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EFFECT OF SOIL FERTILITY AND IRON LEVELS ON YIELD, QUALITY AND NUTRIENT UPTAKE IN ONION IN ALLUVIAL SOIL

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ABSTRACT

A field experiment was conducted at R. B. S. College Research farm Bichpuri, Agra (U.P.) during rabi season to study the effect of graded levels of soil fertility (control, 50,75 and 100% RD of NPK) and iron (0,5,10 and 20 kg Fe 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 sixteen treatment combinations and three replications. The results revealed that the fresh weight of a bulb and yields 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 28.13 tonnes ha^{-1} bulb and dry matter yield (4.30 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 (4.81%) and protein yield (20.68 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 10 kg Fe ha^{-1} gave the highest yield of bulbs (23.73t ha^{-1}) which was 15.4% more than that of control. Application of iron increased the content (4.50%) and yield (16.33 q ha^{-1}) of protein up to 10 kg Fe ha^{-1}. The minimum value of Zn uptake by onion bulbs was recorded at 20 kg Fe ha^{-1}. Iron application up to 10 kg ha^{-1} significantly increased the uptake of N, P, K and S by the onion bulb over control followed by a reduction at 20 kg Fe 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 Fe improved up to 20 kg Fe ha^{-1}. On the other hand, status of P and K decreased at 20 kg Fe ha^{-1} over 10 kg Fe ha^{-1} and zinc over 5 kg Fe ha^{-1}.

Key words: Iron, 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 important 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 (Fe). Among the various agronomic practices use of sub-optimum and imbalanced fertilization are 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 iron in soils have led to depletion of the reserves of Fe 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. Iron is essential in both plant and animal nutrition. Iron is a structural component of porphyrin molecules cytochromes, haemes, hematin, ferrichrome and leg-haemoglobin involved in oxidation-reduction reactions in respiration. It is an important part of the enzyme nitrogenase which is essential for nitrogen fixation through nitrogen fixing bacteria. The ferrodoxins are Fe-S proteins and are the first stable redox compound of the photosynthetic electron transport chain (Havlin *et al.* 2014).. However, such information on iron nutrition of onion crop under different fertility levels is not available for onion under agro-climatic conditions of Agra region. Therefore, a field experiment was conducted to study the effect of Fe and soil fertility on yield, quality and nutrient uptake by onion in alluvial soil.

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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 Fe (0.5, 10 and 20 kg Fe 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. Iron was applied as ferrous oxide 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 protein 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.

RESULTS AND DISCUSSION

Yield attribute and yield

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. A perusal of data (Table 1) revealed that the application of graded doses of Fe to onion significantly enhanced the weight of a bulb over control. The maximum weight (61.7 g) of a bulb was recorded with the application of 10 kg Fe ha^{-1} over rest of the levels of iron. The increase in weight of bulb may be due to low available Fe status of the soil. There was a reduction in weight of bulb with 20 kg Fe ha^{-1} over 10 kg Fe ha^{-1}. Choudhary *et al.* (2015) reported similar results.

Table 1: Effect of Soil fertility and iron levels on 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		
Soil fertility					
Control	60.9	16.76	2.71	3.75	10.16
50% NPK	77.3	20.15	3.08	4.12	12.68
75% NPK	82.4	24.91	3.86	4.37	16.86
100% NPK	92.8	28.13	4.30	4.81	20.68
SEm±	2.46	0.13	0.22	0.16	1.40
CD (P= 0.05)	4.95	0.27	0.45	0.33	2.81
Iron (kg ha^{-1})					
0	75.8	20.57	3.13	4.12	12.89
5	78.6	22.55	3.44	4.37	15.03
10	81.0	23.73	3.63	4.50	16.33
20	78.0	23.10	3.53	4.37	15.88
SEm±	2.46	0.13	0.22	0.16	1.40
CD (P= 0.05)	4.95	0.27	0.45	0.33	2.81

Grading doses of fertilizer application had significant effect on bulb yield, dry matter yield of bulb. The yields increased with an increase in dose of fertilizer over control. Application of 100% RDF recorded the highest bulb yield (28.13 t ha^{-1}) being 12.9 and 20.1% higher over 75 and 50% RDF. This may be owing to build up to 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). Application of 10 kg Fe ha^{-1} produced significantly higher bulb yield and bulb dry matter yield in comparison to control (Table 1). The highest mean bulb yield and dry matter yields of bulbs were recorded with the application of 10 kg Fe ha^{-1}, which were respectively, 15.3 and 16.0% higher than of the control. The response of onion to Fe may be due to low available Fe status of the soil. Similar results were reported by Chandel *et al.* (2013) and Choudhary *et al.*(2015).

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.* (2003). The protein yield increased significantly up to 100% RDF over control. The wide vareations 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).Application of iron increased the protein content in onion bulb and this increase was significant over control. The maximum value of protein content (4.50%) was noted at 10 kg Fe ha^{-1}. This increase in protein content with iron application may be attributed to its involvement in nitrogen metabolism. Similar results were reported by Chandel *et al.* (2013). The protein production increased from 12.89 q ha^{-1} at control to 16.33 q ha^{-1} with 10 kg Fe ha^{-1}. The increase in protein yield with iron application may be ascribed to greater bulb production.

