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Short communication

Foliar application of micronutrients on growth and yield of okra under different irrigated conditions

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Abstract

A field experiment was conducted at Water Management Research Unit, Vellanikkara from December 2018 to March 2019 to study the effect of foliar application of zinc and boron on growth and yield of okra under drip irrigation and conventional irrigation methods. Treatments consisted of foliar sprays of zinc as $ZnSO_4$ (0.5%), boron as Solubor® (0.5%), combination of zinc and boron [$ZnSO_4$ (0.5%) + Solubor® (0.5%)] and KAU multi mix (Sampoorna, 0.5%), three times at three week intervals and these treatments were tested against treatment without foliar application of micronutrients both under drip irrigation and conventional irrigation. All the treatments were supplied with soil test based application of NPK at recommended dose and FYM at 20 t/ha. Results of the study revealed that under drip irrigated condition, foliar application of KAU multi mix resulted in greater plant height, leaf area, fruit length, fruit weight and fruit yield. However, under conventional irrigation, foliar application of micronutrients did not produce any yield advantage over treatments without foliar application.

Key words: Boron, Drip irrigation, KAU Multi Mix (Sampoorna), Micronutrient management, Okra, Zinc.

Intensive cropping and imbalanced use of high analysis fertilizers have induced deficiencies of micronutrients in many parts of the country. To achieve high yield and sustain the same over years, it becomes pertinent to foresee the emerging nutrient deficiencies and to evolve suitable ameliorating technologies. Balanced fertilization is inevitable to boost crop productivity. Micronutrient deficiencies in soils not only hamper crop productivity, but also deteriorate quality of produce. In severe deficiency conditions, the yield loss could be as high as 100 per cent. Micronutrients play an important role in the enzymatic processes in plants, synthesis of chlorophyll, carbohydrate production and respiration. They also activate a number of biochemical processes in plants. Even though micronutrients have such a major role in crop growth and yield, research on micronutrient application and schedule of application for various crops are limited. Foliar application has proven to be an excellent method of supplying secondary and micronutrients for meeting plant requirements. Foliar application of micronutrients produced yield responses in many crops. It has been shown to avoid the problem of leaching out in soils and prompts a quick reaction in plants. In many parts of Kerala the soils are deficient in zinc and boron. Okra is an important vegetable crop of Kerala. It is a warm season crop well adapted to many areas of humid tropical and subtropical zones. It is grown throughout India for its tender fruits. In Kerala, okra is grown in all seasons both under drip and conventional irrigated condition. Literature on response of okra to zinc, boron and their combinations is not available. The present study was conducted with the objective to find out the effect

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of foliar application of micronutrients on productivity of okra under conventional and drip irrigation.

The present experiment was conducted at Water Management Research Unit, Vellanikkara, Thrissur, Kerala during the period from December 2018 to March 2019. The experimental plot is located geographically at $13^{0}32$N latitude and $76^{0}26$E longitude, at an altitude of 40.3 m above MSL. Okra variety Arka Anamika was used for study, which was conducted in summer. Soil texture of the experimental site is sandy loam belonging to the taxonomic order Ultisol. The soil pH of the experimental field for drip irrigation was 5.86 and it was low in available nitrogen (194.43kg/ha), high in phosphorus (108.04 kg/ha) and medium in potassium (381.17 kg/ha). The soil pH of the conventionally irrigated field was 5.23 and it was low in available nitrogen (156.80 kg/ha), high in phosphorus (43.35 kg/ha) and high in potassium (186.10 kg/ha). Data on the initial and final nutrient status of the fields are given in Tables 1, 8, 9 and 10. The experiment was laid out in Randomized Block Design (RBD) with four replications. Experiment was conducted separately for conventional and drip irrigation with five treatments for each experiment. Treatments consisted of three foliar sprays of zinc as $ZnSO_4$ (0.5%), boron as Solubor® (0.5%), combination of zinc and boron [$ZnSO_4$ (0.5%) + Solubor® (0.5%)] and KAU multi mix (Sampoorna, 0.5%), and a treatment without foliar application. Three foliar sprays were given, the first at 15 days after sowing and subsequently at three week intervals. Recommended dose of nutrients were applied based on soil test values, and FYM as per POP were applied uniformly to all the treatments. Sampoorna is a multi-nutrient mix developed by KAU which contains Zn (4.5-5.5%), B (2.5-3.5%), Cu (0.35-0.45%), Fe (<2.5%), Mn (<0.2%), and Mo (<0.01%). Under conventional irrigation, 1.5cm irrigation water was applied at two day intervals as hose irrigation, and drip irrigation was given at 125% pan evaporation daily. Economics of cultivation was worked out based on prevailing market rate. Observations on plant height, leaf area, dry matter production, and yield and yield attributes were recorded and analyzed statistically.

