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Assessing the relationship of soil and leaf boron status with fruit yield, nutrients and biochemical constituents of Mallika mango

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ABSTRACT

An experiment was conducted on 20 year old trees of Mallika mango to assess the yield, nutrient contents and enzymatic and protein activities as influenced by different boron treatments. Results indicated that the lower foliar B content (15.3 to 24.1 mg kg^{-1}) and yield were significantly correlated. Highestpulp B content was observed in metalosate treated (T-9) fruits (4.30 mg kg^{-1}) as compared to control (2.63 mg kg^{-1}), boric acid spray (3.17 to 3.47 mg kg^{-1}) and soil application of borax (3.33 mg kg^{-1}). Boron spray improved thefruit yield which, in turn showed positive and significant correlation with pulp B content (r = 0.727*). Enzymatic activities like that of invertase increased inmetalosate treated fruits as compared to control. A range of 0.002 to 0.028 and 0.013 to 0.0145 ΔOD/ 100 mg fresh weight polyphenol oxidase (PPO) was recordedamong the treatments. The protein content increased significantly in the B treated plots (T-9 and T-10) as compared to its non-application with the highest being 0.854 and 0.974 mg per 100 mg tissue protein in the respective years. The study concluded that foliar or soil application of B proved effectivein the improvement of quality in respect of pulp nutrients and protein content of mango cv. Mallika.

Key words: *Mangifera indica*, borax, enzymes, protein, pulp nutrients.

INTRODUCTION

Soil system undergoes continuous change in its nutrient contents; gets exhausted after continuous cultivation of fruit trees. Under such situation, replenishment of nutrients is essential in order to maintain good soil health and continuous flow of nutrient in soil solution. Many a times, soil showed hidden hunger symptoms instead of showing deficiency symptoms in foliar parts but. In such situation, it is essential to apply nutrients either through spray on trees or soil in readily available form of nutrients so that flow in soil-plant continuum does not get blocked. Soils of mango orchards are often deficient in one or more soil nutrients. The mobility of boron within the plant system depends on a number of soil and plant factors (Brown and Hu, 2) and its deficiency symptoms are often visible at the top of leaves in a tree. Many a times, farmers had to harvest poor quality mango fruitsas fruits get cracked leading to low fruit yield due to fruit drop because of nutrient imbalance in soil and plant ecosystem. Spray of B is beneficial as it improves the quality through number of parameters like improved fruit weight, pulp content, nutrient content and enhanced enzymatic and protein contents. Wojcik and Wojcik (20) recorded positive effects of B fertilization on increasing nutrient and storability in pear tree.

Enzymatic activities in a fruit are a function of stage of maturity, soil and foliar nutrient management system, abiotic and biotic stress complexes, growth regulators, physiological disorders, etc. (Lima *et al*., 12). The pulp content may vary with nutrient management in deprived soil. Micronutrients play an essential role in synthesis of sugars, enzymes and proteins with the fruit and also vary with the stage of maturity. Application of B often improves the enzymatic activities and protein contents in fruits along with quality (Vieira *et al*., 19). Among mango cultivars, Mallika is recognized as one of the best because of its rich content of bio-accessible β-Carotene (0.89 mg/100 g) (Supriya *et al*., 18). Dayal *et al.* (4) observed higher peroxidase and glutathione reductase activity in Mallika on K-5 and Olour rootstock, respectively. Thus, the present study aimed at assessing the changes in soil, leaf, pulp nutrient content, enzymatic and protein variations in Mallika in response to various B treatments.

MATERIALS AND METHODS

Field experiment was conducted on sandy loam soil during 2015-17 to find out the changes in soil, leaf and pulp nutrient content and enzymatic activities in 20 yr old mango cv. Mallika at ICAR-CISH, Rehmankhera, Lucknow. Initial soil and leaf samples were taken in month of October 2015 (Table 1). Standard and uniform doses of NPK were applied in September to the mango trees. The details

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Table 1. Initial plant and soil nutrient status of experimental field.

Plant/ Soil	OC	P	K	Zn	Cu	Mn	Fe	B
Soil	0.37%	26.89 mg kg^{-1}	259.42 mg kg^{-1}	0.30 mg kg^{-1}	1.51 mg kg^{-1}	6.40 mg kg^{-1}	8.04 mg kg^{-1}	-
Plant	-	0.07%	1.05%	21.17 mg kg^{-1}	6.50 mg kg^{-1}	92.67 mg kg^{-1}	382.00 mg kg^{-1}	21.04 mg kg^{-1}

Table 2. Treatment details for assessing the efficacy of boron on Mallika mango.

