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Productivity, quality and uptake of nutrients in cabbage (*Brassica oleracea*) as affected by levels of zinc

MAYANK GAUR AND VINAY SINGH

Department of Agricultural Chemistry and Soil Science, Raja Balwant Singh College, Bichpuri, Agra (U.P.) 283105

ABSTRACT

A field experiment was conducted at Research Farm, R.B.S. College, Bichpuri, Agra (U.P.) to study the effect of levels of zinc on productivity, quality and uptake of nutrients in cabbage (Brassica oleracea Var. Capitata). The experiment was laid out in randomized block design with six levels of zinc (0, 2.5, 5.0, 7.5, 10.0 and 15.0 kg ha^{-1}) with three replications. The results indicated that significantly higher head and dry matter yields were obtained with the application of zinc over control. The highest head (36.06 t ha^{-1}) and dry matter yield (2.93 t ha^{-1}) of cabbage were recorded with 7.5 kg Zn ha^{-1}. Application of 7.5 kg Zn ha^{-1} resulted in 36.5% higher head yield and 31.4% dry matter yield than the yield obtained in the control (26.85 t ha^{-1} head and 2.23 t ha^{-1} dry matter yield). The content and yield of protein increased significantly with increasing zinc levels, thus cabbage fertilized with 10 kg Zn ha^{-1} recorded the highest yield of protein (158.4 kg ha^{-1}). The maximum value of protein content (5.68%) was recorded with 15 kg Zn ha^{-1}. The uptake of N and Zn in cabbage crop increased upto 10 kg Zn ha^{-1} followed by reductions at higher level of zinc. The uptake of P, K and Z tended to increase with zinc application up to 5 and 7.5 kg Zn ha^{-1} respectively over control. Thereafter, a significant reduction was noted at higher levels of Zn. Nutrient status in post harvestsoil improved significantly with levels of zinc. The status of available N and Zn improved significantly upto 10 kg Zn ha^{-1} whereas P, K and S contents increased upto 7.5 kg Zn ha^{-1}.

Key words: Cabbage, quality, nutrient uptake yield, zinc.

INTRODUCTION

Vegetables play a very important role in the human diet. They are valuable roughages which promote digestion and help to prevent constipation. Cabbage is a leafy green plant grown as vegetable crop for its dense leaved heads. Among the several constraints, improper nutritional management is an important impediment for increasing the productivity of cabbage. Vegetable crops have a high zinc requirement. Widespread and extensive occurrence of zinc deficiency has been reported in the cultivated soils of Agra region of Uttar Pradesh (Singh and Singh 2018). It is, therefore, imperative to apply zinc in such soils in addition to major nutrients for obtaining maximum yields. Application of zinc to soil is the most satisfactory way to cure zinc deficiency. Studies on Zn fertilizer proved that the application of zinc greatly influenced growth, yield and quality of vegetable crops (Solanki et al, 2010). Zinc has specific and essential physiological functions in plant metabolism. It plays a major role in synthesis of tryptophan, which is precursor of indole acetic acid. Zinc is also important in protein synthesis. Therefore, zinc management needs greater attention in crop production to combat with widespread zinc deficiency in vegetable growing areas. Since, not much work has been done to assess the response of cabbage to zinc fertilization. Therefore, present study was undertaken to study the effect of levels of zinc on yield and quality of cabbage.

MATERIALS AND METHODS

A field experiment was conducted at research farm of R.B.S. College, Bichpuri, Agra (U.P.). The soil of experimental site was sandy loam in texture, alkaline in reaction (pH 8.0) with organic carbon content 3.4 g kg^{-1}, available N 160 kg ha^{-1}, available phosphorus 8.4 kg ha^{-1}, available potassium 115 kg ha^{-1}, and DTPA-Zn 0.54 mg kg^{-1}. The field experiment was conducted with the six levels of zinc (0, 2.5, 5.0 7.5, 10.0 and 15.0 kg ha^{-1}) in randomized block design with four replications. The seedling of cabbage was planted in third week of November. Recommended dose of fertilizers was applied @ 120: 80: 60 (N, P_2O_5, K_2O kg ha^{-1}) as urea, single superphosphate and muriate of potash, respectively. Full dose of P and K along with half nitrogen were applied at planting and remaining

