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Effect of Nutrient Management on the Growth and Yield of Cabbage (*Brassica oleracea* var. *capitata* L.) in Calcareous Soils of Bangladesh

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Abstract

An investigation was carried out in the calcareous soil of Chapai Nawabganj belonging to the High Ganges River Floodplain during November 2008 to March 2009 to examine the effect of different macro and micronutrients (N, P, K, S, Zn, B and Mo at 150, 50, 100, 20, 3, 3 and 1 kg/ha, respectively) on the growth and yield of cabbage. Application of different nutrients exhibited significant influence on the growth and yield of cabbage. The highest plant spread (70.76 cm), height (37.89 cm), leaf length (37.83 cm), leaf breadth (27.13 cm), head thickness (12.85 cm), head diameter (23.02 cm), marketable head yield (76.53 t/ha) which is 191% increase over control), early head formation and maturity were recorded from the plot receiving N, P, K and B at the rate of 150, 50, 100 and 3 kg/ha, respectively. The treatment N, P, K and S showed the highest weight of loose leaves (640 g/plant) and decreased the weight of folded leaves or head weight, whereas, the treatment N, P, K and B increased the folded leaves or maximum head weight (1894.18 g/plant).

Keywords: Cabbage, fertilizer management, growth, yield

1. Introduction

Cabbage (*Brassica oleracea* var. *capitata* L.) is one of the most important, high nutritive and palatable leafy vegetables widely cultivated in Bangladesh. It is a rich source of protein, minerals and vitamin A (Uddin *et al*., 2009). It has some medicinal value as it prevents constipation, increases appetite, speeds up digestion and is very useful for diabetic patient. China is the leading cabbage producer (36,335,000 tons) all over the world (FAO, 2009). Bangladesh produces 211,097 tons from 16,102 hectares of land (BBS, 2009).

Fertilizer enhances plant growth by providing amendments to the soil via various macro and micronutrients. The fertilizer application for cabbage should ensure adequate levels of all nutrients. Optimum fertilization is required to produce top quality and high yields while a lack of essential fertilizers will stunt its growth, leading to undersized and poorly developed heads.

Cabbage is well known to be an exhaustive crop and has the capacity to absorb higher amount of nutrient from soil. The supply of proper nutrient must be ensured during its cultivation, which is related to the judicious application of fertilizer. In the upland field, cabbage yields were high when chemical fertilizers were applied (Kamiyama *et al*., 1995). The crop production system with high yield targets cannot be

sustainable unless nutrient inputs to soil are at least balanced against nutrient removal by crops (Jahiruddin and Rijpma, 2004). Farmers of Bangladesh use only about 172 kg nutrients/ha annually (132 kg N, 17 kg P, 17 kg K, 4 kg S and 2 kg Zn+ B+ others), while the crop removal is about 250 kg/ha (Islam, 2002). As a result other nutrients such as Mo, Mn, Mg etc. are being observed as deficient in many parts of Bangladesh.

Some researchers investigated the effect of macro and micronutrients for cabbage production and recommended organic manure with macro and micronutrients to be added to the soil for increased head yield of cabbage (Farid *et al*., 1998). Boron is a very sensitive micronutrient and the range of deficiency and toxicity are narrow. However, in cole crops like cabbage, boron requirement is very high (Tisdale *et al*., 1995). Ullah *et al*. (1999) reported the significant influence of combined application of N, P, K and S on the yield of cabbage.

The average yield of cabbage is very low in Bangladesh compared to other developed countries due to unbalanced application of fertilizers and no consideration of micronutrients (Islam *et al*., 1989). Therefore, it is necessary to improve the yield of cabbage through judicious application of fertilizers. The present experiment was, therefore, conducted with the aim of improving the performance of cabbage in terms of yield and quality through the use of both macro and micronutrients in calcareous soil of Bangladesh.

2. Materials and Methods

2.1. Experimental site and soil

The investigation was carried out at the Horticulture Centre, Kallyanpur, Chapai Nawabganj during November 2008 to March 2009. The soil of the experimental site was silty clay loam belonging to the High Ganges River Floodplain (BARC, 2005). The organic matter and total nitrogen contents of the experimental field were very low while others nutrients were above critical level (Table 1).

