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Effect of Foliar Application of Micronutrients on Yield, Nutrient Uptake and Storage Quality of Onion (*Allium cepa* L.) Grown in *Alfisols*

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A field experiment was conducted at the College of Horticulture, OUAT, Chiplima during 2014-2015 to study the effect of foliar application of micronutrients on yield, nutrient uptake and storage quality of onion var. Arka Niketan. The treatments consisted of foliar application of Fe, Zn, Cu, B, Mn and their mixture at 30 and 45 days after planting including control. Foliar application of the micronutrient mixture recorded the highest values for average bulb weight (69.55 g), plant height (76.05 cm), total dry matter yield (4.79 t ha^{-1}) and C grade bulbs (33.70 %), whereas, lowest values for percent weight loss (21.09 %), sprouting (4.07 %), rotting (31.08%) and doubles (0.44 %) were recorded in the same treatment. Foliar application of Zn (0.5 %) and B (0.25 %) reduced the production of bolters and recorded lower percent of bolters (6.62 and 6.35 %, respectively). Foliar application of micronutrients did not yield any significant improvement in bulb quality in terms of total soluble solids (TSS). Due to foliar application of Zn and B, highest N (250.0 and 257.5 kg ha^{-1}) and K (458.8 and 478.4 kg ha^{-1}) uptake was recorded. However, Mn application had a significant effect on P and S uptake. Among the treatments a significant variation was also noticed in uptake of both macro and micronutrients.

(***Key words:*** *Yield, Nutrient uptake, Storage quality, Onion*)

Onion (*Allium cepa* L.) is widely cultivated in almost all throughout the world and is an important commercial crop used alone as a vegetable and for flavoring various dishes (Manna and Maity, 2016). Besides culinary purposes, it is also used for medicinal purposes. The healing properties of onion in case of cardiac diseases, rheumatism, cancer, digestive disorders, blood sugar and prolonged cough are well known across the globe. In India, The production of onion in Odisha is 378.67 MT from an area of 33.44 ha with a productivity of 11.32 MT ha^{-1} during 2016-17 (Anonymous, 2017). Although India enjoys second position in the world in area and production after China, the productivity of this crop is much lower (16.12 t ha^{-1} as against China's 21.85 t ha^{-1}and USA's 55.95t ha^{-1}) (Anonymous, 2017). There is an acute shortage of onion in relation to its requirement in this country. The high demand of onion in the country can only be met by increasing the per hectare yield, which can be achieved by the judicious application of fertilizers and proper management practices.

Micronutrients and macronutrients are elements with specific and essential physiological functions in plant metabolism (Epstein, 1956; Marschner, 1986). Compared with macronutrients, micronutrients are required for growth in lower amounts. As a constituent of prosthetic groups they enhance enzyme reactions by influencing the molecular configuration of an enzyme or substrate (e.g. Zn). In addition to N, P, K, and S application in crops like onion, micronutrients like zinc (Zn) and boron (B) have been found to be very beneficial for proper vegetative growth, bulb development, quality and bulb yield of the crop (Acharya *et al*., 2015; Aske *et al*., 2017; Ballabh *et al*., 2013: Manna *et al*., 2014; Manna and Maity, 2016). The information on the influence of micronutrients on onion growth, yield and quality under storage is meager. Hence the present work was conducted to study the influence of foliar application of micronutrients on growth, yield and quality of

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onion in the *Alfisols* of Odisha.