half dose of nitrogen was applied after 45 days of planting. Zinc was applied through zinc sulphate at the time of planting. The crop was raised with recommended agronomic practices. The crop was harvested at physiological maturity and cabbage head yield was recorded. The head was cut in to small pieces, dried in oven and dry matter yield was recorded. The head samples of cabbage were digested in diacid mixture of HNO_3; $HClO_4$ (10:4) and sulphur content was determined turbidimetrically (Chesnin and Yien 1951). Phosphorus, K and Zn in diacid digest were determined by vanadomolybdate yellow colour method (Jackson, 1973), flame photometer and atomic absorption spectrophotometer, respectively. Nitrogen content was estimated by modified Kjeldahl method. The uptake of nutrients was obtained as product of their concentration and dry matter yield. Post harvest soil samples collected after harvest were analyzed for organic carbon, available N (Subbiah and Asija, 1956), available P (Olsen et al, 1954), available K (Hanway and Heidel 1952), available S (Chesnin and Yien, 1951)and DTPA-Zn (Lindsay and Norvell, 1978). The data thus obtained were analyzed statistically using analysis of variance technique for various parameters at 5% level of significance.

RESULTS AND DISCUSSION

Yield

With successive increase in zinc levels, cabbage head and dry matter yeld increased significantly upto 7.5 kg Zn ha^{-1} but a further increase in Zn level did not significantly increase the yields. The highest cabbage head (36.06 t ha^{-1}) and dry matter (2.93 t ha^{-1}) yields were recorded with 7.5 kg Zn ha^{-1} which registered 36.5 and 31.4% higher head and dry matter production, respectively over control. This increase in yields due to zinc application may be attributed to the fact that Zn is main yield limiting plant nutrient in zinc deficient soils. Applied Zn is reported to enhance the absorption of native as well as added major nutrients and thereby improved overall growth and development of plant and ultimately the yields. In addition, the beneficial influence of Zn application on the head yield of cabbage may be attributed to its role in various enzymatic reactions, growth processes, hormone production and protein synthesis and also the translocation of photosynthates to reproductive parts thereby leading to higher yield of crop Singh et al (2009). Solanki et al (2010) and Pal et al (2016) also reported significant response to vegetable crops to Zn application.

Table 1: Effect of levels of zinc on yield and quality of cabbage crop

Zn levels (kg ha^{-1})	Cabbage head yield (t ha^{-1})	% response	Dry matter yield (t $ha^{-1)}$	Protein content in head (%)	Protein yield (kg ha^{-1})
0	26.85	-	2.23	4.31	96.1
2.5	29.00	9.0	2.39	4.62	110.4
5.0	33.24	25.2	2.72	4.93	134.0
7.5	36.06	36.5	2.93	5.25	153.8
10.0	35.51	35.1	2.88	5.50	158.4
15.0	31.5	22.7	2.61	5.68	148.2
SEm ±	0.61	-	0.08	0.09	2.3
CD (p=0.05)	1.31	-	0.17	0.19	5.0

Quality

Increasing levels of zinc significantly increased the protein content in cabbage head from 4.31 to 5.68% with 15 kg Zn ha^{-1}. The increase in protein content owing to Zn addition might be attributed to its involvement in the nitrogen metabolism. Dubey et al (2003) and Singh *et al.* (2009) reported an increase in protein content with Zn application. Corresponding application of Zn also increased the protein yield from 96.1 to 158.4 kg ha^{-1}. This increase in protein yield were significant upto 10 kg Zn ha^{-1} over the control. Since, variation in protein contact has genetic and biochemical limitation, the protein yield is more influenced by dry matter yield of cabbage head. Dubey et al (2003) also reported similar results.

