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Effect of zinc nutrition on yield, quality and uptake of nutrients in cabbage (*Brassica oleracea*)

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ABSTRACT

A field experiment was conducted during winter (rabi) seasons of 2012-13 and 2013-14 to study the response of zinc fertilization on cabbage (Brassica oleracea, var. Capitata) in alluvial soil at Bichpuri, Agra (U.P.). The treatments comprised five levels of zinc (0, 2, 4, 6 and 8 kg ha^{-1}) were evaluated in randomized block design with four replications. The results revealed that the application of zinc up to 6kg Zn ha^{-1} significantly increased the edible head yield and dry matter production of cabbage over control. The magnitude of mean response to 6 kg Zn ha^{-1} application was recorded as 38.4% over control. Successive zinc levels had a significant beneficial effect on its uptake by the vegetable crop up to 8 kg Zn ha^{-1}. A phenomenal increase in N, K and S uptake, except of P was recorded in the crop due to increasing levels of Zn up to 6 kg ha^{-1}. Zinc application significantly improved the content and yield of protein in the crop over control and maximum values were recorded at 6 kg Zn ha^{-1}. The apparent recovery of zinc was influenced by its levels with maximum at 4 kg Zn ha^{-1} in cabbage. Better zinc use efficiency in cabbage (1917.5 kg produce/Zn applied) was obtained with 4 kg Zn ha^{-1}. The zinc use efficiency decreased with its increasing levels and minimum use efficiency was recorded with 8 kg Zn ha^{-1} application.

Keywords: Apparent recovery, cabbage, protein yield, Response, zinc

INTRODUCTION

Vegetables play a very important role in the human diet. They are valuable roughages, which promote digestion and help to prevent constipation. They supply carbohydrate, fats, protein, vitamins and mineral elements. Cabbage is a leafy green plant grown as vegetable crop for its dense leaved heads. The vegetables have given a push to Indian economy and boosted up her trade. Average productivity of vegetable crops is however, very low and not sufficient to meet the need of local consumption. Among the several constraints, improper nutritional management is an important impediment for increasing the productivity of cabbage. Vegetable crops have a high Zn requirement due to its many functions in plant growth. Zinc application is less expensive but can give higher profits than other nutrients (Solanki *et al.*, 2010).Zinc, as a plant nutrient, has the strongest impact on yield and quality of vegetable crops. Zinc also plays a role in the activation of enzymes, nucleic acids and forms a part of biotin and thiamine. In recent years, an increased frequency of zinc deficiency has been observed in crops and Zn may become a factor limiting yield and quality of crops. Zinc deficiency is observed mainly due to high crop yield, therefore, higher rate of zinc removed by crops and lesser use of zinc containing fertilizers. The farmers of the area, by and large, use N, P and K fertilizers in vegetable crops and as a consequence, deficiency of zinc is increasing. About 50% soils of India are low in available zinc and these soils are under intensive cultivation with no or little application of zinc fertilizers (Shukla, 2011). The information regarding the response of cabbage to zinc application under identical soil and weather conditions was considered to be of interest. It was felt imperative to find out the response of cabbage to zinc application for higher production and quality. However, the information pertaining to response of cabbage crop to zinc application in light textured soil is limited. Therefore, the present study was planned to assess the response of cabbage crop to zinc application in alluvial soil of Agra district of Uttar Pradesh.

