53	9.11		7.96	8.02	8.01	8.02	6.96	

* Percent physiological loss of weight

Table 2: Effect of preharvest foliar spray of micronutrients on fruit volume at ambient storage conditions in mango cv. Langra.

Treatments	Fruit volume (ml)											
	First Year						Second Year					
	0 day	2 days	4 days	6 days	8 days	% change in fruit volume	0 day	2 days	4 days	6 days	8 days	% change in fruit volume
$B_0Zn_0Fe_0Cu_0$	249.17	224.15	209.16	199.17	194.16	22.07	229.17	211.83	196.50	185.83	181.17	20.95
$B_0Zn_0Fe_0Cu_1$	260.83	235.00	220.08	210.03	205.83	21.09	240.83	215.17	200.00	190.03	185.03	23.17
$B_0Zn_0Fe_1Cu_0$	284.30	259.47	244.30	234.27	229.27	19.36	253.50	230.20	208.67	187.50	166.45	34.34
$B_0Zn_0Fe_1Cu_1$	289.03	264.40	241.60	220.43	200.77	30.54	264.17	238.11	224.00	214.04	209.83	20.57
$B_0Zn_1Fe_0Cu_0$	291.30	264.30	251.30	241.20	236.50	18.81	267.97	242.90	227.97	218.30	213.30	20.40
$B_0Zn_1Fe_0Cu_1$	293.10	267.73	249.43	239.41	234.43	20.02	269.43	244.00	229.00	219.44	216.07	19.80
$B_0Zn_1Fe_1Cu_0$	293.40	271.83	249.53	226.50	204.50	30.30	274.03	249.17	234.17	224.03	219.50	19.90
$B_0Zn_1Fe_1Cu_1$	294.23	269.22	254.21	244.23	239.21	18.69	269.10	247.77	232.76	222.87	218.43	18.83
$B_1Zn_0Fe_0Cu_0$	309.57	287.13	268.55	245.47	224.59	27.45	308.57	283.00	268.07	258.29	253.50	17.85
$B_1Zn_0Fe_0Cu_1$	344.13	317.03	304.33	294.03	255.70	25.70	324.13	299.11	284.10	281.63	269.12	16.97
$B_1Zn_0Fe_1Cu_0$	350.53	317.20	302.21	292.30	287.20	18.07	337.20	315.20	294.53	270.03	246.87	26.79
$B_1Zn_0Fe_1Cu_1$	356.90	329.57	310.60	300.23	251.90	29.42	303.57	282.60	260.33	239.93	218.27	28.10
$B_1Zn_1Fe_0Cu_0$	367.40	342.33	318.00	298.00	284.00	22.70	347.40	322.41	307.40	299.73	292.32	15.85
$B_1Zn_1Fe_0Cu_1$	390.20	368.53	346.51	336.13	331.00	15.16	360.20	341.10	332.00	282.88	246.87	31.46
$B_1Zn_1Fe_1Cu_0$	400.63	372.30	354.65	332.30	312.25	22.06	382.97	360.63	337.30	314.00	291.77	23.81
$B_1Zn_1Fe_1Cu_1$	438.37	415.70	392.14	368.38	345.10	21.28	418.37	393.57	376.23	365.23	360.90	13.74
S.Em. ±	7.97	10.64	9.29	11.79	12.95		9.44	7.85	10.39	12.01	8.97	
C.D. at 5 %	8.73	9.63	8.78	9.67	10.04		9.23	8.00	9.02	9.45	8.06	