Uptake of nutrients

Nutrient uptake in cabbage head increased significantly with increasing levels of Zn and the highest N uptake (25.3 kg ha^{-1}) was

Table 2: Effect of levels of zinc on uptake of nutrients by cabbage head

Zn levels (kg ha^{-1})	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})	Sulphur (kg ha^{-1})	Zinc (g ha^{-1})
0	15.3	4.4	14.2	2.9	56.6
2.5	17.6	4.5	15.5	2.8	64.3
5.0	21.4	5.1	18.2	3.2	76.1
7.5	24.6	4.9	19.9	3.2	85.8
10.0	25.3	4.6	19.5	3.1	89.0
15.0	23.7	3.9	18.0	2.6	83.0
SEm ±	1.36	0.10	0.42	0.12	1.97
CD (p=0.05)	2.92	0.22	0.90	0.26	4.23

observed with 10 kg Zn ha^{-1}. The lowest N uptake by cabbage (15.3 kg ha^{-1}) was noted in control (Table 2). Thus, the beneficial effect of Zn on photosynthesis and metabolic processes augments the production of photosynthates and their translocation in different plant parts, which ultimately increased the uptake of N in cabbage. These results are in accordance with the findings of Singh and Pandey (2006). Phosphorus uptake by cabbage head increased at lower levels of zinc due to increase in yield but at higher level of zinc, it decreased due to reduced P content in cabbage head. This decrease in P uptake with higher doses of zinc might be due to antagonistic effect between P and Zn. Similar results were reported by Solanki et al (20110). The uptake of K by cabbage crop was significantly increased with increasing levels of Zn up to 7.5 kg Zn ha^{-1}. The magnitude of increase in K uptake with 7.5 kg Zn ha^{-1} was 40.0% in cabbage crop. The results are in accordance with the findings of Singh and Pandey (2006). There was a significant increase in sulphur uptake by cabbage head with the application of Zn upto 5 kg ha^{-1}. Thereafter, a reduction in S uptake was noted at higher level of zinc (Pal *et al.* 2016). The uptake of zinc by cabbage crop increased significantly with increasing doses of zinc by cabbage crop increased significantly with increasing doses of Zn and it was highest with the application of 10 kg Zn ha^{-1}. This increase in Zn uptake by cabbage crop with 10 kg Zn was 57.2% over the control. The increase in Zn was in consonance with higher dry matter yield and increase in Zn counter in cabbage head. Similar results were reported by Pal et al (2016).

Table 3: Effect of levels of zinc on the status of nutrients in post harvest soil

Zinc levels (kg ha^{-1})	Organic carbon (g ha^{-1})	Avail. nitrogen (kg ha^{-1})	Avail. phosphorus (kg ha^{-1})	Avail. potassium (kg ha^{-1})	Avail. sulphur (kg ha^{-1})	Avail. zinc (mg kg^{-1})
0	3.0	150	9.0	105	13.2	0.51
2.5	3.5	160	9.0	110	13.5	0.58
5.0	3.8	170	8.4	117	13.8	0.61
7.5	4.2	178	8.3	120	14.0	0.65
10.0	4.5	188	8.1	118	13.7	0.67
15.0	4.5	190	8.0	115	13.5	0.68
SEm ±	0.08	2.04	0.27	1.115	0.09	0.121
CD (p=0.05)	0.19	4.53	0.60	2.55	0.20	0.26

Soil Fertility

The status of organic carbon in post-harvest soil was improved significantly with levels of zinc over control. The highst (4.5 g kg^{-1}) and lowest (3.0 g kg^{-1}) values of organic carbon were noted with 10 kg Zn ha^{-1} and control, respectively. There was a significant build up of available N and K with the application of zinc and maximum amount was noted with 15 and 10 kg Zn ha^{-1}, respectively. The status of available P tended to decrease with increasing levels of zinc and minimum values were recorded with 15 kg Zn ha^{-1}. The available S slightly increased with lower levels of zinc followed by a reduction in available S at higher levels of zinc indicating an antagonistic relationship. The trend was just opposite for DTPA extractable Zn content where the values increased with increasing levels of zinc (Singh and Pandey 2006).

It is inferred from the present study that soil application of zinc upto a dose of 7.5 kg ha^{-1} is beneficial compared to control for yield of cabbage head. Also an improvement in quality of cabbage and uptake of nutrients was recorded with zinc application. Therefore, the present study highlights that application of Zn up to a dose of 7.5 kg ha^{-1} is beneficial for cabbage cultivation in alluvial soils of western Uttar Pradesh.

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