S. No.	Details
T_1	NPK (1000 g N, 500 g P_2O_5: 500g K_2O/year/tree)
T_2	NPK + Soil B through borax (200 g/tree)
T_3	NPK + FYM (50 Kg/tree)
T_4	NPK + foliar spray of 0.017% B through Boric acid
T_5	NPK + foliar spray of 0.034% B through Boric acid
T_6	NPK + foliar spray of 0.051% B through Boric acid
T_7	NPK + foliar spray of 0.0034% B through B Metalosate
T_8	NPK + foliar spray of 0.0085% B through B Metalosate
T_9	NPK + foliar spray of 0.017% B through B Metalosate
T_{10}	NPK + foliar spray of 0.034% B through B Metalosate
T_{11}	T8 + foliar spray of 0.025% Zn through Zn Metalosate
T_{12}	T9 + foliar spray of 0.05% Zn through Zn Metalosate

of the treatment combinations are tabulated in the Table 2,which replicated thrice in RBD (randomized block design). Soil and leaf samples were collected as per procedure, processed and finally chemical analysis was done as per standard procedures (Jackson, 10; Lindsay and Norvell, 13). Trees were sprayed with foot sprayer at 15 days interval during fruit set and fruit development, starting from the pea stage of fruits. Approximately, 25 litres of spray solution was required for a tree. Soil application of borax was done during October after the fruit harvest as one of the treatments, to compare with common practice. Mature fruit samples were collected randomly from the orchards and washed for further analysis. Enzymes *viz.*, invertase, polyphenol oxidase, superoxide dismutase and protein activities in mango fruits were assessed as per standard methodology in order evaluate the effect of boron supplements (Beauchamp and Fridovich,1; Hatch and Glasziou, 8; Henry and Richard, 9; Katsuni and Fukuhara, 11; Lowry *et al.*, 14). Statistical significance of data, correlation etc. was carried out using OPSTAT *(14.139.232.166/opstat/) by* Sheoran *et al*. (17).

RESULTS AND DISCUSSION

The yield varied between 3.9 to 5.9 t ha^{-1} registering its highest value in T11 closely followed by T12. T 5, T6, T9 and T10 proved equally good in respect of fruit yield. as compared to control treatment T1 (3.9 t ha^{-1}) (Fig. 1). The correlation

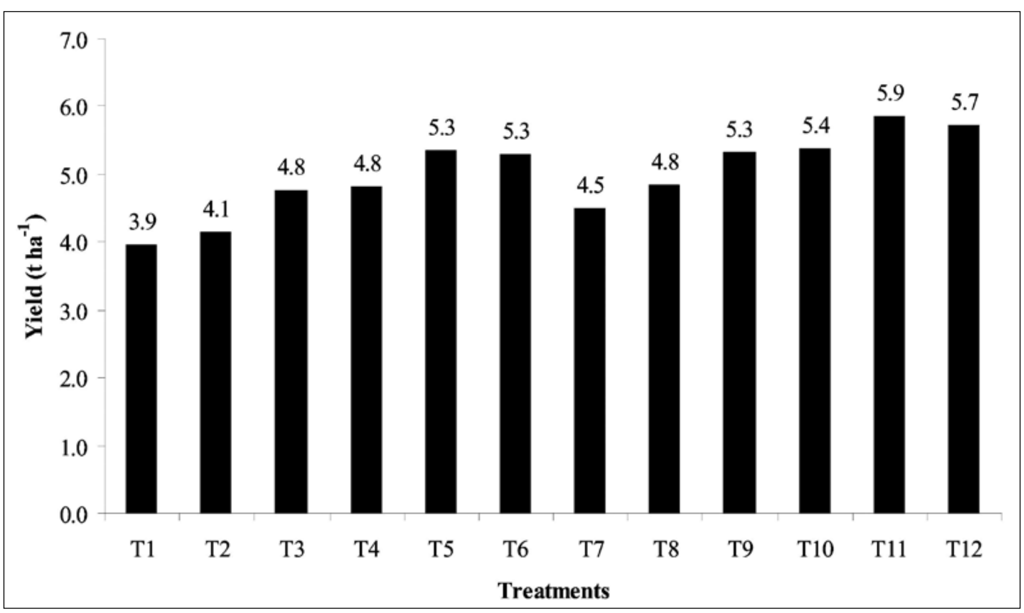

Fig. 1. Yield variations across different treatments in Mallika mango (Pooled mean of two years).

Table 3. Correlation between the yield and foliar B nutrient after spray in Mallika mango.

