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Response of onion to soil and foliar application of micronutrients on growth, yield, storage quality and soil fertility status under vertisols of western Maharashtra

KG Shinde*, HP Hukkeri, MN Bhalekar and BT Patil

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Abstract

Onion is important vegetable crop grown worldwide. For improving yields in onion macro and micronutrients were essential for good growth and development. Micronutrients play an active role in the plant metabolic processes and cellular functions within the plants. In addition, they play an essential role in improving yield and quality and highly required for better plant growth in many crops. Soil and foliar application of micronutrients during crop growth can be successfully used for correcting their deficits and improving the mineral status of plants as well as increasing the crop yield and quality. All the micronutrients were found beneficial in maximizing the yield in onion. For obtaining higher yields through the use of micronutrients applications, the soil application of micronutrient mixture grade I @ 10 kg ha-1 along with recommended dose of fertilizer i.e. 100:50:50 NPK kg + 20 t FYM per hectare followed by the foliar application of micronutrient mixture grade II @ 0.5% at 30 and 45 days after transplanting was found beneficial. It is also better for improvement in soil fertility status and reducing storage losses of onion as compared to only recommended dose of fertilizers.

Keywords: onion, micronutrients, soil fertility status.

Introduction

Onion (*Allium cepa* L.) is one of the important bulb crop known to mankind and consumed worldwide. India is the second largest producer of onion in the world next to China with an area of 12.03 lakh hectares with production of 194.01 lakh MT per annum with average productivity of 16.12 t/ha. At present, Maharashtra is leading state in India in onion production having an area of 4.68 lakh hectares with production of 58.64 lakh MT per annum with 12.53 t/ha average productivity (Anon. 2014). For onion, nutrition is one of the most important factor which govern the onion production. All the essential elements are necessary for onion growth and yield. Macro and micronutrients help in increasing the yield, storage quality and fertility status of soil in onion. The macronutrient such as N, P, K, Ca, Mg, S and micronutrients such as Fe, Zn, Cu, B, Mo and Mn are beneficial in enhancing the growth and yield contributing parameters in onion.

Micronutrients play an active role in the plant metabolic process from cell wall development to respiration, photosynthesis, chlorophyll formation, enzyme activity, nitrogen fixation, etc. Even though, micronutrients are needed by the plants in a minor quantity and present in plant tissue in quantities measured in parts per million but it is involved in a wide variety of metabolic processes and cellular functions within the plants. Also, they work as a co-enzyme for a large number of enzymes. In addition, they play an essential role in improving yield and quality and highly required for better plant growth in many crops. Soil and foliar application of micronutrients during crop growth can be successfully used for correcting their deficits and improving the mineral status of plants as well as increasing the crop yield and quality. Micronutrient fertilizer is almost essential in order to achieve the yield of crops, (Singh, 2005). Improvement in onion growth and yield through micronutrient has been reported by many scientists in different types of soils. There were evidences that micronutrients such as zinc, ferrous and boron increase the dry yield of onion plants and gave higher plant height, bulb fresh weight, bulb diameter and yield. By keeping this point in view, the systematic attempt has been made to study the effect of soil and foliar application of micronutrients on growth, yield, storage quality and fertility status of soil in *rabi* onion.

All India Coordinated Research Project on Vegetable Crops, Mahatma Phule Krishi Vidyapeeth, Rahuri-413722, Maharashtara
*Corresponding author, Email: drkgshinde@rediffmail.com

Material and methods

The experiment was conducted at All India Coordinated Research Project on Vegetable Crops, Mahatma Phule Krishi Vidyapeeth, Rahuri (MS) during *rabi* season 2014-15. The trial was laid out in a Randomized Block Design with three replications have nine treatments including one control i.e. only recommended dose of fertilizers. The onion variety N-2-4-1 was used for present investigation. The soil of the experimental plot was medium black with PH of 8.16, EC (d Sm^{-1}) 0.43, organic carbon 0.46% and available N, P_2O_5 and K_2O were 160.24, 15.21 and 370.30 kg/ha respectively. The available Zn, Fe, Cu, Mn and B were 0.50, 3.50, 1.55, 5.45 and 1.03 mg kg^{-1}. The details of treatments studied are T_1 -RDF 100:50:50 kg NPK + 20 tons FYM ha^{-1} (control), T_2 - T_1 + soil application of Ferrous Sulphate at 25 kg ha^{-1}, T_3 - T_1 + foliar application of Chelated Fe @ 0.20% at 30 and 45 DAT, T_4 - T_1 + soil application of Zinc Sulphate at 20 kg ha^{-1}, T_5 - T_1 + foliar application of Chelated Zn @ 0.20% at 30 and 45 DAT, T_6 - T_1 + soil application of Borax at 5 kg ha^{-1}, T_7 - T_1 + foliar application of Boric Acid @ 0.20% at 45 and 60 DAT, T_8 - T_1 + soil application of micronutrient mixture Grade I @ 10 kg ha^{-1} and T_9 - T_1 + foliar application of micronutrient mixture Grade II @ 0.5% at 30 and 45 DAT.