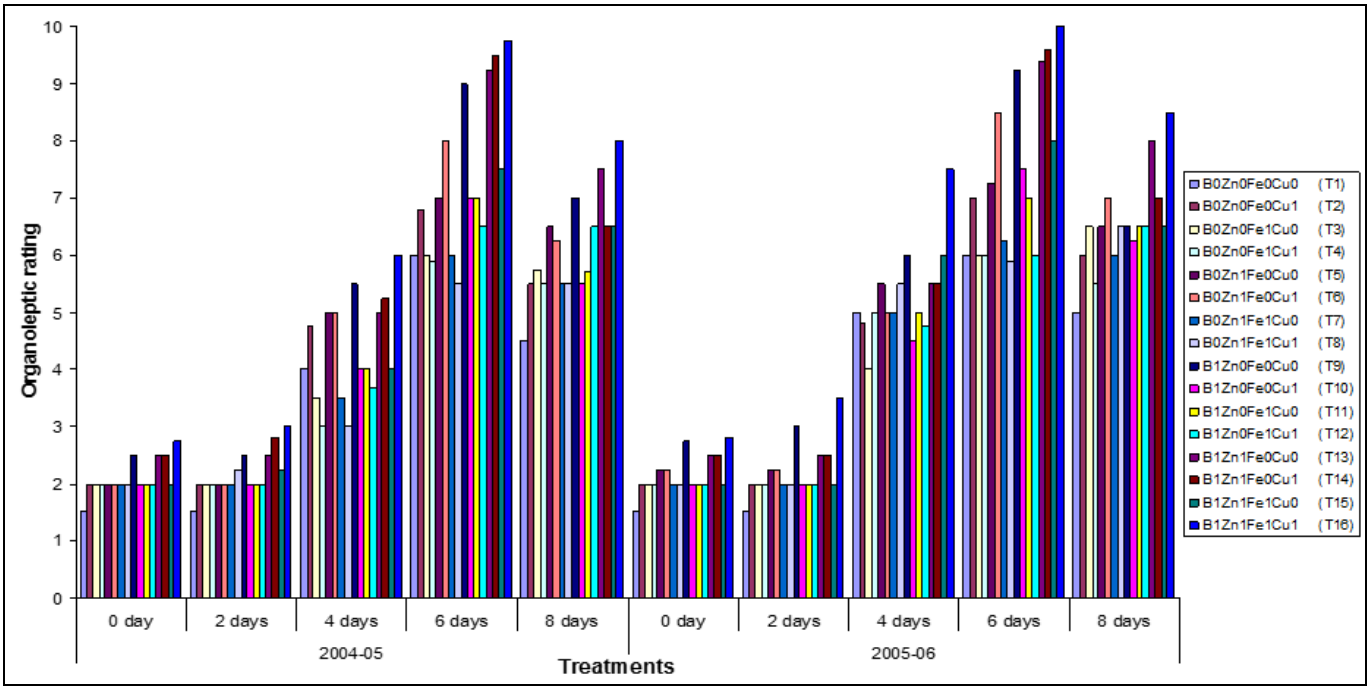

Fig 1: Effect of pre-harvest foliar spray of micronutrients on organoleptic of mango fruit cv. Langra stored at ambient conditions

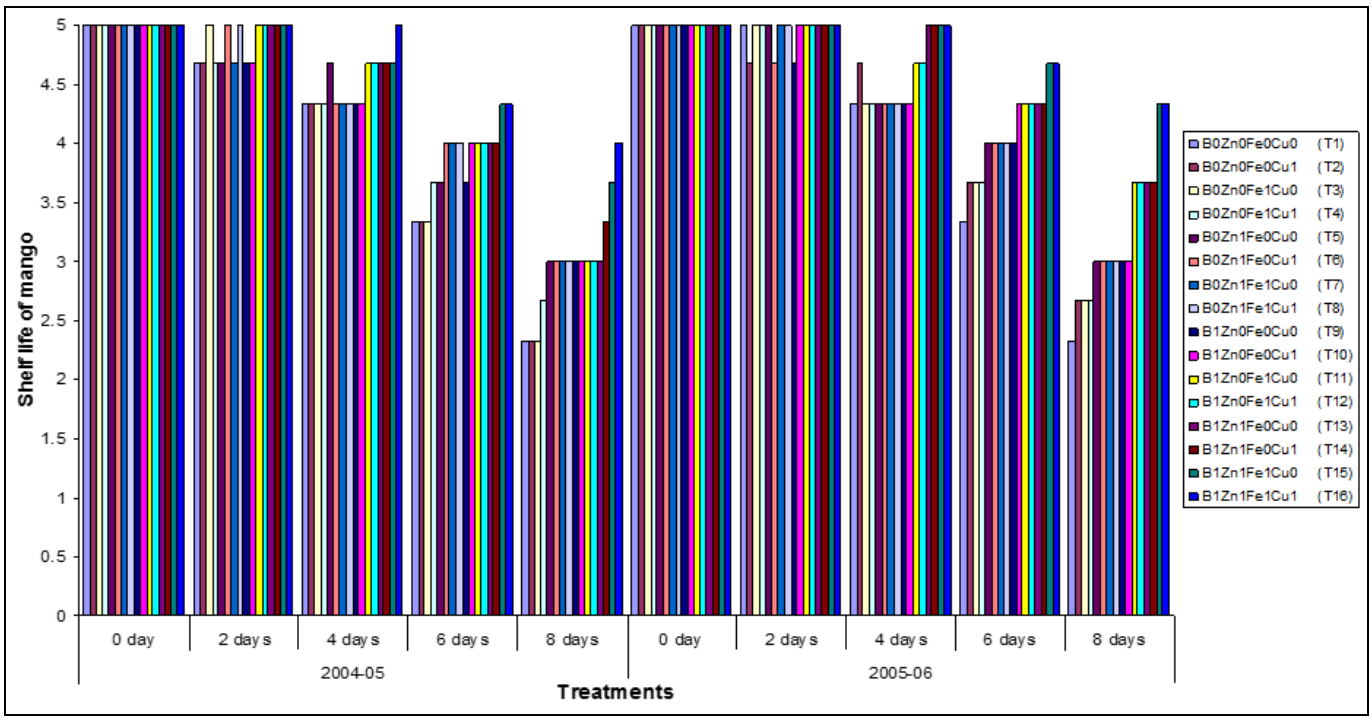

Fig 2: Effect of pre-harvest foliar spray of micronutrients on shelf life of mango fruit cv. Langra at ambient storage conditions

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