	Yield	Foliar boron contentafter first spray	Foliar boron contentafter second spray
Yield	1.000	0.823*	0.381 NS
Foliar boron content after first spray		1.000	0.611*
Foliar boron content after second spray			1.000

between yield and foliar nutrient content indicated that the yield was significantly correlated after first spray of boron (Table 3). This may be because of the fact that the trees were deficient in B and thereby, application of B enhanced leaf content as it is readily available to plants after the application and got translocated to different parts. The correlation between the first and second spray was also significant. B nutrition was found to improve yield and yield components in pear (Wojcik and Wojcik, 20)).

Results on pulp nutrient showed significant differences among the treatments. Improvement in pulp nutrient contents was recorded in the B metalosate treatments as compared to control, soil application of B + NPK and NPK+FYM treatments (Table 4). Pulp P content significantly ranged from 139.33 to 178.67 mg kg^{-1} while non-significant K (0.26 to 0.34 mg kg^{-1}) was recorded in fruit pulp. Higher Zn content of 1.73 to 1.77 were recorded in B and Zn metalosate treated fruit pulps as compared to Control (T_1-0.93mg kg^{-1}) and T_2 (1.23 mg kg^{-1})and T_3 (1.03mg kg^{-1}). The Zn content in Boric acid treated fruits (T_4 to T_6) were statistically *at par* but significantly differs with T_9 to T_{12} treatments wherein metalosate compounds were sprayed. In case of B content in pulp, highest being 4.30mg kg^{-1} (T_9) as compared to 2.63 mg kg^{-1}(T_1). Significant enhancement in pulp B content was revealed in metalosate treated fruits than boric acid spraying and soil application of borax. Similarly, Cu, Mn and Fe contents in fruit pulps ranged between 1.10 to 2.33 mg kg^{-1}, 1.53 to 1.83 mg kg^{-1} and 15.57 to 20.90 mg kg^{-1}, respectively. Mn content in pulp was found non-significant across different treatments. The correlation between yield and nutrient contents in fruit pulp indicated significant differences (Table 5). Pulp B content was significantly correlated with the improvement in yield (r = 0.727*) as well as with Zn content (0.870*), Mn (r = 0.838*) and Fe (0.717*). Pulp P and K content was recorded to have positively significant correlation with the enhancement in yield (r = 0.582* and 0.383*). The positive effect of pre-harvest spray of B on increasing the yield and quality parameters in fruits were observed by Mehta (15) and Gurjar *et al*. (7).

Ripe mango fruits were analyzed for enzymatic activities in response to various boron supplements and data have been presented in Table 6. Activity of invertase increased in response tomost of the treatments in metalosate treated fruits as compared

Table 4. Response of different B treatments on pulp nutrient contents in Mallika mango (Pooled mean of two years).

	P (mg kg^{-1})	K (mg kg^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})	Mn (mg kg^{-1})	Fe (mg kg^{-1})	B (mg kg^{-1})
T1	139.33	0.26	0.93	1.10	1.53	15.57	2.63
T2	164.33	0.29	1.23	1.83	1.60	19.70	3.33
T3	158.33	0.33	1.03	1.17	1.63	15.77	3.09
T4	145.67	0.31	1.17	1.93	1.53	16.40	3.17
T5	153.67	0.32	1.10	2.27	1.50	15.83	3.10
T6	165.00	0.32	1.17	2.10	1.63	17.73	3.47
T7	165.00	0.33	1.27	1.97	1.67	18.17	3.56
T8	176.00	0.33	1.40	1.37	1.67	17.23	3.21
T9	177.00	0.32	1.50	2.33	1.83	20.90	4.30
T10	178.67	0.34	1.77	2.23	1.70	20.27	3.92
T11	174.00	0.30	1.73	1.47	1.67	17.27	4.02
T12	171.33	0.30	1.73	1.33	1.70	17.63	4.09
$C.D_{.(0.05)}$	21.31	NS	0.39	0.48	NS	2.93	0.74
SE(m)	7.22	0.02	0.13	0.16	0.08	0.99	0.25
SE(d)	10.21	0.02	0.19	0.23	0.12	1.40	0.35
C.V.	8	9	17	16	9	10	12

Table 5. Correlation among the yield and fruit pulp nutrient contents in Mallika mango.