Table 1. Initial nutrient status of the soil under drip and conventional irrigation methods

Parameters	Value under drip irrigated condition	Rating	Value under conventional irrigation	Rating
Available N (kg/ha)	194.43	Low	156.80	Low
Available P (kg/ha)	108.04	High	43.35	High
Available K(kg/ha)	381.17	Medium	186.10	High
Exchangeable Ca (mg/kg)	329.15	Low	520.5	Low
Exchangeable Mg (mg/kg)	86.4	High	40.85	Medium
Available S (mg/kg)	6.743	Low	2.89	Low
Available Fe (mg/kg)	13.11	High	9.74	High
Available Mn (mg/kg)	77.99	High	46.65	High
Available Zn (mg/kg)	2.34	High	1.79	High
Available Cu (mg/kg)	4.06	High	4.70	High
Available B (mg/kg)	0.179	Low	0.277	Low

Table 2. Effect of micronutrient application on plant height (cm) of okra under different irrigation methods

Treatments	Drip irrigation			Conventional irrigation		
	30 DAS*	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T1-Zn (0.5%)	20.95	92.50	178.33	20.60	75.75	84.65
T2-B (0.5%	19.85	95.40	111.83	23.65	66.00	72.17
T3-Zn (0.5%) + B (0.5%)	17.45	87.65	100.13	20.50	62.40	82.17
T4-KAU multi mix	23.70	81.03	176.06	20.50	63.05	77.25
T5- Without foliar application (Control)	19.85	90.25	123.33	22.05	72.00	80.17
CD (0.05)	NS	NS	17.06	1.60	NS	NS

* Days after sowing

Table 3. Effect of micronutrient application on leaf area (cm^2) of okra under different irrigation methods

Treatments	Drip irrigation			Conventional irrigation		
	30 DAS*	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T1-Zn (0.5%)	803.32	2012.16	556.65	538.00	1709.40	181.78
T2-B (0.5%)	696.60	2056.24	408.87	668.58	1733.72	325.05
T3-Zn (0.5%) + B (0.5%)	362.12	1792.84	304.32	542.52	1781.36	357.36
T4- KAU multi mix	1245.18	1782.24	392.12	502.00	1615.72	245.84
T5- Without foliar application (Control)	956.90	1973.20	259.80	824.36	1311.00	361.11
CD (0.05)	349.075	NS	NS	NS	NS	NS

* Days after sowing

Table 4. Effect of micronutrient application on dry matter production (kg/ha) of okra under different irrigation methods

Treatments	Drip irrigation			Conventional irrigation		
	30 DAS*	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T1-Zn (0.5%)	270.83	527.78	965.28	222.22	548.60	625.00
T2-B (0.5%)	166.67	423.61	740.28	340.28	479.167	583.33
T3-Zn (0.5%) + B (0.5%)	131.94	701.39	979.17	263.89	541.67	520.83
T4- KAU multi mix	229.17	548.61	834.72	291.67	437.50	916.67
T5- Without foliar application (Control)	215.28	354.17	1090.28	305.56	423.61	1159.72
CD (0.05)	81.96	188.270	159.74	NS	NS	227.046

* Days after sowing

Table 5. Effect of micronutrients on yield attributes of okra under drip irrigation