2.2. Experimental design and treatments

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each block consisted of 11 unit plots. The size of each unit plot was 3.3 m × 2.25 m. The gap between the plots was 50 cm and between the blocks was 100 cm. A total of 11 treatments including the untreated control were selected in this investigation which were: T_o = Control, T_1 = N, T_2 = NP, T_3 = NPK, T_4 = NPKS, T_5 = NPKZn, T_6 = NPKB, T_7 = NPKMo, T_8 = NPKSZn, T_9 = NPKSZnB and T_{10} = NPKSZnBMo. The doses of N, P, K, S, Zn, B and Mo were 150, 50, 100, 20, 3, 3 and 1 kg/ha, respectively.

The sources of N, P, K, Zn, B, S and Mo were urea, triple super phosphate, muriate of potash, zinc oxide, boric acid, gypsum and ammonium molybdate, respectively. The whole amount of TSP, zinc oxide, boric acid, ammonium molybdate, and 50% of urea and MoP were applied during final land preparation. Rest MoP and urea were applied in two equal installments at 15 and 35 days after planting of seedlings followed by irrigation.

Table 1. Characteristics of the soils of experimental field

pH	7.2	Exchangeable K	0.41 meq/100g
Organic matter	0.62%	Available S	11.8 µg/g
Total N	0.04(%)	Available B	0.48 µg/g
Available P	29.0 µg/g	Available Zn	1.32 µg/g

2.3. Land preparation, transplantation of seedlings and intercultural operations

The experimental land was prepared in first week of November 2008 by ploughing and cross ploughing followed by laddering. Large clods were broken into pieces by hand tools, and weeds and stubbles were removed from the field. Finally, the land was leveled and the soil was taken into good tilth. The cabbage seedling of cv. Atlas-70 was collected from the Horticulture Centre, Kallyanpur, Chapai Nawabganj. Thirty days old seedlings were transplanted into the experimental field on 15 November 2008, with a space of 55 cm × 45 cm. Thirty seedlings were planted in each plot and were lightly watered and kept under pieces of banana leaf sheath for 3 days during the day time to protect from sunlight.

Weeds were removed three times to keep the plots free from weeds and the soil was mulched by breaking the upper crust for easy aeration and to conserve soil moisture as and when needed. The crop was irrigated at 15, 35 and 55 days after transplantation. However, each top-dressing was followed by irrigation. Any gap due to seedling mortality was filled by new seedlings. Malathion 57 EC @ 2 ml/L was sprayed once to control the cutworm.

2.4. Harvest of crops and data collection

Cabbage was harvested plot wise at different dates after attaining maturity. The crop was harvested from 11 February to 02 March 2009. Before harvesting, head compactness of the cabbage was tested by pressing with thumb. The compact or matured head showed comparatively hard feelings. Ten sample plants were harvested at first from each plot and then the whole plot was harvested. The yield of individual plot was converted into yield per hectare.

Data were collected from randomly selected 10 plants at 30, 45, 60, 75 days and at harvest. To avoid the border effect outer two lines and the outer plants of the middle lines were excluded. The height of the plants was measured from the ground level to the tip of the highest leaves. Land area covered by the plant was estimated by putting a meter scale on the canopy and was expressed in centimeter. Length and breadth of the largest leaf was measured from the base of the petiole to the tip. To record the diameter, the cabbage heads were sectioned vertically at the middle position and the horizontal distance from one side to other side of the widest part of the sectioned head was measured. The thickness of head was measured as the vertical distance from the lower to the upper most leaves of head. Days required for head formation or maturity was counted from the date of transplanting to the start of head formation or maturity. In order to measure dry matter content in leaves or heads 200 g chopped leaves/head was dried in the direct sun for two days and then in an oven at 70°C for three days till the weight was constant. Percent dry matter was calculated by using the following formula:

$$\text{Dry matter (\%)} = \frac{\text{Dry weight of loose leaves/heads}}{\text{Fresh weight of loose leaves/heads}} \times 100$$

The data were analyzed statistically using MSTAT-C, a statistical package programme. The analyses of variances of all the characters studied were performed by F-test. The significance of the differences among the means was evaluated by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

3. Results and Discussion

3.1. Plant spread

There was significant influence of fertilizer treatments on the spread of cabbage plants at different growth period (Table 2). The spread was rapidly increased up to 60 days, and then gradually up to 75 days while after 75 days, the spread was gradually decreased.