	Yield	P (mg kg^{-1})	K (mg kg^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})	Mn (mg kg^{-1})	Fe (mg kg^{-1})	B (mg kg^{-1})
Yield	1.000	0.582*	0.383*	0.717 NS	0.256 NS	0.427 NS	0.171 NS	0.727*
P (mg kg^{-1})		1.000	0.541 NS	0.822*	0.247 NS	0.840*	0.711*	0.812*
K (mg kg^{-1})			1.000	0.270 NS	0.473 NS	0.388 NS	0.284 NS	0.324 NS
Zn (mg kg^{-1})				1.000	0.149 NS	0.682*	0.580*	0.870*
Cu (mg kg^{-1})					1.000	0.175 NS	0.569 NS	0.369 NS
Mn (mg kg^{-1})						1.000	0.740*	0.838*
Fe (mg kg^{-1})							1.000	0.717*
B (mg kg^{-1})								1.000

Table 6. Effect of boron supplements on enzyme and protein activity in mango fruits.

Treatments	Invertase (µg sugar formed/ mg protein)		Polyphenol Oxidase (ΔOD/100 mg fresh weight)		Superoxide Dismutase (EU/ mg protein)		Protein (mg/ 100 mg tissue)	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
T_1	26.98	60.75	0.028	0.060	1.36	2.57	0.593	0.937
T_2	21.27	33.33	0.004	0.035	1.53	2.42	0.658	0.767
T_3	28.08	53.31	0.002	0.065	0.47	2.26	0.641	0.858
T_4	76.01	33.53	0.002	0.058	0.78	2.15	0.763	0.793
T_5	46.51	65.28	0.002	0.145	1.14	6.36	0.602	0.793
T_6	52.71	33.79	0.014	0.049	1.01	4.85	0.645	0.683
T_7	74.83	72.52	0.002	0.054	3.91	3.66	0.588	0.793
T_8	68.79	111.44	0.028	0.054	2.32	5.82	0.785	0.823
T_9	66.67	24.55	0.002	0.039	1.44	4.08	0.78	0.974
T_{10}	46.84	50.99	0.002	0.013	0.48	4.24	0.854	0.857
T_{11}	46.22	50.75	0.022	0.068	0.99	4.74	0.649	0.975
T_{12}	48.16	87.95	0.014	0.055	0.61	2.85	0.789	0.746
$CD_{(0.05)}$	0.42	1.471	0.11	0.005	0.23	0.091	0.031	0.013

to their respective control (T_1). A range of 21.27 to 76.01 and 24.55 to 111.44 µg sugar formed/ mg protein was recorded in fruits during2015-16 and 2016-17 seasons. Actually, invertase is an enzyme that hydrolyzes sucrose to glucose and fructose, which increases the sweetness of the fruit. B metalosate at lower doses wasmore effective in increasing the enzyme invertase levels. Similarly, a range of 0.002 to 0.028 and 0.013 to 0.0145 ΔOD/ 100 mg fresh weight polyphenol oxidase (PPO**)** was estimated across different treatments. The PPO content didn't show any specific trend.In case of superoxide dismutase (SOD), reactive O_2 species (ROS) are produced in both unstressed and stressed cells. Plants have well-developed defence systems against ROS, involving both limiting the formation of ROS as well as instituting its removal. Within a cell, the superoxide dismutases (SODs) constitute the first line of defence against ROS. SOD activity was higher in B applied fruits as compared to T_1, T_2 and T_3 treatments. A range of 0.47 to 3.91 and 2.149 to 6.358 EU per mg protein SOD was recorded in both the seasons respectively. The protein content increased significantly in the B treated plots as compared to its non-application. It was found that during the first season, a range of 0.593 to 0.854 mg per 100 mg tissue protein was estimated while in the next season, 0.683 to 0.975mg per 100 mg tissue protein was recorded.Actually, enzymatic and protein activities in fruits act as precursors of many nutritional and physiological disorders. The nutrient mediated enhancement in the activities may be observed because of the fact that B helps in translocation of sugars (Gauch and Dugger, 5). Soils deprived of B may induce impairments of cell functions (Chakmakand Römheld, 3; O'neill *et al.*,

16) and addition of even minute quantity in soil, the tree roots may response quickly in order to get well versed (Goldbach *et al*., 6).With the advancement of maturity in fruits, there was increasing trend in the activity of reducing and non-reducing sugars contents and decrease in the starch content. However, sometimes physiological disorders like spongy tissue exhibited lower reducing and non-reducing sugars with increasing trend of starch content(Lima *et al*., 15).

The present study concluded improvements in pulp B content through addition of B as supplement. Enhancement of pulp nutrient content and its significant correlation indicated that B deficient trees respond quickly to restore its content. Further, addition of boron either through soil or through the foliar spray activatedthe associated enzymes also in the plant system.

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