Treatments	Fruit length (cm)	Fruit weight (g)	Number of fruits per plant	Per plant yield (g)	Yield (Mg ha^{-1})
T_1-Zn (0.5%)	17.12	13.22	22.50	242.59	13.48
T_2-B (0.5%)	16.87	10.87	23.00	230.21	12.79
T_3-Zn (0.5%) + B (0.5%)	16.25	12.27	17.00	199.37	11.08
T_4- KAU multi mix	17.97	14.64	20.50	295.38	16.41
T_5- Without foliar application (Control)	17.34	10.47	19.00	216.99	12.06
CD (0.05)	0.99	1.95	1.29	36.74	2.04

Table 6. Effect of micronutrients on yield attributes of okra under conventional irrigation

Treatments	Fruit length (cm)	Fruit weight (g)	Number of fruits per plant	Per plant yield (g)	Yield (Mg ha^{-1})
T_1-Zn (0.5%)	17.15	11.80	20.75	214.85	11.94
T_2-B (0.5%)	15.51	10.77	18.00	168.843	9.38
T_3-Zn (0.5%) + B (0.5%)	15.84	10.10	17.00	184.30	10.24
T_4- KAU multi mix	13.28	9.62	18.00	156.87	8.72
T_5- Without foliar application (Control)	13.24	12.56	15.25	207.45	11.53
CD (0.05)	1.03	1.55	1.19	31.79	1.77

Table 7. Effect of micronutrient application on economics of cultivation of okra under drip irrigation and conventional irrigation

Treatments	Drip irrigation				Conventional irrigation			
	Cost of cultivation (₹)	Gross return (₹)	Net return (₹)	B:C ratio	Cost of cultivation (₹)	Gross return (₹)	Net return (₹)	B:C ratio
T_1-Zn (0.5%)	101481	269539	168058	2.66	104375	238717	134342	2.29
T_2-B (0.5%)	120590	255787	135197	2.12	123484	187603	64119	1.52
T_3-Zn (0.5%) + B (0.5%)	123701	221520	97819	1.79	142795	204777	61982	1.43
T_4-KAU multi mix	108325	328197	21987	3.03	111119	174299	63180	1.57
T_5-Without foliar application (Control)	94170	241098	146928	2.56	97064	230499	133435	2.38
CD (0.05)		40826	40826	0.381		35315	35315	0.302

Table 8. Effect of micronutrient application for okra under different irrigation methods on available N, P and K in soil

Treatments	Drip irrigation			Conventional irrigation		
	N(kg/ha)	P(kg/ha)	K(kg/ha)	N(kg/ha)	P(kg/ha)	K(kg/ha)
T_1-Zn (0.5%)	263.42	40.38	114.80	257.15	159.80	332.92
T_2-B (0.5%)	238.34	46.57	142.80	294.78	117.98	340.48
T_3-Zn (0.5%) + B (0.5%)	263.42	41.89	66.89	294.78	165.27	416.64
T_4-KAU multi mix	294.78	35.41	115.36	260.29	160.08	294.56
T_5- Without foliar application (Control)	244.61	62.70	125.44	288.51	149.65	362.60
CD (0.05)	20.88	14.78	NS	25.93	26.24	NS
Pre experimental value	156.8	43.35	186.10	194.43	108.04	381.17

Table 9. Effect of micronutrient application for okra under different irrigation methods on available secondary nutrients (Ca, Mg and S) in soil

Treatments	Drip irrigation			Conventional irrigation		
	Ca (mg/kg)	Mg (mg/kg)	S (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	S (mg/kg)
T_1-Zn (0.5%)	920.88	59.19	1.02	429.23	82.88	21.20
T_2-B (0.5%)	1021.04	61.29	1.33	344.73	75.11	11.08
T_3-Zn (0.5%) + B (0.5%)	736.38	47.00	1.02	441.81	104.83	8.91
T_4-KAU multi mix	963.75	67.04	2.59	443.21	76.13	8.25
T_5- Without foliar application (Control)	864.25	67.70	1.81	379.70	74.31	6.32
CD (0.05)	145.21	NS	0.84	NS	6.27	2.31
Pre experimental value	520.5	40.85	2.89	329.15	86.4	6.74