MATERIALS AND METHOD

The field experiment was conducted during winter seasons of 2012-13 and 2013-14 at Research farm, Raja Balwant Singh College, Bichpuri, Agra (U.P.) The farm is situated at 27º

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2” N latitude,77º9” E longitude and at an altitude of 163.4 meter above mean sea level. The experimental site is characterized by semi-arid climate with extreme temperature during summer (45º to 48º C) and very low temperature during winter (as low as 2º C). The average rainfall is about 650 mm, most of which is received from June to September. The soil was sandy loam in texture having pH (7.8), EC (0.29 dS m^{-1}), organic carbon (3.2 g kg^{-1}), available N (140 kg ha^{-1}), P (9.7 kg ha^{-1}), K (110 kg ha^{-1}), S (8.0 mg kg^{-1}) and DTPA – Zn (0.48 mg kg^{-1}). The treatments consisting 5 levels of Zn (0, 2, 4, 6 and 8 kg ha^{-1}) were tested in randomized block design with four replications. The seedlings of cabbage were planted on 22 November in both the years. A basal dose of 120 kg N, 80 kg P_2O_5 and 60 kg K_2O ha^{-1} was applied through urea, di-ammonium phosphate and muriate of potash, respectively. Full dose of phosphorus and potassium 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 yields were recorded. The cabbage head was cut in to small pieces, dried, ground and digested with di-acid mixture of HNO_3 and $HClO_4$ in 9 : 1 ratio. Phosphorus, K, S and Zn were determined by vanadomolybdophosphoric yellow colour method, flame photometer, turbidimetric method (Chesnin and Yien, 1951) and atomic absorption spectrophotometer, respectively. Nitrogen content was determined following micro Kjeldahl method (Jackson 1973). The protein content was computed from the nitrogen content multiplied by a factor 6.25. The uptake of nutrient was calculated by multiplying the concentration values with respective economic yield data. The following formulae were used to calculate zinc use efficiency and apparent Zn recovery:

Zinc use efficiency (kg produce/kg Zn applied): Yield (F) – Yield (C)/Fertilizer Zn applied
Apparent Zn Recovery (%) = [Uptake of Zn in treated plot – Uptake of Zn in control plot/applied Zn dose] x 100

Where F and C are fertilizer treated and control plot, respectively.
Data obtained from consecutive two years were statistically analyzed as per procedure given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Economic Yield

The results on economic yield distinctly indicated that the test crop responded markedly to zinc application. In general, each additional dose of zinc application up to 6 kg Zn ha^{-1} increased significantly the yields. Thereafter, a decreasing trend was observed at 8 kg Zn ha^{-1} (Table 1). The per cent increase in head yield due to 6 kg Zn ha^{-1} over control was 38.4. This increase in yields with Zn levels seems to be associated with the increased Zn availability from applied zinc as the experimental soil was low in available Zn. The response to zinc may be attributed to improved nutritional management as a result of increased Zn supply which might have favourable influence on the growth and yield of cabbage crop. Solanki *et al.* (2010) and Singh *et al.* (2009) also reported significant response of vegetable crops to zinc application. Increasing levels of zinc significantly increased dry matter production in cabbage from 2.37 to 3.31 tonnes ha^{-1} (Table 1).

Table 1: Effect of zinc fertilization on yield and quality of cabbage (mean of 2 years)

Zinc(kg ha^{-1})	Head yield (t ha^{-1})	% response	Dry matter yield (t ha^{-1})	Protein content (%)	Protein yield (t ha^{-1})
0	28.50	-	2.37	4.35	10.31
2	31.50	10.5	2.62	4.60	12.06
4	36.17	26.9	3.05	4.85	14.80
6	39.44	38.4	3.31	5.00	16.55
8	37.16	30.4	3.10	5.10	15.82
SEm $\pm$	0.61	-	0.08	0.09	0.80
CD (P=0.05)	1.31	-	0.17	0.19	1.66

The average dry matter yield of cabbage crop exhibited practically no difference at higher levels of Zn. Hence, 6 kg Zn ha^{-1} can be regarded as suitable dose for cabbage crop. Increase in dry matter production due to zinc addition was largely a function of improved growth, translocation of more photosynthates towards sink and consequent accumulation of more dry matter in edible heads. The lowest dry matter production in cabbage was noted in control. Solanki *et al.* (2010) also reported significant response of the vegetable crops to zinc application.

