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Growth, Productivity and Economics of Cabbage (*Brassica oleracea* var. *Capitata* L.) in Gird Zone as influenced by different levels of Zinc and Sulphur levels

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ABSTRACT
A field experiment was conducted at Gwalior in M.P. during the *Rabi* season of 2010 to study the Growth, Productivity and Economics of Cabbage (*Brassica oleracea* var. *Capitata* L.)in Gird Zone as influenced by different levels of Zinc and Sulphur levels. Results revealed that growth parameters like plant height, plant spread and number of leaves per plant at all crop growth stages (except 20 DAT), yield attributing characters, length and diameter of head and weight per head, cabbage yield per hectare net return and benefit cost ratio increased with increasing levels of sulphur from 20 to 80 kg/ha and zinc from 2 to 8 kg/ha. The crop responded only upto 60 kg S/ha and 6 kg Zn/ha.

Introduction

Cabbage (*Brassica oleracea* L. var. Capitata) is grown in every part of the country and also in northern Madhya Pradesh especially in Gwalior region. It is grown in a large area during winter months due to its adaptability to the soil and climatic condition of this tract however its per hectare production is low as compared to other developed nations. In India nearly 10% and 15% production of total vegetable are attributed to cabbage and cauliflower only (Singh, 2004a). According to Tandom (1986) 15-20% of cultivated area in India may have some degree of sulphur deficiency. Kanawar and Mohan (1962) reported that light textured soils are more liable to sulphur deficiency in becoming widespread due to continuous use to sulphur free fertilizers.

Besides sulphur, zinc also play an important role in plant nutrition. The main function of zinc in plant is of a metal activator of enzyme like dehydrogenase, proteinases and peptinases. Zinc is essential for the synthesis of tryptophan, a precursor of IAA, which is essential for normal cell division and other metabolic process and helps in the formation of chlorophyll. Zinc has catalytic function and is required for the transformation of carbohydrate. The deficiency also causes interveinal chlorosis, reduced root growth blossoming and flowering. Similarly, shortened internodes and chloratic areas of older leaves due to its deficiency were reported by Shanmugavlu (1989).

Material and Method

A field experiments was carried out during *Rabi* seasons of 2010 at College of Agriculture, Gwalior, which is located at 26°13' north latitude and 74°4' east longitude in "Gird zone" in the north tract of M.P at an altitude of 208 m above the mean sea level. The total rainfall received during the crop season 2010-11 was 22.32 mm with 4 rainy days, the maximum temperature ranged from 20.73^0 to 32.02^0C, minimum temperature from 5.13^0 to 13.48^0 C and range of relative humidity was 63.28 to 74.66%. The soil of the experimental field was sandy clay loam in texture (Typic ustochrept), neutral in reaction (pH 7.9) and low in available N (189.5kg/ha), medium in available P (17 kg/ha) with low organic carbon (0.43%) but high in available K (238 kg/ha). The soil moisture content at field capacity was 21%, having bulk density and infiltration rate 1.4mgm^{-3} and 2.2 mm/hr. The experiment was laid out in factorial Randomized Block design with three replications. The treatment combinations comprised four sulphur levels (20, 40, 60 and 80 kg/ha); and four zinc levels (2,4,6 and 8 kg/ha). The crop were sown on 8th November 2010. The cabbage seeds were sown @ 10 g/bed by line sowing. As per treatment, the agriculture grade gypsum of a size passing 100 per cent material through 2.5 mm sieve and applied up to depth of 10-15 cm before 21 days of transplanting. Zinc as per treatments was applied through $ZnCl_2$. The weighted quantity of zinc was mixed with soil and incorporated uniformly in whole plot.

Result and Discussion

Plant growth

Plant growth as judged by plant height, spread of plant and number of leaves per plant was improved significantly by application of sulphur and zinc. Results in regards to plant growth parameters, most of the growth parameters significantly increased with each increment in level of sulphur and zinc respectively up to 60 kg/ha and 6 kg/ha. However, maximum value of these growth parameters was recorded by 80 kg S/ha and 8 kg Zn/ha. Thus, 60 kg/ha dose of sulphur and 6 kg/ha dose of zinc was significantly more effective than rest of the doses. These results are clearly indicative of growth promoting effect of sulphur and zinc. It is obvious, because of the fact that application of sulphur has been reported to improve not only the availability of sulphur but of other nutrient too, which are considered important for growth and development of plant. Application of sulphur has been reported to help in lowering soil pH resulting in increased availability of several nutrients (Hossan and Olsen, 1966). Sulphur also plays an important role in activation of a number of enzymes and carbohydrate metabolism (Tandorr, 1986). Increased vegetative growth of cabbage due to sulphur application in the present investigation is

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Table. Effect of different levels of Zinc and Sulphur on Growth, Yield and Economics of Cabbage