At the initial stage of 30 or 45 days, the highest spread was recorded in treatment T_6 which received N, P, K and B. It seems that application of N, P, K and B significantly increased plant spread while S and Zn had negative effect. The results showed that the addition of B was more

effective as B can be fixed with organic matter at primary stage. The results are in agreement with that reported by Das (1999) who reported that added Ca and Mg can fix available B. Application of N P, K, S and Zn significantly increased plant spread. Similar response was noted after 60 and 75 days when the highest spread was obtained in T_6. With a few exceptions, S and Zn decreased the plant spread as they decrease B availability in the soil and B can fix with organic matter during early stage of crop growth. The results are in agreement with the observation of Tandon (1995) and Das (1999). A reduction in plant spread was recorded at the time of harvest although the highest coverage was noted in T_6. The results of the present study is in agreement with that of Sarma *et al*. (2002), who reported reduced plant spread during harvest of cabbage and with the rate of spreading being slower compared to the increasing rate of previous growth period.

3.2. Plant height

The height of cabbage plant was significantly influenced by different fertilizer management (Table. 3). At the early stages of 30 and 45 days, the tallest plant was recorded in the treatment T_6 which contained N, P, K and B while the shortest was observed in control plots. Similar result was recorded after 60 and 75 days. Plant height was slightly reduced at harvest. The decreasing rate was slower as compared with the increasing rate of previous growth stages. The tallest plant was recorded in T_6 as before which was followed by T_3, T_{10} and T_7. The results indicated that boron had significant effect on plant height when added with N, P and K while sulfur, zinc or molybdenum had no effect at this stage.

3.3. Length of largest leaf

The size of leaf is an important growth parameter of cabbage which was significantly influenced due to different fertilizer treatments (Table 4). The leaf length was rapidly increased up to 60 days, then slowly up to 75 days and finally it was decreased at harvest. At 30 DAT, the largest leaf was found when B was added to the soil along with N, P and K while it was the lowest in control plots. The results indicated that B as boric acid is directly absorbed by plants at initial stage. Similar results were noted after 45 and 60 days. The results showed that application of NPK + B significantly increased leaf size but S and Zn with NPK decreased the leaf size. The results were almost similar as recorded after 75 days and at the time of harvest. The results obtained at harvest indicated that boron had prominent effect while S and Mo had no effect on the length of cabbage leaf when added with NPK.

Table 2. The spread of cabbage plant as influenced by different fertilizer management

Treatments	Plant spread (cm) at				
	30 DAT	45 DAT	60 DAT	75 DAT	Harvest
T_0=Control	28.73h	33.57i	39.57h	43.34h	42.22h
T_1=N	31.47g	37.77h	45.60g	53.27g	52.02g
T_2=NP	34.10f	43.30g	52.45f	59.29f	56.34f
T_3=NPK	39.60cd	48.53de	58.30cd	63.66de	61.93de
T_4=NPKS	36.44e	45.00f	55.93e	62.73e	61.40e
T_5=NPKZn	38.47d	47.63e	57.40de	64.26d	62.80d
T_6=NPKB	45.64a	54.43a	65.33a	71.45a	70.76a
T_7=NPKMo	41.10e	50.70bc	59.29bc	67.33c	65.30c
T_8=NPKSZn	38.53d	48.53de	58.20cd	64.41d	62.75e
T_9=NPKSZnB	39.37cd	49.43ed	58.37cd	68.37c	67.50b
T_{10}=NPKSZnBMo	42.83b	51.24b	60.37b	69.86b	66.50b
LSD (P≥0.05)	1.68	1.51	1.62	1.27	1.35
CV (%)	2.61	1.9	1.72	1.19	1.52

Table 3. Height of the cabbage plants as influenced by different fertilizer managements

Treatments	Plant height (cm) at				
	30 DAT	45 DAT	60 DAT	75 DAT	Harvest
$T_{0=}$Control	23.53h	24.70f	25.79f	26.44g	26.31g
T_1=N	26.30g	29.77e	31.07e	32.00f	31.45f
T_2=NP	28.10ef	30.32de	32.27d	34.02e	33.76d
T_3=NPK	30.27bcd	34.78a	35.74b	36.83b	36.52b
T_4=NPKS	26.73fg	30.81cde	32.31d	33.40e	32.96de
T_5=NPKZn	29.09de	31.22bcd	33.11cd	34.15e	33.70d
T_6=NPKB	32.42a	35.13a	36.93a	38.23a	37.89a
T_7=NPKMo	31.37ab	32.25b	33.80c	35.33cd	35.01c
T_8=NPKSZn	28.96de	30.70cde	32.77d	33.82e	33.33de
T_9=NPKSZnB	29.65cd	31.87bc	32.49d	34.49de	33.88cd
T_{10}=NPKSZnBMo	30.67bc	32.19b	33.76c	35.80c	35.42bc
LSD (P≥0.05)	1.42	1.17	0.94	1.00	1.22
CV (%)	2.9	2.19	1.69	1.73	1.60

In a column, figures having same letters do not differ significantly by DMRT at 5% level.