Table 10. Effect of micronutrient application for okra under drip irrigation and conventional irrigation on available micronutrients (mg/kg) in soil

Treatments	Drip irrigation					Conventional irrigation				
	Fe	Mn	Zn	Cu	B	Fe	Mn	Zn	Cu	B
T_1-Zn (0.5%)	13.15	43.78	2.67	4.92	0.11	12.91	55.00	9.15	4.39	0.71
T_2-B (0.5%)	12.70	45.95	1.76	5.73	0.77	13.71	57.84	2.41	4.13	0.43
T_3-Zn (0.5%) + B (0.5%)	16.37	50.54	2.86	5.80	0.42	12.50	56.67	4.50	4.48	0.32
T_4-KAU multi mix	12.85	47.43	2.26	5.70	0.42	13.78	55.09	3.40	4.23	0.16
T_5- Without foliar application (Control)	14.01	50.86	2.26	6.18	0.30	11.92	46.84	2.27	3.99	0.14
CD (0.05)	2.40	NS	NS	NS	0.34	NS	NS	1.25	NS	0.07
Pre experimental value	9.74	46.65	1.79	4.70	0.28	13.11	77.99	2.34	4.06	0.18

Under drip irrigated condition, foliar application of KAU multi mix (0.5%) given in three splits at three week intervals significantly enhanced the yield of okra plants. Among the five treatments, KAU multi mix application gave 36 per cent increase in yield (16.41 Mg/ha) compared to treatment without foliar application. This may be due to the significantly higher fruit length, fruit weight and per plant yield obtained with the application of KAU multi mix (Table 5). The plants receiving KAU multi nutrient mix showed improved growth characters, like plant height and leaf area, during initial stages of growth of okra crop (Tables 2 and 3). This may have improved the yield attributing characters and finally led to significantly higher yield. Foliar application of micronutrient mix might have provided both secondary and micronutrients in adequate quantity in addition to the nutrients provided by soil application of fertilizers and FYM. Similar results were obtained by Baloch et al. (2008) in chilli. They observed that HiGrow®, a compound fertilizer containing macro and micronutrients, when given as foliar spray significantly increased plant height, number of branches, number of fruits, fruit length, fruit weight and fresh fruit yield of chilli. As per Mehraj et al. (2015), all micronutrients have significant influence in plant physiology. Balanced application of these nutrients might have resulted in stimulation of enzymatic activities which led to higher rate of photosynthesis, respiration and finally led to a higher vegetative growth and yield in okra. Polara et al. (2017) observed significant increase in vegetative growth as well as yield and yield attributes in okra plants applied with multi micronutrient mix either as foliar spray or by soil application based on soil test values. Increased growth parameters such as plant height and leaf area resulted in higher photosynthetic rate and in higher yield attributing characters and fruit yield.

Under drip irrigated condition foliar applications of Zn, B or their combination were unable to produce any significant yield advantage compared to treatment without foliar application. The initial soil test data showed that the soil was not deficient in Zn. This may be the reason for not getting any yield advantage from foliar application of Zn. Boron application also showed no significant increase in the yield of okra even though the soil of the experimental site was deficient in B. This may be due to the low response of okra to boron. Bennett (1993) reported that low response crops showed no effect on foliar application of nutrients even though the soil was deficient in a particular nutrient.

Foliar application of zinc and boron in combination recorded lowest yield (11.08 Mg/ha) under drip irrigation, which could be attributed to the lowest values for yield attributes resulting from poor growth during the initial stage of growth of okra which received this treatment (Table 5). Reduction in plant height, leaf area and dry matter production during initial stages of growth might have been due to the phytotoxicity developed from application of Solubor® (0.5% concentration) along with zinc. Lowest fruit length, number of fruits per plant and per plant yield recorded in this treatment could be attributed to poor vegetative growth of okra plants during the initial stages. El-Feky et al. (2012) obtained similar results in barley. They observed that foliar application of boron as boric acid above 3 mg/L concentration significantly reduced growth as well as yield of barley. Boron when applied alone or in combination with zinc caused phytotoxicity during the initial period. This resulted in reduced leaf area and dry matter production during the initial period which may have affected the productivity of okra (Tables 3 and 4). Phytotoxicity caused due to boron application resulted in reduction in leaf area, chlorophyll content as well as yield parameters.