The half dose of nitrogen and full dose of phosphrous, potassium and FYM were given at the time of transplanting. The soil application of $FeSO_4$, $ZnSO_4$, borax and micronutrient mixture Grade I was done in each bed as per treatment and well mixed in soil before transplanting of onion seedlings. The foliar application of chelated Fe, chelated Zn, Boric Acid and micronutrient mixture Grade II was done as per treatment at 30 and 45 days after transplanting (DAT) of onion except boric acid, it was done at 45 and 60 DAT. The half dose of nitrogen was applied one month after transplanting i.e. top dressing with urea. Seeds of the cultivar N-2-4-1 was sown on raised beds on 3rd October, 2014. The main field was prepared to fine tilth and flat beds of 5.25 x 1.5 m^2 was prepared. Eight week old, health and uniform seedlings having about 15-20 cm height were used for transplanting. The transplanting was done on 11th December, 2014 at 15 x 10 cm spacing. Recommended agronomic practices and plant protection measures were taken up to grow healthy crop. Five randomly selected plants were taken for recording the biometrical parameters like plant height (cm), number of leaves, neck thickness (cm), polar and equatorial diameter of bulb (cm), average weight of bulb (g), % A, B and C grade bulbs, bolting (%), twin bulb (%), TSS %, total bulb yield (t/ha) and marketable bulb yield (t/ha). The 10 kg bulb of each treatment was kept for storage study from May to November (180 days i.e. 20th May, 2015 to 20th November, 2015) to record storage losses in % as quality parameter. The PH, EC, Organic carbon and available N, P, K, Zn, Fe, Cu, Mn and B was analyzed and uptake of N, P, K, Zn, Fe, Cu, Mn and B was estimated. The soil nutrient status was analyzed before the application of treatments and after the harvesting of the crop by adopting the methods suggested by A.O.A.C. (1990). The data recorded for each observation was analyzed by the method suggested by Panse and Sukhatme (1985).

Results and Discussion

To enhance the onion productivity, the balanced nutrition to onion is essential alongwith micronutrients. Significant variations among the treatments were observed for characters like plant height, number of leaves, neck thickness, polar and equatorial diameter, average weight of bulb, % ABC grade bulbs, % bolters and twin bulbs, % TSS, total bulb yield and marketable bulb yield (t/ha) (Table 1). The soil and foliar application of micronutrients alongwith recommended dose of fertilizers improved these characters when compared to sole application of recommended dose of fertilizers.

Table 1: Effect of micronutrients on yield and yield contributing character of onion

Treatment	Plant height (cm)	Number of leaves	Neck thickness (cm)	Polar diameter (cm)	Equatorial diameter (cm)	Average weight of bulb (g)	A grade bulb (%)	B grade bulb (%)	C grade bulb (%)	Premature bolters (%)	Twin bulb (%)	TSS (^{0}B)	Total bulb yield (t/ha)	Marketable bulb yield (t/ha)
T1	66.10	10.82	1.11	4.23	5.25	71.85	20.63	58.03	21.20	0.45	1.72	11.23	26.16	23.99
T2	68.03	11.30	1.08	4.54	5.47	72.43	16.80	65.90	15.93	0.87	1.70	11.00	30.00	27.43
T3	68.40	11.24	1.05	4.55	5.71	71.74	18.71	64.40	16.06	0.54	1.67	11.07	29.30	27.09
T4	72.40	11.41	1.38	4.72	5.75	81.20	17.40	67.50	13.43	0.46	1.55	11.40	36.69	34.38
T5	71.36	11.45	1.27	4.69	5.69	79.99	16.23	66.70	14.16	0.52	1.73	11.23	32.72	30.63
T6	71.53	11.54	1.06	4.65	5.73	75.75	16.63	65.97	16.16	0.98	1.59	12.10	31.59	29.02
T7	70.17	11.45	1.02	4.57	5.67	75.01	16.47	62.93	17.26	0.68	1.43	11.17	30.82	28.71
T8	77.47	13.20	0.96	4.94	5.81	83.50	17.10	70.40	11.30	0.71	1.60	12.70	38.49	36.48
T9	73.80	12.26	0.99	4.75	5.80	83.00	17.03	68.50	12.05	0.43	1.66	12.10	37.63	35.38
SE ±	0.93	0.10	0.01	0.10	0.07	1.66	0.42	0.83	12.06	0.01	1.23	0.16	1.37	1.27
CD at 5%	2.79	0.31	0.04	0.31	0.23	4.99	1.27	2.51	NS	0.04	NS	0.69	4.11	3.81