Table 2: Uptake of N, P, K, S (kg ha^{-1}) and Zn (g ha^{-1}) in cabbage as influenced by zinc fertilization (mean of two years)

Zinc (kg ha^{-1})	Nitrogen	Phosphorus	Potassium	Sulphur	Zinc
0	16.5	3.9	15.5	2.8	58.9
2	19.6	4.9	16.8	3.0	67.4
4	23.5	5.2	19.4	3.2	79.9
6	27.2	5.0	21.4	3.2	90.3
8	26.9	4.7	21.2	2.5	95.1
SEm $\pm$	1.40	0.10	0.41	0.06	1.91
CD (P=0.05)	3.00	0.22	0.88	0.13	4.11

Uptake of nutrients

Nitrogen uptake by cabbage increased significantly with increasing levels of zinc and the highest N uptake (27.2 kg ha^{-1}) was observed with 6 kg Zn ha^{-1} and the lowest in the control i.e. 16.5 kg ha^{-1} (Table 2). Thus, the beneficial effect of Zn on N uptake by the crop seems to be associated with promoted nitrogen availability with a concomitant increase in crop yield. The significant increase in P uptake by cabbage crop was noticed with the application of Zn and maximum value was recorded at 4 kg Zn ha^{-1}. Thus, zinc application increased the efficiency of vegetable crops to utilize the phosphorus (Solanki *et al.* 2010). A progressive increase in Zn levels up to 6 kg ha^{-1} gradually increased K uptake by the cabbage crop. Higher uptake of K might be due to higher yield and K content in the edible heads of cabbage crop (Singh *et al.* 2009). Application of 4 kg Zn ha^{-1} increased S uptake in cabbage from 2.8 to 3.2 kg ha^{-1}. This could be ascribed to increase in the available S content in plant tissues and also greater head production at 4 kg Zn ha^{-1} application. Since, the uptake of nutrient is a function of dry matter and nutrient content, the increased dry matter yield of cabbage crop with higher Zn content resulted in greater uptake of this element (Singh *et al.* 2009). The zinc uptake increased from 58.9 to 95.1 g ha^{-1} with 8 kg S ha^{-1}. It seems that application of Zn enriched the available Zn status of soil which was easily utilized by the crop. The results indicate beneficial effect on zinc utilization by cabbage crop under higher levels of zinc (Singh *et al.* 2009 and Radder *et al.* 2006).

Table 3: Effect of zinc levels on efficiency indices in cabbage (mean of two years)

Zinc level (kg/ha	Apparent Zn recovery (%)	ZnUE (kg produce/kg Zn supplied)
0	-	-
2	4.25	1500.0
4	5.25	1917.5
6	5.23	1823.3
8	4.52	1082.5

Efficiency indices

The maximum value of apparent recovery of zinc by cabbage was 5.25% at 4 kg Zn ha^{-1} (Table 3). The minimum value of apparent recovery of zinc in the crop was noted at 8 kg Zn ha^{-1} level. The yield improvement over unit quantity of Zn addition was calculated as Zn use efficiency. Critical examination of the data (Table 3) showed that the different levels of Zn tried had influenced the Zn use efficiency. The response varied from 1500.0 to 1975.5 kg edible head/kg Zn in cabbage. Zinc use efficiency (kg produce increase/kg zinc) increased with an increase in the rates of zinc up to the level of 4 kg Zn ha^{-1} in the vegetable crop. Better zinc use efficiency was obtained with 4 kg Zn ha^{-1} and recorded 1975.5 kg produce in cabbage head per kg zinc applied. The Zn UE in the vegetable crop decreased at 8 kg Zn ha^{-1}. This may be due to the fact that input-output relationship follows the law of diminishing return as far as the relationship between zinc and yield is concerned. Similar findings have been reported by Solanki *et al.* (2010).

Based on two years of field study, it may be concluded that application of 6 kg Zn ha^{-1} to cabbage is sufficient dose for increased productivity and quality of produce under zinc deficient soils of Agra, Uttar Pradesh.

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