Table 2: 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	16.3	3.0	12.7	7.6	99.2	84.0
50% NPK	20.3	4.0	15.4	8.9	122.6	107.1
75% NPK	27.0	6.2	20.8	12.0	161.3	153.6
100% NPK	33.1	7.7	25.4	14.2	187.5	173.6
SEm±	2.32	0.39	1.12	0.60	9.6	7.1
CD (P= 0.05)	4.66	0.78	2.25	1.21	19.3	14.3
Iron (kg ha^{-1})						
0	20.6	4.7	16.3	9.4	93.9	119.7
5	24.1	5.8	18.8	10.6	127.5	127.5
10	26.2	5.4	19.2	11.2	166.1	134.6
20	24.8	4.9	18.0	10.2	193.8	126.0
SEm±	2.32	0.39	1.12	0.60	9.6	7.1
CD (P= 0.05)	4.66	0.78	2.25	1.21	19.3	14.3

Nutrient uptake

The uptake of N by onion bulb with fertility levels varied from 16.3 to 33.1 kg ha^{-1}. The increase in N uptake may be attributed to increased N content in bulbs along with bulb dry matter yield. The uptake of nitrogen by onion bulbs increased significantly with lower levels of iron addition followed by a reduction at 20 kg Fe ha^{-1}. The maximum value of N uptake (26.2 kg ha^{-1}) was recorded at 10 kg Fe ha^{-1}. The increase in N uptake with lower levels of iron may be due to higher bulb production.

Choudhary *et al.* (2015) also reported similar results The application of higher level of fertility (100% RDF) gave significantly higher uptake of phosphorus in dry matter of bulb and it was higher by over medium (75%) and lower (50%) level of fertility (Table 2). The utilization of P by onion bulbs increased significantly with lower levels of Fe over control. The higher level (20 kg Fe ha^{-1}) caused a significant reduction in P uptake by onion crop over 10 kg Fe ha^{-1}. This reduction may be due to reduction in dry matter yield of onion bulbs. Similar results were reported by Chandel *et al.* (2013). The significantly higher uptake of potassium by onion bulb was recorded under higher level of fertility. It was higher by 22.1 and 65.0% over medium and low level of fertility, respectively. The K uptake by onion bulbs increased significantly and consistently up to 10 kg Fe ha^{-1}. Thereafter, a reduction in potassium uptake by onion bulbs was noted at 20 kg Fe ha^{-1}. Increasing levels of soil fertility improved the uptake of sulphur by onion bulb and maximum value of 14.2 kg ha^{-1} was recorded under 100% NPK. The S uptake by onion bulbs increased significantly with increasing levels of Fe over control (Table 2) which may be due to increased availability of S in soil. In onion bulbs, S uptake ranged from 9.4 (control) to 11.2 kg ha^{-1} (10 kg Fe ha^{-1}). The iron uptake by onion bulbs also increased significantly due to fertility levels. It varied from 99.2 to 187.5 g ha^{-1}. The maximum iron uptake was recorded with the application of 100% NPK. Application of Fe progressively increased its uptake by onion bulb up to 20 kg Fe ha^{-1}, it was significantly higher over control with all levels of iron. This increase may be due to increased availability of iron in soil (Chandel *et al.,* 2013). Increasing levels of fertility significantly increased the uptake of zinc in onion bulbs over control. The zinc uptake increased from 84.0 g ha^{-1} at control to 173.6 g ha^{-1} with 100% NPK. The increase in Zn uptake may be attributed to enhanced Zn content in onion bulbs along with dry matter yield of bulbs. The Fe application had significant effect on Zn uptake by the onion bulb. The highest level of Fe (20 kg ha^{-1}) reduced the Zn uptake compared with its lower l as a result of lower content of Zn in bulbs.

Table 3: Effect of soil fertility and iron levels on status of available nutrients in post harvest soil N, P, K, S (kg ha^{-1}) and Fe and Zn (mg kg^{-1}) by onion

Treatment	Nitrogen	Phosphorus	Potassium	Iron	zinc
Soil fertility					
Control	100.4	7.5	106.4	6.15	0.49
50% NPK	139.7	10.0	116.0	7.45	0.51
75% NPK	170.6	13.7	129.5	7.03	0.52
100% NPK	185.3	15.2	138.0	5.72	0.50
SEm±	5.04	0.45	1.82	0.65	0.015
CD (P= 0.05)	10.13	0.91	3.65	1.31	NS
Iron (kg ha^{-1})					
0	140.4	11.8	121.0	3.75	0.51
5	147.0	12.2	122.6	5.10	0.52
10	152.3	12.0	124.0	7.25	0.50
20	156.3	10.4	122.3	10.25	0.49
SEm±	5.04	0.45	1.82	0.65	0.015
CD (P= 0.05)	10.13	0.91	NS	1.31	NS

Soil fertility

Available nitrogen status in post harvest soil improved significantly with all the levels of NPK fertilizers, the increase being 44.6 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 Fe levels indicating beneficial effect of iron 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 20 kg Fe 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. The amount of available K in soil also improved with application of iron but the difference were statistically non-significant between the levels of iron. Data on available iron content (Table 3) 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 build up available iron in soil due to different levels of iron and maximum value of available Fe was recorded under 20 kg Fe ha^{-1}.Available Zn status depleted under control which may be attributed to higher uptake of native zinc by the crop. Application of NPK levels slightly improved the status of available Zn over control. The effect of NPK levels on zinc status in post harvest soil was statistically non-significant. The amount of available Zn in soil also slightly improved with lower levels of Fe but this improvement was statistically non-significant.

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