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RESPONSE OF ONION TO ZINC FERTILIZATION UNDER VARYING FERTILITY LEVELS IN ALLUIVAL SOILS

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ABSTRACT

A field experiment was conducted at R. B. S. College Research farm Bichpuri, Agra (U.P.) to study the effect of graded levels of soil fertility (control, 50,75 and 100% RD of NPK) and zinc (0,2.5,5.0 and 10.0 kg ha^{-1}) on yield attributes, yield, quality and uptake of nutrients in onion (Allium cepa L.). The experiment was laid out in randomized block design with three replications. The results revealed that the fresh weight of a bulb and yield of bulb increased significantly with 100% RD of NPK over control. The yields of onion bulb were significantly lower with the sub-optimal doses of NPK. Application of 100% NPK produced 28.80 tonnes ha^{-1} bulb and dry matter yield (4.40 tonnes ha^{-1}) of onion which was significantly superior to 75 and 50% NPK. The content and yield of protein in onion bulbs increased significantly with an increase in level of soil fertility. The maximum protein content (4.75%) and protein yield (20.9 q ha^{-1}) were obtained with 100% NPK. The uptake of N, P, K, S, Fe and Zn by onion bulbs was found to be associated with production of dry matter resulted by application of 100% NPK. Application of 5 kg Zn ha^{-1} gave the highest yield of bulbs (23.50t ha^{-1}) which was 15.4% more than that of control. The magnitude of zinc response progressively increased with increasing levels of soil fertility and Zn response was maximum at optimum level of soil fertility (100% NPK). Application of zinc significantly increased the uptake of nutrients by onion bulbs over control. The maximum content (4.56%) and yield (17.2 q ha^{-1}) of protein was recorded at 5 kg Zn ha^{-1}. Available nutrient status of post harvest soil was higher with 100% NPK level over control except those of iron and zinc. The lowest values of nutrients status were recorded under control. The status of N and Zn improved up to 10 kg Zn ha^{-1}. On the other hand, status of P. Fe and K decreased at 10 kg Zn ha^{-1} over 5 kg Zn ha^{-1}.

Key words: Zinc, soil fertility, yield, quality, nutrient uptake, onion.

INTRODUCTION

Onion (*Allium cepa L*) is one of the most important commercial vegetable crop grown all over the world. Onion has culinary, dietary and medicinal importance in daily life of Indian people and due to its export trade, it is also a major vegetable crop to gain foreign currency. Increasing productivity of onion with high quality is an important target of onion growers. Onion requires substantial amounts of plant nutrients and responds very well to the added fertilizers (Verma *et al.,* 2014) The productivity of soil depends upon the adequate and balanced amount of all the essential nutrients including micronutrients (Zn). Among the various agronomic practices, use of sub-optimum and imbalanced fertilization is responsible for low productivity of onion. Use of optimum fertilization is the key factor in increasing the productivity which can be realized with the judicious application of plant nutrients to onion crop. Intensive cropping along with lower use of organic manures and very low rates of application or practically no use of zinc in soils have led to depletion of the reserves of Zn in soils, limiting the crop productivity. The low yields of bulb crops and poor quality of the produce are due to various constraints including micronutrient management. Zinc plays a significant role in various enzymatic and physiological activities of the plant body. Zinc catalyses the process of oxidation in plant cells and plays a vital role in transformation of carbohydrates, regulates the consumption of sugar, increases the source of energy for the production of chlorophyll, adds in the formation of auxins and promotes absorption of water. Zinc is also important micronutrient reported deficient in Indian soils and plays a significant role in various enzymatic and physiological activities of plant bodies. Response to applied zinc for better growth and yield of vegetable crops has also been reported from almost all corners of country (Solanki *et al.,* 2010). Soil fertility shows interaction with Zn and affects the zinc nutrition of crops. However, such information on zinc nutrition of onion crop under different fertility

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levels is not available for onion under agro-climatic conditions of Agra region. Therefore, a field experiment was conducted to study the effect of Zn and soil fertility on yield, quality and nutrient uptake by onion in alluvial soil.