Treatments	Plant Spread	Plant Height (cm)	No. of leaves	Length of Head(cm)	Diameter of Head(cm)	Weight/head (g)	Yield (q/ha)	Net Income('000' Rs.)	BC Ratio
Zinc levels									
Z_1(2 kg/ha)	40.74	19.66	14.71	12.00	10.89	0.481	256.55	81.39	3.39
Z_2(4 kg/ha)	43.88	21.19	15.43	13.23	12.00	0.559	297.77	99.89	3.92
Z_3(6 kg/ha)	47.77	23.07	15.98	14.05	12.75	0.611	338.26	118.06	4.45
Z_4(8 kg/ha)	48.07	23.39	16.03	14.13	12.82	0.620	341.23	119.34	4.48
S.E.(m) ±	0.63	0.33	0.20	0.17	0.20	0.014	4.84	2.08	0.07
C.D.(at 5%)	1.82	0.95	0.57	0.48	0.57	0.041	13.98	6.00	0.19
Sulphur levels									
S_1(20 kg/ha)	42.36	19.91	14.23	12.11	11.05	0.487	268.73	87.84	3.65
S_2(40 kg/ha)	44.55	21.38	15.46	13.12	11.96	0.558	300.65	101.51	4.00
S_3(60 kg/ha)	45.89	22.59	16.15	13.86	12.54	0.604	325.15	111.82	4.24
S_4(80 kg/ha)	47.67	23.42	16.31	14.33	12.91	0.623	339.29	117.50	4.34
S.E.(m) ±	0.63	0.33	0.20	0.17	0.20	0.014	4.84	2.08	0.07
C.D.(at 5%)	1.82	0.95	0.57	0.48	0.57	0.041	13.98	6.00	0.19

in close conformity with the finding of Hajiboland and Amjad (2008) and Habiba *et al.* (2009).

Yield and yield attributes

The yield and yield attributes studies made in this investigation responded significantly to sulphur and zinc. Therefore, it is important to discuss the effects of sulphur and zinc on yield and yield attributes. Application of both sulphur and zinc in general was beneficial in increasing yield of cabbage (q/ha). All three higher doses of both micronutrients i.e. 40, 60 and 80 kg/ha doses of sulphur and 4, 6 and 8 kg/ha doses of zinc, increased the yield of cabbage per hectare significantly over respective lowest level (20 kg S/ha and 2 kg Zn/ha). Furthermore, with each increase in the level of sulphur up to 60 kg/ha, there was corresponding increase in the yield of cabbage. The successive increase in cabbage yield with progressive rise in sulphur level was statistically significant. Similarly, with each increase in the level of zinc up to 6 kg/ha, there was corresponding significant increase in the yield of cabbage. Thus, the maximum benefit in yield of cabbage accrued with the application of 60 kg S/ha and 6 kg Zn/ha as also indicated by their significant interaction effect on yield of cabbage. In fact, the yield of cabbage per unit area mainly depends upon performance of individual plants.

The weight per head is governed mainly by the length and diameter of head. In the present investigation the effect of sulphur was significant on the length and diameter of head which showed significant increase with successive increase in the level of sulphur from 20 to 60 kg/ha. Similarly, the application of zinc @ 6 kg/ha significantly increased the length and diameter of head over 2 and 4 kg/ha, though the increasing trend continued up to 8 kg/ha, the highest tested dose of zinc. Thus, it is clear that weight per head was the significantly maximum at 60 kg S/ha and 6 kg Zn/ha due to the highest length and diameter of head and ultimately the yield of cabbage per hectare was significantly maximum at same dose of both sulphur and zinc.

The increase in yield attributes was probably due to source and sink relationship. The increase in yield attributes can be consequently the enhanced partitioning of photosynthates towards sink.

The advantageous effect of zinc on yield and yield attributes might be possible due to increased supply of zinc through soil application that improved the availability of zinc in the plant together with other plant food elements. Zinc has been suggested to play an important role in regulating the auxin concentration in plants. Besides this, zinc also enhances the absorption of essential element via increasing the cation exchange capacity of roots. Thus, application of zinc in a soil deficient improved overall growth and development of plant and ultimately the head yield.

Increase in yield and yield attributes of cabbage and other related crops due to sulphur and zinc has also been reported by Kumar *et al.* (2008), Singh and Singh (2004a), Singh and Singh (2004b), Narayan *et al.* (2006), Lashkari *et al.* (2007) and Habiba *et al.* (2009).

Economics of treatments

Treatment 60 kg S/ha and 6 kg Zn/ha individually resulted in significantly maximum net return and benefit cost ratio. The maximum net return and benefit:cost ratio under these treatments probably occur due to highest head yield. However, the highest net income and B:C ratio were annexed with highest applied level of sulphur and zinc without significant margin. The present investigation is in close conformity with the finding of Singh *et al.* (2015)

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