Table 2: Effect of micronutrients application on total losses at 30, 60, 90, 120, 150 and 180 days after storage (DAS) in onion

Treatment	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	180 DAS
T1	7.14	11.36	18.14	22.61	27.09	35.13
T2	6.57	9.93	16.36	19.29	24.64	29.45
T3	6.36	9.81	16.52	19.71	23.56	28.76
T4	6.17	9.11	15.69	18.86	22.10	28.21
T5	6.61	9.44	15.62	21.53	23.76	28.56
T6	6.59	10.18	16.05	20.95	24.57	29.04
T7	6.56	9.92	16.74	20.86	24.61	30.15
T8	5.31	8.89	14.97	17.71	21.50	24.31
T9	5.67	9.50	14.94	19.26	23.76	25.62
SE ±	0.09	0.24	0.29	0.57	0.55	0.60
CD at 5%	0.27	0.72	0.88	1.71	1.66	1.80

These is considerable range of variation was observed from T_1 to T_9 treatments under study. The only recommended dose of fertilizers (T_1) recorded the minimum values while T_8 treatment recorded the maximum values for different characters under investigation. The treatment T_8 i.e. RDF + soil application of micronutrient mixture Grade I @ 10 kg ha^{-1} recorded maximum plant height (77.42 cm), number of leaves (13.20) and minimum neck thickness (0.96 cm) as compare to T_1 i.e. only RDF (66.10, 10.82 and maximum 1.11 respectively). These results were in close agreement with the observations recorded by Sindhu and Tiwari (1993).

With regard to yield and yield contributing parameters, the treatment T_8 recorded the maximum polar diameter (4.94 cm), equatorial diameter (5.81 cm) and average weight of bulb (83.50 g) than other treatment. The total yield (t/ha) was also maximum in T_8 treatment i.e. 38.49 t/ha followed by T_9 (37.63 t/ha) and T_4 (36.69 t/ha). The same tread was also observed for marketable yield (t/ha). This may be due to additional supply of micronutrients to respective treatments. The increase in yield could be due to better uptake of nutrients from soil which might have contributed to increased plant height, number of leaves, bulb diameter and average weight of bulb ultimately enhanced the yield. The micronutrient mixture consists of Fe-2.5%, B-0.5%, Zn-3.0%, Cu-1.0% and Mn-1.0%. All the micronutrients have a combined effect on growth and development of onion and that leads to the highest total yield as compared to other treatments. The soil application of micronutrient mixture was found better treatment followed by foliar application of micronutrient mixture and soil application of zinc sulphate. Bhonde et.al. (1995), Ballah and Rana (20120 and Sindhu and Tiwari (1993) also reported that the combined use of micronutrient mixture gives the higher yield as compare to only recommended dose of fertilizer to onion crops.

The total number of marketable bulbs per treatment is compared of different sized bulbs which can be graded into A grade (above 6.5 cm), B grade (6.5 to 4.5 cm) and C grade (4.5 to 3.5 cm) size bulbs. The percentage of premature bolters and doubles (twin bulbs) regarded as unmarketable bulbs. The A grade bulb percentage recorded in the range of 16.23 to 20.63. The B grade was 58.03 to 70.40 and C grade was 12.05 to 21.20 and was non-significant. The bolters was range from 0.43 to 0.98 and the double (twin bulb) percentage was in the range from 1.43 to 1.72 in various treatments. Kadam (2012) also recorded maximum percentage of A grade and minimum percentage C grade bulbs with micronutrients application treatments compared to

Table 3: Effect of micronutrient application on available nutrient status of soil in onion