Table 4. Length of largest leaf of cabbage at different growth period as influenced by different nutrient combinations

Treatments	Largest leaf length (cm) at				
	30 DAT	45 DAT	60 DAT	75 DAT	Harvest
T0=Control	17.83f	22.71d	24.09f	24.97h	24.45g
T1=N	20.15e	28.11c	29.13e	30.43g	29.96f
T2=NP	22.413d	28.96c	31.59d	32.10f	31.98e
T3=NPK	24.83bc	31.11b	33.83bc	34.73cd	34.56bc
T4=NPKS	24.43c	30.75b	33.67bc	33.93e	33.43d
T5=NPKZn	24.95bc	30.93b	34.73b	35.37bc	35.07b
T6=NPKB	26.19a	32.36a	35.97a	38.33a	37.83a
T7=NPKMo	24.27c	30.96b	33.73bc	34.10de	33.72cd
T8=NPKSZn	24.00c	30.57b	33.20c	34.07de	33.87c
T9=NPKSZnB	24.20c	31.12b	34.17bc	35.17bc	34.67bc
T10=NPKSZnBMo	25.87ab	31.65ab	34.70b	35.63b	34.93bc
LSD (P≥0.05)	1.11	1.09	0.95	0.67	0.80
CV (%)	2.77	2.12	1.71	1.16	1.21

In a column, figures having same letters do not differ significantly by DMRT at 5% level.

3.4. Breadth of the largest leaf

The breadth of leaves of cabbage is an important parameter for proper head formation. Different nutrient management had significant effect on the breadth of leaves (Table 5). The breadth was increased gradually up to 45 days, then rapidly and finally slowly from 75 days. The widest leaf was recorded in treatment T_6 having N, P, K and B at all growth periods. The effect of B was most prominent when added any other nutrients. The results revealed that B in addition to NPK showed positive response on leaf breath at all

growth periods. The lowest breadth of largest leaf always recorded in unfertilized control plots. The results showed that molybdenum did not show any significant effect on leaf breadth. Sulfur exhibited negative response on leaf breadth of cabbage at all growth stage. When Zn was added with NPK, it did not exhibit any effect, while the combination of S and Zn with NPK increased leaf breadth significantly.

3.5. Days required for head formation

Application of different nutrients and their combinations exhibited significant influence on head formation (Table 6). The control plots required the longest time (59.16 days) for head formation, while NPKB required only 43.89 days although it was statistically similar to NPKZn, NPKSZn and NPKSZnBMo. NPKS delayed head formation. It required 49.46 days. Application of NPK took only 47.50 days for head formation. Alam (2007) reported that early head formation of cabbage was significantly influenced by the application of B fertilizer in calcareous soils of Bangladesh. This indicates that head formation of cabbage is sensitive to B, but has inverse relation with S.

3.6. Days required for head maturity

Different fertilizer combinations had significant effect on days required for head maturity of cabbage (Table 6). The cabbage grown in the plot receiving N, P and K with B (T_6) required minimum days (88.92 days) for maturity although it was statistically similar with the treatments T_5, T_7, T_8, T_9 and T_{10}. Maturity of head was delayed by one day due to S application when added to NPK fertilizers as compared with only NPK treatments. The results showed that B inhibits early maturity whereas S delayed it in calcareous soils. The results are in partial agreement with the findings of Wang-Xiude *et al.* (1996).

3.7. Weight of root

Root weight of cabbage plants was significantly influenced by different fertilizer treatments (Table 6). The maximum weight (35.61 g/plant) was recorded in treatment T_3 (receiving N, P and K only) while the minimum was recorded in unfertilized control plots (20.66 g). The results showed that application of N, P and K increased the weight of root whereas application of B, Zn and Mo had no such effect.

3.8. Weight of stem

The maximum weight (33.66 g/plant) of stem was found in treatment T_3 (receiving N, P and K only) while the minimum (22.48 g) was obtained from unfertilized control plots. The results showed that application of N, P and K increased the weight of stem whereas application of B, Zn and Mo had no such effect.