Under conventional irrigation, foliar application of Zn produced a yield of 11.94 Mg/ha which was statistically on par with the yield obtained from the treatment without foliar application. The initial soil test data revealed that the soil was sufficient in Zn. This might be the reason for failure of foliar application of Zn to produce any yield advantage. The yield obtained from zinc treatment was statistically on par with the yield from treatment receiving soil test based application of NPK fertilizers without micronutrient application (11.53 Mg/ha) (Table 6). These plants recorded highest yield attributing characters like fruit weight and per plant yield. Higher yield in soil test based application of fertilizers could be attributed to the sufficient supply of macro as well as micronutrients from the soil test based application of primary nutrients and FYM as per recommendation. Since the application of NPK fertilizers and FYM supplied the essential nutrients for plant growth, micronutrient application could not produce significant yield response in okra under conventional irrigation. As per Kanaujia (2016), yield of rice-wheat cropping system was significantly improved by application of recommended dose of NPK fertilizer along with FYM. They also observed an increase in uptake of N, P and K as a result of this treatment.

Foliar application of KAU multi mix showed no effect on the yield of okra under conventional irrigation (8.72 Mg/ha) (Table 6). The fruit weight and per plant yield was lowest in this treatment. Application of boron alone or in combination with zinc showed no increase in yield compared to treatment without foliar application of micronutrients. Foliar application KAU multi mix gave significantly higher yield under drip irrigated condition but showed no response under conventional irrigation. This might have been due to effective utilization of water under drip irrigation over conventional hose irrigation. Tiwari et al. (2003) also reported same results. They found that cabbage gave 62.44 per cent more yield under drip irrigated condition compared to surface irrigation method.

Results of the study indicated that under drip and conventional irrigated conditions, foliar application of zinc, boron and their combination produced no significant increase in yield compared to treatments without foliar application. This might have been due to the fact that all the treatments received recommended dose of FYM @ 20 t/ha and soil test based NPK recommendation. Due to sufficient application of organic manure, plants could receive enough micronutrients from soil even though the soil showed deficiency of boron. Increase in the micronutrient content of soil after the experiment indicated that there was sufficient supply of micronutrients due to the application of FYM @ 20 t/ha (Tables 8, 9 and 10).

Micronutrient application significantly influenced economics of cultivation of okra under drip and conventional irrigation. Foliar application of KAU multi nutrient mix to okra under drip irrigation produced higher B:C ratio indicating the effect of higher yield (Table 7). Similar results were obtained by Polara et al. (2017) in okra. Though there was significant variation in yields between zinc application and KAU multi nutrient mix application, B:C ratio of zinc application was statistically on par with B:C ratio of KAU multi nutrient mix application due to lower cost of cultivation for zinc application compared to other micronutrient treatments. Lowest B:C ratio in combined application of zinc and boron could be attributed to the lowest yield as well as higher cost of cultivation due to added input cost of $ZnSO_4$ and Solubor®. Under conventional irrigation, highest B:C ratio was obtained by control treatment (Table 7) and this might be due to the higher yield obtained in this treatment. Also cost of cultivation in the control treatment was lowest because of less input and labour cost since there was no micronutrient application. B:C ratio of control treatment was on par with B:C ratio of zinc application. Lowest B:C ratio was observed for combined application of Zn and B because of its lowest yield.

Result of the study indicated that under drip irrigated condition, okra performed better with the foliar application of KAU multi mix due to effective utilization of water under drip irrigation over conventional hose irrigation. Under conventional irrigation, application of 20 t/ha of FYM could meet the micronutrient requirement of okra, hence foliar application of micronutrients produced no response. Soils without Zn deficiency showed no response to foliar application of Zn. Even though the soil was deficient in B, foliar application of B failed to show any response due to the low responsive nature of okra to boron.

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