Treatment	PH	EC (dsm^{-1})	Organic carbon (%)	Total available N (kg ha^{-1})	Total available P (kg ha^{-1})	Total available K (kg ha^{-1})	Available Zn (mg kg^{-1})	Available Fe (mg kg^{-1})	Available Cu (mg kg^{-1})	Available Mn (mg kg^{-1})	Available B (mg kg^{-1})
T1	8.18	0.43	0.51	176.40	18.44	389.47	0.52	2.42	1.53	4.43	0.98
T2	8.06	0.41	0.57	174.16	18.18	384.19	0.51	4.65	1.47	4.12	0.76
T3	8.12	0.42	0.53	174.34	17.98	385.22	0.43	4.35	1.37	4.21	0.83
T4	8.24	0.44	0.53	171.32	20.50	382.22	0.95	2.90	1.42	3.84	1.06
T5	8.14	0.45	0.55	171.14	19.27	385.53	0.78	2.65	1.35	3.92	1.01
T6	8.31	0.47	0.48	173.53	18.20	387.07	0.46	2.60	1.52	4.08	1.92
T7	8.17	0.43	0.50	174.23	17.73	385.73	0.45	2.71	1.43	4.15	1.79
T8	8.25	0.46	0.56	168.24	19.68	372.45	0.58	3.85	2.17	5.72	1.10
T9	8.21	0.44	0.53	170.32	19.05	374.67	0.53	3.35	1.94	5.51	1.05
SE ±	0.01	0.01	0.39	0.86	14.78	0.84	0.07	0.16	0.11	1.50	0.05
CD at 5%	0.05	NS	NS	NS	NS	2.53	0.21	0.48	NS	4.50	0.17
Initial values	8.16	0.43	0.46	160.24	15.21	370.30	0.50	3.50	1.55	5.45	1.03

Table 4: Effect of micronutrients application of total uptake of nutrient in onion.

Treatment	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Zn (g ha^{-1})	Fe (g ha^{-1})	Cu (g ha^{-1})	Mn (g ha^{-1})	B (g ha^{-1})
T1	74.83	21.88	65.99	85.80	497.20	176.90	132.10	135.40
T2	79.17	22.56	67.66	127.50	775.10	227.50	186.30	148.40
T3	78.91	21.83	66.08	112.50	753.70	219.60	172.40	143.47
T4	79.54	18.65	68.27	264.70	613.20	258.20	247.50	163.40
T5	78.10	19.50	67.00	224.10	595.30	247.30	236.80	158.70
T6	79.87	22.43	67.38	170.50	573.40	238.30	193.20	194.80
T7	78.12	22.96	66.76	148.90	561.20	223.10	181.70	188.37
T8	85.14	20.29	72.78	259.80	674.50	356.30	311.60	176.90
T9	82.14	21.19	70.25	240.50	638.60	324.50	298.40	167.43
SE ±	0.92	0.41	0.60	5.67	23.27	6.79	6.11	4.63
CD at 5%	2.76	1.23	1.82	16.00	70.80	20.38	18.35	13.89

control, which confirms the present findings.

As regards storage studies in onion bulbs influenced by various micronutrient treatments, the treatment T_1 recorded the maximum losses viz., 7.14, 11.36, 18.14, 22.61, 27.09 and 35.13% as compared to T_8 viz., 5.31, 8.89, 14.97, 17.71, 21.50 and 24.31% which recorded minimum total losses for 30, 60, 90, 120, 150 and 180 days after storage (Table 2). These results were in close agreement with those of Singh and Tiwari (1992) and Kadam (2012).

The analysis of soil nutrient status (Table 3) before the treatment application and also after the harvest of the crop revealed that the organic carbon was found significantly more in treatment T_8 or in micronutrients applied plot as compare to control. The available N, was highest in T_1 (176.40 kg ha^{-1}) and lowest in T_8 (168.24 kg ha^{-1}). The available P_2O_5 was highest in T_8 (19.68 kg ha^{-1}) and lowest in T_7 (17.73 kg ha^{-1}). The available K_2O was highest in T_1 (389.17 kg ha^{-1}) and lowest in T_8 (372.45 kg ha^{-1}). The available Zn was maximum in T_5 (0.78 mg kg ha^{-1}) and minimum in T_7 (0.45 mg kg^{-1}). The available Fe was maximum in T_2 (4.65 mg kg^{-1}) and minimum in T_1 (2.42 mg kg^{-1}). The available Cu was maximum in T_8 (2.17 mg kg^{-1}) and minimum in T_5 (1.35 mg kg^{-1}). The available Mn was maximum in T_8 (5.72 mg kg^{-1}) and minimum in T_4 (3.84 mg kg^{-1}). The available B was maximum in T_7 (1.79 mg kg^{-1}) and minimum in T_3 (0.83 mg kg^{-1}). The PH was highest in T_8 (8.25) and lowest in T_2 (8.06) the EC was highest in T_6 (0.47) and lowest in T_2 (0.41). The initial values was also recorded for each nutrients. From these studies, it is clearly seen that the use of micronutrients along with recommended dose of fertilizers results in significant improvement in available N, P, K, Zn, Fe, Cu, Mn and B status of the soil. Similar findings were also reported by Siag and Yadav (2004) and Kumar and Khajuria (2007).

