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EFFECT OF DIFFERENT LEVEL OF MACRO NUTRIENTS (N, P, K and S) AND THEIR COMBINATIONS ON THE GROWTH AND YIELD OF BROCCOLI

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ABSTRACT

An experiment was carried out at the Horticultural Research Farm, of Sher-e Bangla Agricultural University (SAU), Dhaka during the period from September 2008 to March 2009. The experiment was laid out in Randomized Complete Block Design with three replications to observe the interaction effects of N, P, K and S on growth and yield of broccoli. The experiment included 14 treatments using four doses of nitrogen, namely 0, 60, 120, 180 kg/ha, four doses of phosphorus, namely 0, 50, 100, 150 kg/ha, four doses of potassium, namely 0, 70, 140 ,210 kg / ha and four doses of sulfur (Gypsum) namely, 0, 10, 20, 30 kg /ha. The results of the experiment showed that the application of NPK and S fertilizers influenced growth and curd yield of broccoli. The highest curd yield of broccoli (19.11 t/ha) was obtained from T_3 ($N_{120}P_{100}K_{140}S_{20}$ kg/ha) treatment while the lowest yield (7.52 t/ha) was produced by T_{14} ($N_0P_0K_0S_0$ kg / ha) treatment.

Key words: Broccoli, macronutrient and yield

INTRODUCTION

Broccoli (*Brassica oleracea* L var. *italica*) is one of the cole crops in Bangladesh. It can be grown in wide range of soils but it thrives best on a deep, loose loamy soil. Fleshy, green and compact curds are desirable for fresh market. It is mainly a cold loving crop but it can be grown at a relatively higher temperature without much difficulty. It can be eaten either boil or processed form. Broccoli can play a vital role in elevating the nutritional status of Bangladesh, as it is rich in vitamins and minerals such as carotene and ascorbic acid and contains appreciable quantities of thiamin, riboflavin, niacin, calcium and iron (Thompson and Kelly, 1985). But enough broccolis are not produced in our country to satisfy its demand. The growth and yield of broccoli in Bangladesh are also not good as in other countries. The main reasons for such poor growth and yield of broccoli in this country are lack of judicious application of fertilizers followed by the growers. It is evident that balanced application of fertilizer is the prerequisite for obtaining higher yield and better quality of broccoli (Brahma *et al.*, 2002a). So it is important to study the interaction effect of different levels of NPK and S on growth and yield of broccoli and to determine best combination of these nutrient elements for higher curd yield.

MATERIALS AND METHODS

The experiment was conducted at the Horticulture Research Farm of Sher-e-Bangla Agricultural University, (SAU), Dhaka during the period from September 2008 to March 2009; to examine the effect of different levels of macro nutrients (N P K and S) and their combinations on the growth and yield of broccoli .The soil of the experimental plot was sandy loam in texture having p^H 5.6. The research work conducted with the seeds of the hybrid variety 'Premium crop' was used in the experiment. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The whole experimental area was divided into three blocks, representing three replications. Each block was further subdivided into 14 unit plots. The single factor experiment