3.9. Weight of loose leaves

The maximum weight of loose leaves (640 g/plant) was obtained from T_4 (NPKS), whereas the lowest value was recorded in control plots. This result indicated that folding mechanism is directly related with nutrients. When B was added with NPK, the weight of loose leaves was decreased but started early head formation and maturity. Application of S with NPK significantly increased the weight of loose leaves but delayed head formation and head maturity. The results are in full agreement with that of Haro and Sonoda (1981).

3.10. Dry matter of loose leaves

There was no significant effect of nutrients on the dry matter accumulation in loose leaves of cabbage (Table 6) although the highest dry matter (9.34%) was found in T_4 while the lowest (8.36%) was in treatment T_3.

3.11. Dry matter of head

The highest dry matter content (6.62%) of cabbage head was recorded in treatment T_8 (receiving N, P, K, S and Zn), whereas the lowest was in T_1 (receiving N only). The results indicated that application of K, S and Mo decreased dry matter whereas P, Zn & B increased head dry matter content of cabbage.

3.12. Diameter of cabbage head

The diameter of cabbage head at harvest

responded significantly to fertilizer application and varied from 11.18 to 23.02 cm (Table 7). The maximum diameter of the head was recorded in the plot where B was added with NPK while the smallest (11.18 cm) was noted in control plots. The results showed that NPKB significantly increased the head diameter while Zn and S decreased it.

Table 5. Breadth of the largest leaf of cabbage as influenced by different nutrient management at five growth stages

Treatments	Breadth of the largest leaf (cm)				
	30 DAT	45 DAT	60 DAT	75 DAT	Harvest
$T_{0=}$Control	10.90d	12.01g	16.18e	16.58g	15.58g
T_1=N	11.75cd	14.53f	20.86d	23.03f	21.93f
T_2=NP	12.59bcd	15.25f	21.31d	24.67e	23.37e
T_3=NPK	15.50abc	18.19d	23.53c	26.87bc	25.84bc
T_4=NPKS	13.63abcd	16.67e	21.48d	25.41de	23.91de
T_5=NPKZn	15.93ab	20.33bc	23.90bc	26.23cd	25.23c
T_6=NPKB	17.28a	22.26a	25.93a	28.43a	27.13a
T_7=NPKMo	14.78abc	19.87c	23.54e	25.88cd	24.48d
T_8=NPKSZn	15.38abc	21.13ab	24.20bc	26.87bc	25.87bc
T_9=NPKSZnB	16.04ab	21.63a	24.68b	27.34b	26.34b
T_{10}=NPKSZnBMo	16.24ab	21.73a	24.68b	26.64c	26.38b
LSD (P≥0.05)	3.37	1.15	1.02	1.02	1.12
CV (%)	13.67	3.34	2.62	2.36	2.24

In a column, figures having same letters do not differ significantly by DMRT at 5% level.

Table 6. Effect of nutrient management on growth and yield parameters of cabbage

Treatments	Days required to head formation	Days required for head maturity	Wt. of root (g/plant)	Wt. of stem (g/plant)	Wt. of loose leaves (g/plant)	DM of loose leaves (%)	Dry matter of head (%)
$T_{0=}$Control	59.16a	106.19a	20.66g	22.48d	360f	9.20a	5.36d
T_1=N	53.34b	93.78b	26.30f	31.52bc	410e	8.71a	5.35d
T_2=NP	50.80c	92.17cd	30.52e	33.11ab	520c	9.31a	6.36ab
T_3=NPK	47.50d	92.21cd	35.61a	33.66a	570b	8.36a	5.62cd
T_4=NPKS	49.46c	93.33bc	31.89cde	32.55abc	640a	9.34a	5.42d
T_5=NPKZn	45.50ef	91.20de	32.88bc	31.91bc	506e	8.94a	6.53a
T_6=NPKB	43.89f	88.92e	32.21bcd	31.25c	511c	9.13a	6.24abc
T_7=NPKMo	46.62de	91.11de	33.30bc	31.31c	423e	8.54a	5.58cd
T_8=NPKSZn	45.56ef	90.75e	33.47b	32.12abc	470d	8.93a	6.62a
T_9=NPKSZnB	44.89f	90.17e	33.52b	32.49abc	460d	9.07a	6.33ab
T_{10}=NPKSZnBMo	44.89f	90.17e	33.52b	32.49abc	460d	9.07a	6.33ab
LSD (P≥0.05)	1.55	1.14	1.32	1.43	17.49	1.37	0.65
CV (%)	1.87	0.72	2.49	2.67	2.12	2.84	6.44

In a column, figures having same letters do not differ significantly by DMRT at 5% level.