MATERIALS AND METHODS

Field experiments were conducted at R.B.S. College Research farm (Agra). The climate of the study area is semi-arid with an average rain fall of about 650 mm per annum, about 80% of which is received during June to September. The soil of the experimental field was sandy loam in texture, having pH 8.1, organic carbon 3.9 g kg^{-1} and available N, P, K, Fe and Zn 145, 9.2, 115 kg ha^{-1}, 4.2 and 0.55 mg kg^{-1}, respectively. The experiment was laid out in randomized block design with three replications. The treatments included four levels each of soil fertility (control, 50, 75 and 100% RD of NPK) and Zn (0, 2.5, 5.0, and 10.0 kg ha^{-1}). Recommended dose of N, P and K (150 kg N, 100 kg P_2O_5 and 50 kg K_2O ha^{-1}) were applied as urea, di-ammonium phosphate and muriate of potash, respectively. Potassium and phosphorus were applied at planting but the crop received nitrogen in two splits, half as basal and half at 60 days after planting. Zinc was applied as zinc sulphate at the time of planting. The seedlings of onion cv Nasik Red N-53 were planted in mid December during both the years. The spacing adopted was 20x10 cm. Onion crop was irrigated after planting and later as and when required. The crop was harvested at physiological maturity and yield data were recorded. The yield attributes of onion crop were recorded at harvest. Processed bulb samples were analyzed for their nutrients by digesting the samples using di-acid mixture (HNO_3 : $HClO_4$:10 : 4) followed by estimation of Fe and Zn on an AAS. Phosphorus, K and S were determined by vanadomolybdophosphoric yellow colour method, flame photometer (Jackson 1973) and turbidimetric method (Chesnin and Yien 1951), respectively. Nitrogen content was determined following micro Kjeldahl method. The proteln content was computed from the nitrogen content multiplied by a factor 6.25. The uptake of nutrients was then computed from their concentrations in bulb samples and bulb dry matter yield. The soil samples collected after harvest were analysed for available N, (Subbaih and Asija 1956), available P (Olsen *et al.,* 1954), K (Jacson 1973), S (Chesnin and Yien 1951). These soil samples were also extracted by DTPA (Lindsay and Norvell 1978) and Fe and Zn contents were determined using atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Yield attribute and yield

The various fertility levels had favourable influence on the fresh weight of a bulb (Table 1). The weight of a bulb increased significantly with successive increase in fertility levels up to 100% RDF (Table 1) which may be attributed to increased dry matter as a result of increased cell division and enlargement due to the application of NPK nutrition. The improvement in bulb weight due to fertility levels might have resulted in better interception and utilization of radiant energy leading towards higher photosynthesis and finally more accumulation of dry matter in onion bulbs. Similar results were reported by Singh and Pandey (2006) and Pal *et al.,* (2016 b). Grading doses of fertilizer application had significant effect on bulb and, dry matter yield of bulb. The yields increased with an increase in dose of NPK fertilizer over control. Application of 100% RDF recorded the highest bulb yield (28.80 t ha^{-1}) being 15.7 and 41.7% higher over 75 and 50% RDF, respectively. This may be owing to build up of soil fertility that led to increased nutrient availability. There was a continuous and significant increase in dry matter yield of onion bulbs at each level of NPK addition over control. The difference in increase obtained in the yields at 75 and 100% NPK indicates the superiority of optimal dose apparently because the yield may be economically increased. Similar results were reported by Singh and Pandey (2006) and Singh *et al.,* (2015). Purohit and Nagaich (2015) reported higher yield with 100% NPK application.

Effect of Zn fertilization on weight of bulb of onion was significant upto 5 kg Zn ha^{-1} over the control. These attributes tended to decrease with higher level of zinc. Application of graded doses of zinc to onion significantly enhanced the bulb yield (Table 1). Highest bulb yield and bulb dry matter yields were recorded with 5 kg Zn ha^{-1} over rest of the treatments. Application of 5 kg Zn ha^{-1} increased the bulb yield and bulb dry matter yield to the tune of 16.9 and 17.1 % over the control, respectively. The favourable influence of Zn application on the yield of onion may be attributed to its role in various enzymic reactions, growth processes, hormone production and protein synthesis and also the transformation of photosynthates to reproductive parts thereby leading to higher yield of the crop. Increase in yield owing to Zn application is quite obvious, as the soil under study was deficient in available Zn (0.55 mg kg^{-1}) Solanki et al (2010) and Pal *et al.,* (2016 a) reported similar results in onion.

Table 1: Effect of fertility and zinc levels on yield attribute, yield and quality of onion (mean of two years)

Treatments	Weight of bulb (g)	Yield (t ha^{-1})		Protein content (%)	Protein yield (q ha^{-1})
		Fresh bulb	Dry matter		
Fertility					
Control	61.4	16.71	2.69	3.87	10.4
50% NPK	77.8	20.37	3.15	4.12	13.0
75% NPK	83.2	24.89	3.81	4.31	16.4
100% NPK	93.3	28.80	4.40	4.75	20.9
SEm±	1.64	0.93	0.31	0.11	0.72
CD (P= 0.05)	3.29	1.87	0.63	0.23	1.46
Zinc (kg ha^{-1})					
0	74.6	20.87	3.23	4.06	13.1
2.5	79.9	22.00	3.41	4.31	14.7
5.0	82.4	24.40	3.78	4.56	17.2
10.0	78.8	23.50	3.63	4.37	15.8
SEm±	1.64	0.93	0.31	0.11	0.72
CD (P= 0.05)	3.29	1.87	0.63	0.23	1.46