MATERIAL AND METHODS

A field experiment was conducted during 2014-2015 at the research farm of All India Network Project on Onion and Garlic, Odisha University of Agriculture and Technology, Chiplima, Sambalpur, Odisha, India which is situated at 20°21′ N latitude and 80° 55′ E longitude and at an altitude of 178.8 m above mean sea level. The objective of the experiment was to study the effect of foliar application of micronutrients on yield, nutrient uptake and storage quality of onion variety Arka Niketan in *Alfisols* of Odisha. The experimental soil was sandy loam in texture and slightly acidic in reaction (pH 6.16). Soil properties of the experimental field are given in Table 1. The experiment was laid out in a randomized block design (RBD) with seven treatments and three replications. The treatment were T_1: Foliar application of iron ($FeSO_4$) @ 0.5 % at 30 and 45 days after planting,T_2: Foliar application of zinc ($ZnSO_4$) @0.5 % at 30 and 45 days after planting, T_3: Foliar application of copper ($CuSO_4$) @0.1 % at 30 and 45 days after planting, T_4: Foliar application of boron (Borax) @0.25 % at 30 and 45 days after planting, T_5: Foliar application of manganese ($MnSO_4$) @ 0.1 % at 30 and 45 days after planting, T_6: Foliar application of mixture of these micronutrient @ 0.25% at 30 and 45 days after planting and T_7: Control. All the experimental plots received recommended dose of FYM (5 t ha^{-1}) and N, P, K and S (150:80:80:50 kg ha^{-1}).1/3rd N and whole amount of FYM, P, K and S were applied at the time of final land preparation, and the remaining N was applied in two equal split doses at 30 and 45 days after planting. Onion seedlings of 40 days old were transplanted in the experimental plot of 12 m^2 (6.0 m x 2.0 m) size at spacing of 15 cm x 10 cm. Three irrigations were given during the cropping period using drip. Bolting was discouraged by nipping off the flower stalks whenever they appeared during the growing period of the crop. The crop was harvested when 85% of the plants showed the sign of maturity. The growth and yield attributes of onion were recorded randomly from ten selected plants of each plot. After harvest, the bulbs of individual plots were graded on the basis of their bulb diameter and observations were recorded as A grade (4.0 - 6.0

Table 1. *Physico-chemical properties of the experimental soil*

1. Sand (per cent)	60.75
2. Silt (per cent)	23.5
3. Clay (per cent)	15.75
4. Textural class	Sandy loam
5. Organic carbon (g kg^{-1})	5.9
6. Available N (kg ha^{-1})	203.84
7. Available P (kg ha^{-1})	12.85
8. Available K (kg ha^{-1})	217.28
9. Available S (kg ha^{-1})	58.8
10. Available Zn (ppm)	0.80
11. Available B (ppm)	0.13
12. pH (1:2.5 soil to water)	6.16
13. Electrical conductivity (dSm^{-1})	0.25
14. Particle density (gcm^{-3})	2.16
15. Bulk density (gcm^{-3})	1.39
16. Porosity (%)	35.64

cm), B grade (3.5 - 4.0 cm) and C grade (2.0 - 3.5 cm) bulbs. Accordingly the percent production of A, B, and C grade bulbs were recorded. The storage quality of the bulbs was observed at different days after storage such as loss of weight, number of rotting bulbs and sprouting of bulbs. At the time of harvest of the crop the leaf and bulb weight were taken from the individual plots for final calculation of dry matter. Digital hand refractometer was used for estimation of total soluble solids (TSS °Brix).The data recorded on various parameters was statistically analyzed by calculating the least square difference (LSD) values at 5% level of significance following the method as outlined by Panse and Sukhatme (1985).

RESULTS AND DISCUSSIONS

Growth parameters

Yield and yield attributing characters like plant height, number of leaves, neck thickness, polar and equatorial diameter of onion as influenced by micronutrients application are depicted in Table 2. Plant height of onion responded better to micronutrients and it varied from 70.08 to 77.35 cm. Application of boron had a significant influence on the plant height (77.35 cm) and number of leaves (16.38) followed by application of zinc. The neck thickness of onion ranged from 10.17 to 11.35 mm and polar diameter of the bulb varied from 4.88 to 5.46 cm due to application of micronutrients. The equatorial diameter of the bulb varied from 4.81 to 5.38 cm in different micronutrient applied plots. However, except neck thickness (11.35 mm) the polar diameter (5.46 cm) and equatorial diameter (5.38 cm) of onion bulb differed significantly in plots that received micronutrient mixture. The average bulb weight ranged from 55.35 to 69.55 g in different plots. Significantly higher bulb weight was recorded in treatment T_6 where micronutrient mixture @0.25 was applied at 30 and 45 days after planting. Of the micronutrients, Zn and B had a significant influence on the bulb weight of onion. Application of Zn alone in T_2 could enhance the bulb weight to a tune of 67.73 g, whereas application of B alone in T_4 increased the bulb weight to a tune of 68.95 g as compared to other micronutrients applied. Micronutrient application in general increases the enzymatic activity in plant cell. This enhanced enzymatic activity may be the possible reason to enhance the metabolic pathways and increase in bimolecular concentration in cell (Abedin *et al*., 2012 and Ballabh *et al*., 2013) which ultimately got translated in to higher growth of the plants.