Table 7. Yield and yield components of cabbage as influenced by nutrient management.

Treatments	Head diameter (cm)	Head thickness (cm)	Weight of marketable head (g)	Yield (t/ha)	Increased yield (%) over control
T_0=Control	11.18g	8.25f	650.16h	26.27h	-
T_1=N	15.02f	9.27e	1078.04g	43.56g	66
T_2=NP	17.51e	10.42d	1201.99f	48.56f	85
T_3=NPK	19.72d	10.77cd	1298.05e	53.55e	104
T_4=NPKS	20.17cd	11.37bcd	1418.80d	52.45d	100
T_5=NPKZn	22.50ab	12.00ab	1779.51b	57.32b	118
T_6=NPKB	23.02a	12.85a	1894.18a	76.53a	191
T_7=NPKMo	20.57bcd	11.88ab	1661.46e	71.90c	174
T_8=NPKSZn	20.97bc	12.16ab	1785.73b	67.13d	156
T_9=NPKSZnB	21.50b	12.48ab	1827.06ab	72.15ab	175
T_{10}=NPKSZnBMo	21.50b	12.48ab	1827.06ab	73.82ab	181
LSD (P≥0.05)	0. 91	1.02	90.86	1.09	
CV (%)	2.75	5.34	3.69	3.69	

In a column, figures having same letters do not differ significantly by DMRT at 5% level.

3.13. Head thickness

The thickness of cabbage head from 8.25 to 12.85 cm and was significantly influenced by nutrient management (Table 7). The maximum head thickness of 12.85 cm was recorded in treatment T_6 (receiving N, P, K and B) although it was statistically identical with T_5, T_7, T_8, T_9 and T_{10}. It was observed that B had positive effect on cabbage thickness when added with N, P and K while other micronutrients were not able to exhibit such effect.

3.14. Marketable head

The marketable head of cabbage responded significantly due to nutrient management and it ranged from 650.16 to 1894.18 g/plant (Table 7). The highest weight of marketable heads of 1894.18 g/plant was obtained from the treatment T_6 (N, P, K and B) while the lightest heads were recorded in the control plots.

3.15. Yield

Different fertilizer managements created a significant impact on the yield of cabbage (Table 7). Wide variation was noted in cabbage yield (26.27 to 76.53 t/ha). The head yield directly depends on head weight of cabbage. The highest yield (76.53 t/ha) as well as 191% increase over control was obtained from the treatment T_6 which contained N, P, K and B. There were no significant differences in yields among the treatments T_6, T_9 and T_{10}. The lowest yield was recorded in the control plots.

The results revealed that all the fertilizers contributed on the yield of cabbage while the effect of B was more prominent than other nutrients. Sulfur exhibited reduced yield when added with NPK as compared with the yield under NPK. It seems that S had negative effect on the yield. It was observed that N alone could increase yields by 66%, while NP, NPK, NPKS, NPKZn, NPKB, NPKM, NPKSZn, NPKSZnB, and NPKSZnBMo increase yields by 85, 104, 100, 118, 191, o 174, 156, 175 181%, respectively over control. These results agree with the observation of Alam (2007) who obtained the highest yield of cabbage by applying boron as boric acid at 4 kg/ha although it was similar to that given by 3 kg/ha. Sarma *et al*. (2002) recorded the highest yield of cabbage (cv. Green express) with the application of 0.5% borax. Similarly, Kanujia *et al*. (2006) recorded the maximum yield of cabbage (var. Golden

Acre) with foliar application of mixture of boron and other micronutrients at the rate of 100 ppm.

4. Conclusions

In this experiment, fertilizers had significant effect on the growth and yield of cabbage. The highest plant height, spread, leaf length, leaf breadth, head thickness, head diameter, period to head formation and maturity and marketable yield were obtained from the plot receiving N, P, K and B at the rates of 150, 50, 100 and 3 kg/ha, respectively. The treatment N, P, K and S showed the highest weight of loose leaves. Single dose of boron was used in the present investigation. The study may be continued further to find out the yield potentiality of cabbage under different doses of boron.

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