Interaction

Soil fertility and zinc interacted significantly in influencing the bulb yield of onion (Table 2). Treatment (100% NPK x 5 kg Zn ha^{-1}) produced 32.72 t ha^{-1} onion bulbs which proved significantly superior to the rest of the treatment combinations. Application of NPK enhances the Zn requirement of onion and external application of zinc upto 5 kg ha^{-1} meets the same and both synergistically enhance the bulb production. Application of 10 kg Zn ha-1 tended to reduce the bulb yield at all the fertility levels. The minimum yield of bulb (15.98 t ha^{-1}) was recorded under control (no NPK x no zinc) treatment.

Table 2: Interaction effect of fertility and zinc levels on bulb yield (t ha^{-1}) of onion

Zinc (kg ha^{-1})	Soil Fertility (kg ha^{-1})			
	Control	50% NPK	75% NPK	100% NPK
0	15.98	18.52	23.75	25.01
2.5	16.93	20.03	24.41	26.67
5.0	17.12	22.00	26.03	32.72
10.0	16.79	21.05	24.91	30.71
SEm ±	1.86			
CD (P=0.05)	3.74			

Quality

The successive increase in fertility levels up to 100% RDF significantly increased protein content and protein yield (Table 1) over control. The increase in protein content with increasing fertility levels may be the result of enhancement in amino acid formation. Our results confirm the findings of Pachauri *et al.,* (2005). The protein yield increased significantly up to 100% RDF over control. The wide variations in protein yield were largely due to the differences in bulb yield because protein yield is the resultant of bulb yield and protein content. These results are in agreement with the findings of Singh and Pandey (2006). The lower values of protein content and yield were recorded in control (Table 1) which may be attributed to low nitrogen status of the soil.

The protein content in onion bulb increased from 4.06 to 4.56 % with 5 kg Zn ha^{-1}. This increase in protein content with Zn addition may be attributed to its involvement in nitrogen metabolism. The protein yield increased significantly with each increment in zinc dose over control. The highest protein yield was obtained with 5 kg Zn ha^{-1} which was significantly higher than the control and lower levels of Zn. This was mainly owing to higher dry matter yield of bulb and protein percentage in onion bulbs. Solanki *et al.,* (2010) also reported such results in onion.

Nutrient uptake

The value of nutrient uptake followed the pattern of yield obtained in different fertility levels. The N uptake by bulbs significantly increased with increasing levels of NPK upto 100% level which may be attributed to greater production of onion bulbs. The uptake of P by onion bulbs was significantly higher with all fertility levels over control and maximum value (7.9 kg ha^{-1}) was recorded with 100% NPK. This may be due to better growth and dry matter productionof plants and deeper ramification of roots which causes higher uptake of phosphorus. Singh *et al.,* (2015) reported similar results. The uptake of potassium increased with increasing levels of NPK fertilizers which may be due to higher availability of the nutrient in question as compared to control. The uptake of sulphur by onion crop increased significantly with levels of NPK fertilizers over control which may be attributed to greater bulb production. All the fertility levels significantly improved the utilization of zinc and iron by onion bulbs and lowest uptake was recorded in control. Increase in Zn uptake could be due to increase in dry matter production and Zn concentration in bulbs. Solanki *et al.,* (2010) also reported similar results.

Table 3: Effect of soil fertility and iron levels on uptake of N, P, K, S (kg ha^{-1}) and Fe and Zn (g ha^{-1}) by onion (mean of two years)

Treatment	Nitrogen	Phosphorus	Potassium	Sulphur	Iron	zinc
Soil fertility						
Control	16.7	2.9	12.6	8.0	87.8	75.3
50% NPK	20.8	4.1	16.4	9.7	105.4	95.8
75% NPK	26.3	6.0	21.7	12.1	134.4	119.6
100% NPK	33.4	7.9	26.4	15.0	154.2	140.4
SEm±	1.21	0.22	0.98	0.51	4.6	3.8
CD (P= 0.05)	2.13	0.45	1.97	1.03	9.3	7.7
Zinc (kg ha^{-1})						
0	21.0	4.8	17.4	10.3	110.5	81.4
2.5	23.5	5.8	19.0	11.2	123.0	98.5
5.0	27.6	5.7	20.4	12.1	127.3	122.0
10.0	25.8	5.1	19.2	11.1	117.2	129.5
SEm±	1.21	0.22	0.98	0.51	4.6	3.8
CD (P= 0.05)	2.43	0.45	1.97	1.03	9.3	7.7

Nitrogen uptake by onion increased significantly with increasing levels of zinc and the highest N uptake was observed with 5 kg Zn ha^{-1} i.e. 27.6 kg ha^{-1} and lowest in the control (21.0 kg ha^{-1}). Thus, the beneficial effect of Zn on photosynthesis and metabolic processes augments the production of photosynthates and their translocation to different plant parts including bulb. These results are in accordance with the findings of Pal *et al.,* (2016 a). Phosphorus uptake first increased due to increase in yield but at the higher doses of zinc, it decreased due to reduced P content in bulb. The decrease in P uptake with higher level of zinc might be due to antagonistic effect between P and Zn. Similar results were reported by Singh and Pandey (2006) and Singh *et al.,* (2015).