It is evident from the results obtained on the total nutrient uptake of N, P, K, Zn, Fe, Cu, Mn and B by onion crop were significantly influenced by various treatment (Table 4). Total nitrogen uptake by onion was recorded maximum in treatment T8 (85.14 kg ha-1) and minimum in treatment T_1 (74.83 kg ha^{-1}). However, total phosphrous uptake was recorded minimum (18.65 kg ha^{-1}) in treatment T_4 and maximum (22.96 kg ha^{-1}) in treatment T_7. Total potassium uptake by onion bulb was recorded minimum in treatment T_1 (65.99 kg ha^{-1}) and maximum in T_8 (72.78 kg ha^{-1}). This may be because of application of various micronutrients along with recommended dose of N, P and K which are responsible for increasing nutrient use efficiency by the crop. Uptake of nutrients increased with increasing availability of nutrients and also with nitrogen use efficiency. Similar results were reported by Kumar and Khajuria (2007) and Shinde et.al. (2013). It was significantly increase the uptake of Zn, Fe, Cu, Mn and B in various treatments as shown in Table 4. These results were in close agreement with those of Siag and Yadav (2004) and Shinde et.al. (2013).

Considering the yield contributing characters, storage losses and soil nutrient status, it can be conducted that for obtaining higher yields through use of micronutrient applications, the soil application of micronutrient mixture grade I @ 10 kg ha^{-1} along with recommended dose of fertilizers i.e. 100:50:50 NPK in kg + 20 t FYM per hectare was found beneficial for improvement in soil fertility status and maximizing yield and reducing storage losses of onion as compared to only recommended dose of fertilizers. The foliar application of micronutrient mixture grade II @ 0.5% at 30 and 45 days after transplanting was also found better in increasing the yields in onion for *rabi* season. All the micronutrient was found beneficial in maximizing the yields in onion.

सारांश

प्याज एक महत्वपूर्ण सब्जी फसल है जिसकी खेती विश्वभर में होती है। प्याज अधिक उपज के साथ फसल वृद्धि एवं विकास सुनिश्चित करने के लिए मुख्य एवं सूक्ष्म पोषक तत्वों की भूमिका महत्वपूर्ण है। सूक्ष्म पोषक तत्वों की सक्रिय भूमिका पौध चयापचय प्रक्रिया एवं

कोशिकीय प्रक्रियाओं में होती है। इसके साथ–साथ ये तत्व उपज व गुणवत्ता हेतु आवश्यक भूमिका का निर्वाह करते हैं तथा कई फसलों के अच्छी विकास हेतु आवश्यक हैं। फसल वृद्धि के समय पर्णीय प्रयोग के तौर पर कमी को पूरा करने के लिये सफलतापूर्वक उपयोग किया जा सकता है तथा पौधों में खनिज लवण के स्तर सुधार तथा फसल उपज व गुणवत्ता में वृद्धि के लिए आवश्यक है। सभी सूक्ष्म तत्व प्याज की उपज बढ़ाने में लाभदायक है। सूक्ष्म तत्वों के उपयोग से अधिक उपज प्राप्त करने के लिये सूक्ष्म पोषक तत्व मिश्रण ग्रेड–I की 10 किलोग्राम/हेक्टेयर के साथ संस्तुत उर्वरक की मात्रा अर्थात 100:50:50 नत्रजन, फास्फोरस, पोटाश+20 टन गोबर की खाद/हेक्टेयर तत्पश्चात सूक्ष्म पोषक तत्व मिश्रण ग्रेड–II की 0.5 प्रतिशत पौध रोपड़ के 30 व 45 दिन उपरान्त सबसे लाभदायक सिद्ध हुआ। यह मृदा उर्वरता स्थिति सुधार हेतु भी अच्छा रहा तथा केवल संस्तुत उर्वरक प्रयोग की तुलना में प्याज के भण्डारण नुकसान में कमी पायी गयी।

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