Yield, dry matter production and nutrient uptake

The data on yield, dry matter and nutrient uptake under different treatments are presented in Table 3. Application of micronutrients influenced the different grades of onion bulbs. A variation was noticed among all grades of onion bulbs (A, B and C grades). Numerically higher percent of A- grade onions were recorded in T_6 where micronutrient mixture was applied (Table 3). Among different micronutrient treated plots the B-grade onions were significantly higher in treatment T_2 (31.22%) and T_4 (32.85 %) where Zn and B were applied respectively. These results are in corroboration with the observations of Manna *et al*. (2014) and Manna and Maity (2016). The presence and absence of bolters and doubles in onion

Table 2. *Effect of micronutrients on different growth parameters of crop onion*

Treatments	Plant height (cm)	No. of leaves	Neck thickness (mm)	Polar diameter (cm)	Equatorial diameter (cm)	Avg. bulb weight (g)
T1	76.15	16.12	10.76	5.26	5.32	63.45
T2	76.18	15.18	11.02	5.43	5.38	67.73
T3	75.12	14.13	10.32	5.13	5.08	66.82
T4	77.35	16.38	10.92	5.15	5.25	68.95
T5	74.08	14.12	10.14	4.89	4.87	65.98
T6	76.05	15.98	11.35	5.46	5.38	69.55
T7	70.12	14.33	10.17	4.88	4.81	55.35
SEm (±)	1.43	0.26	0.51	0.10	0.11	3.38
C.D. (p = 0.05)	4.41	0.87	1.58	0.32	0.34	10.43

Table 3. *Effect of micronutrients on different yield and quality parameters of crop onion*

Treatments	A Grade (%)	B Grade (%)	C Grade (%)	Bolters (%)	Double (%)	Total yield (t ha^{-1})	Marketable yield (t ha^{-1})	Dry matter yield (t ha^{-1})		
								Leaf	Bulb	Total
T_1	9.04	20.47	30.22	9.23	0.97	25.84	18.35	1.01	2.60	3.61
T_2	9.47	21.73	31.22	6.62	0.94	28.67	20.64	1.38	2.84	4.22
T_3	8.33	22.52	29.57	9.90	0.97	23.76	15.35	1.25	2.70	3.95
T_4	8.99	23.10	32.85	6.35	0.81	25.92	17.44	1.55	2.73	4.28
T_5	8.20	21.22	29.17	9.10	0.97	25.56	17.45	1.05	2.04	3.09
T_6	10.57	21.11	33.70	9.76	0.44	29.98	21.57	1.53	3.26	4.79
T_7	7.93	19.83	28.98	9.87	1.30	18.61	11.96	0.45	1.83	2.28
SEm (±)	0.08	0.13	0.73	0.10	0.02	1.64	1.41	0.09	0.17	0.23
C.D. (p = 0.05)	0.27	0.43	2.27	0.33	0.07	5.07	4.37	0.30	0.54	0.73

Table 4. *Effect of micronutrients on uptake of different nutrients in crop onion*

Treatments	Nutrient uptake (kg ha^{-1})								
	N	P	K	S	Fe	Mn	Zn	Cu	B
T_1	236.2	29.8	424.7	9.74	22.12	28.22	0.66	1.59	0.35
T_2	257.0	27.6	478.1	9.74	22.60	24.50	0.69	1.50	0.53
T_3	210.5	40.1	428.2	10.75	20.50	27.10	0.57	1.49	0.16
T_4	250.5	30.9	438.8	17.46	22.82	26.46	0.60	1.52	0.94
T_5	218.7	44.5	458.4	17.57	20.90	29.40	0.62	1.51	0.18
T_6	228.7	25.9	427.4	13.40	21.68	25.28	0.57	1.60	0.75
T_7	251.2	40.5	431.4	9.74	19.36	24.36	0.46	1.52	0.31
SEm (±)	0.68	1.16	2.68	0.61	0.60	0.65	0.01	0.01	0.005
C.D. (p = 0.05)	2.11	3.58	8.27	1.88	1.87	2.01	0.04	0.05	0.01

Table 5. *Effect of treatments on storage loss and bulb quality of onion*

Treatments	Storage loss after 5 months			Bulb quality at harvest	Bulb quality after 5 months
	PLW (%)	Sprouting (%)	Rotting (%)	TSS (°Brix)	TSS (°Brix)
T_1	22.53	5.01	39.13	12.59	13.64
T_2	21.09	4.19	31.31	13.13	14.09
T_3	22.55	6.70	45.00	12.84	13.75
T_4	21.18	5.31	31.86	11.91	13.02
T_5	23.45	5.50	42.10	11.24	12.85
T_6	21.01	4.07	31.08	12.56	13.84
T_7	26.88	10.66	55.23	9.88	11.02
SEm (±)	0.27	0.09	1.25	0.62	0.23
C.D.(0.05)	0.83	0.28	3.86	1.92	0.71