The uptake of K by onion bulb significantly increased with increasing levels of Zn upto.5.kg Zn ha^{-1}. The magnitude of increase in K uptake with 5 kg Zn ha^{-1} was 17.2 per cent in onion bulb. There was a slight increase in sulphur uptake by onion bulb with the application of Zn up 5 Kg Zn ha^{-1} over the control. Thereafter, a reduction in S uptake was noted at higher levels of Zinc.Zinc application up to 5 kg Zn ha^{-1} increased the Fe uptake by onion bulbs significantly over control. However, the higher level of Zn (10 kg ha^{-1}) tended to decrease Fe uptake over 5 kg Zn ha^{-1}).Zinc uptake by onion bulbs increased significantly with increasing levels of Zn application (Table 3). Highest Zn uptake was found with 10 kg Zn ha^{-1} and lowest in control. The increase in Zn uptake by onion bulbs with 10 kg Zn ha^{-1} was 59.0 per cent over the control. The higher Zn removal due to Zn application could be attributed to the priming effect caused by higher crop growth and consequently higher removal due to balanced fertilization. Pal *et al.,* (2016 a) also reported similar results.

Table 4: Effect of soil fertility and zinc levels on status of available N, P, K (kg ha^{-1}), Fe and Zn (mg kg^{-1}) in post harvest soil (mean of two years)

Treatment	Nitrogen	Phosphorus	Potassium	Iron	Zinc
Soil fertility					
Control	101.2	7.2	107.0	6.20	1.08
50% NPK	141.0	9.6	117.1	7.54	1.12
75% NPK	171.5	13.5	130.0	7.00	1.14
100% NPK	188.0	15.6	139.2	5.80	1.01
SEm±	5.61	0.57	2.52	0.56	0.037
CD (P= 0.05)	11.28	1.15	5.06	1.12	0.074
Zinc (kg ha^{-1})					
0	142.0	11.5	121.5	6.80	0.49
2.5	148.5	12.0	123.0	7.10	0.88
5.0	153.0	12.6	125.3	6.70	1.21
10.0	158.2	9.8	123.5	5.94	1.77
SEm±	5.61	0.57	2.52	0.56	0.037
CD (P= 0.05)	11.28	1.15	NS	1.12	0.074

Soil fertility

Available nitrogen status in post harvest soil improved significantly with all the levels of NPK fertilizers, the increase being 43.8 kg ha^{-1} in 100% NPK treatment as compared to the initial value (145 kg ha^{-1}). Increase in available N due to graded levels of NPK fertilizers has been reported by Verma *et al.,* (2014). Available N status of the soils also improved with Zn levels indicating beneficial effect of zinc addition. Available phosphorus status in soil increased with all the fertility levels over control. There was a significant increase in available P content in soil with increasing levels of NPK fertilizer and relatively higher amount was noted in 100% NPK level. This may be attributed to the increased amount of P in soil due to application of phosphatic fertilizers. Addition of 10 kg Zn ha^{-1} reduced the available P content in soil over control. Increasing levels of NPK fertilizers improved the status of available K in soil after the harvest of onion crop over control. The highest level (100% NPK) proved more beneficial in respect of available K content in soil (Pal *et al.,* 2016 b). The amount of available K in soil also improved with application of zinc but the difference were statistically non-significant between the levels of zinc. Data on available iron content (Table 4) clearly show that available Fe content in post harvest soil increased with fertility levels over control. The maximum and minimum values were recorded under 50% NPK and control, respectively. There was a significant reduction available iron in soil due to higher levels of zinc over no zinc.Available Zn status depleted under control which may be attributed to higher uptake of native zinc by the crop. Application of NPK levels improved the status of available Zn over control. The effect of NPK levels on zinc status in post harvest soil was statistically significant and maximum build up was noted with 75% NPK. DTPA - extractable Zn in soil varied from 0.49 to 1.77 mg kg^{-1} soil. The highest concentration of Zn was recorded with 10 kg Zn ha^{-1}. The higher levels of Zn increased available Zn content in soil over the critical limit of 0.60 mg kg^{-1}.

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