PLW=Percentage loss of weight TSS=Total soluble solids

crop affects marketable yield of the crop (Acharya *et al.*, 2015). A significant variation in the number of bolters and doubles in different micronutrient treated plots was noticed. Interestingly percent doubles in onion were recorded less (0.44%) in plots that received the micronutrient mixture (T_6). Variation in the total yield (t ha^{-1}) and marketable yield (t ha^{-1}) of onion was noticed due to different micronutrient application. The total yield of onion ranged from 18.61 to 29.98 t ha^{-1} whereas the marketable yield varied from 11.96 to 21.57 t ha^{-1}. Highest onion yield was noticed in T_6 followed by T_2.

Total dry matter (TDM) production of onion is dependent on the size of the photosynthetic system and the length of growth period (Aske *et al*., 2017). In this experiment the total dry matter increased from 2.28 to 4.79 t ha^{-1} in different micronutrient treated plots (Table 3). A significantly higher TDM was recorded in treatment T_6 (4.79 t ha^{-1}) where micronutrient mixture @ 0.25 % was applied as foliar spray at 30 and 45 days after planting followed by treatments T_2 (4.22 t ha^{-1}) and T_4 (4.28 t ha^{-1}) where Zn and B were applied, respectively.

Nutrient applied and nutrient uptake in a crop is not always related proportionately. Interestingly, uptake of nutrient by crop is influenced by a number of soil and environmental factors like soil texture, pH, organic matter, climatic conditions, ion exchange capacity of soil, etc. (Mandal *et al*., 2004). The macro and micronutrient uptake by onion crop under different treatments has been presented in Table 4. Significant variation was observed in macronutrient (N, P, K, S) uptake with respect to micronutrient application. Foliar application of Zn had a positive influence on N (250 kg ha^{-1}) and K (478.4 kg ha^{-1}) uptake. However, foliar application of micronutrient mixture enhanced the S uptake by onion to a tune of 43.40 kg ha^{-1}. Application of Mn ($MnSO_4$ @0.1 % at 30 and 45 days after planting) had a significant impact on uptake of P (44.5 kg ha^{-1}) and S (17.57 kg ha^{-1}) by onion crop. The overall influence of foliar application of micronutrients on nutrient uptake by onion crop was recorded to be significant.

Storage loss and bulb quality

The percentage of weight loss of onion bulbs after 5 months of storage was significantly influenced by foliar application of micronutrients (Table 5). Loss in weight of bulb is usually known to be caused by rotting, dehydration, transpiration, respiration, sprouting and other metabolic activities. Observations were taken at an interval of 30 days and after 5 months of storage the final weight loss was recorded and it ranged from 21.09 to 26.88 %. Maximum weight loss was recorded in control. Percentage of rotten bulbs of onion at different days after storage was significantly influenced by foliar application of micronutrient fertilizers. In treatment T_6 the percentage of rotten bulbs (31.08 %) was less after 5 months of storage over other treatments and was as per with the treatments T_2 (31.31%) and T_4 (31.86 %) where Zn and B were applied, respectively (Manna and Maity, 2016). Bulb quality (TSS °Brix) at harvest and after 5 months of storage was studied with respect to foliar application of micronutrients. Total soluble solids (TSS °Brix) at harvest ranged from 9.88 to 13.13 °Brix and after 5 months the content (TSS °Brix) in different micronutrient treated plots varied significantly over control and it ranged from 11.02 to 14.09 °Brix.

From the above results, it could be concluded that, the growth, yield and storage quality of onion was influence by the type of micronutrients applied. Application of micronutrient mixture on onion crop had a positive response with respect to growth and yield of the crop. Interestingly, the application of Zn and B alone could also enhance the growth attributes significantly with respect to other micronutrients except some growth attributes like plant height and number of leaves. Besides, Zn and B application had a beneficial effect on onion yield as compared to other micronutrients applied. Hence, it could be concluded that instead of applying all the micronutrients to onion crop, Zn and B nutrition can increase crop yield in Alfisols of Odisha.

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