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included 14 treatments .The four levels of N (N=0,60,120and 180 kg/ha i.e. Urea= 0, 130,260 and 391 kg/ha), four levels of P (P=0, 50,100 and 150 kg/ha i.e. TSP = 0,104,208 and 312.5kg/ha), four levels of K(K=0, 70,140 and 210kg/ha i.e. MP=0,166, 233 and 350 kg/ha), and four levels of S (S= 0, 10, 20, and 30 kg/ha i.e. Gypsum= 0, 55.6, 111.2, and 166.8 kg/h) fertilizers formed 14 treatments were allotted to the 14 unit plots per block. The size of unit plot was 2.4 m x 2 m. Healthy and uniform seedlings of 20 days old were transplanting in the experimental plots on 25 October 2007 with 60 cm× 40 cm plant spacing. Well-decomposed cow dung manure was applied at the rate of 15 ton per hectare and was incorporated into the soil during final preparation. Urea, Triple super phosphate (TSP), Muriate of potash (MOP), Gypsum was used as the source of nitrogen, phosphorus, potassium and sulphur, respectively. The total amount of phosphorus and gypsum were applied to the plot as per experimental design during final land preparation. Nitrogen, potassium were applied in three equal installments at 20, 30 and 40 days after transplanting in ring method. Transplanting was done in the afternoon. The seedlings were watered immediately after transplanting. The young transplants were shaded by banana leaf sheath during day time to protect them from scorching sunshine up to 7 days until they were set in the soil. They (transplants) were kept open at night to allow them receiving dew and other intercultural operations such as weeding, gap filling, earthing up, irrigation etc were done as and when necessary. Cut warms were controlled both mechanically and spraying Darsban 29Ec @ 3%. Fleshy, green and compact curds suitable for use as vegetable were harvested with 15 cm long fleshy stalk by using with a sharp knife and weight to estimate the curd yield. Data were recorded periodically from the sample plants at 20 days interval. Monitoring of plant height, total number of leaves per plant , length of leaf (cm), breadth of leaf (cm), plant canopy (cm), days required for curd initiation, length of stem (cm), length of root (cm), fresh weight of stem (g), fresh weight of leaves (g) per plant, primary curd diameter (cm), stem diameter (cm), number of secondary curds per plant, weight of primary curd per plant (g), dry matter percentage of curd, yield per plot (kg), yield per hectare (ton). The recorded data on different parameters were statistically analyzed using MSTAT computer programme. The differences between the pairs of treatment means were compared using the Least Significant Differences (LSD) test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Plant height is an important growth contributing characters of broccoli plant. The data on plant height were taken periodically at 20, 40, and 60 days after transplanting (DAT). The result revealed that variance in NPK and S fertilizer doses had significant influence on plant height at different growth stages (Fig. 1). The results showed that the plant height was gradually increased with the time being the

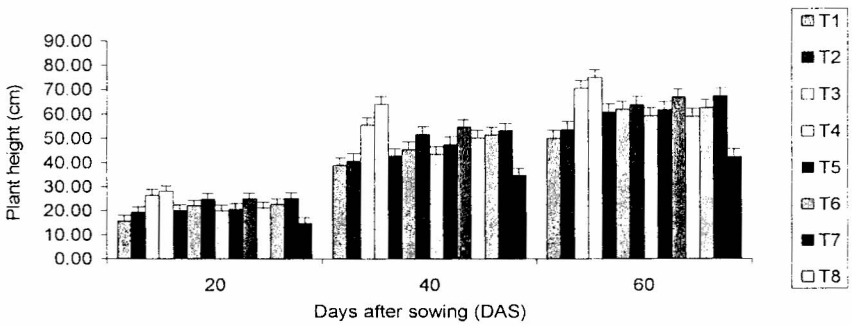

Fig. 1. Effect of different macro nutrients (NPK and S) on plant height of broccoli at different DAT

highest at 60 DAT in all the treatments. The height increase was with the increase in nitrogen doses. At 20, 40, and 60 DAT the highest plant height were 28.07 cm, 64.09 cm and 75.08 cm respectively which

was recorded with the treatment combination of T_4 (N_{180} P_{100} K_{140} S_{20} kg/ha) while the lowest height of 14.79 cm, 34.73cm, 42.48 cm were observed at the control treatment T_{14} (N_0 P_0 K_0 S_0 kg/ha) at the same DAT, respectively. This may be inferred that the increase in height may be due to the influence and absorption of nutrients and in particular nitrogen might have played a dominant role in growth. The present result was similar to that obtained by Haque *et al.* (1996), who obtained the highest plant height of broccoli with 180 kg N/ ha. In the present study, the number of leaves per plant was significantly influenced by the application of different levels of N, P, K and S fertilizers. The highest significant number of leaf per plant (20.02) at 60 DAT was found in T_3 (N_{120} P_{100} K_{140} S_{20} kg/ha) treatment combination. (Table 1) which are significantly different from other treatment combinations and the minimum number of leaves (10.13) was produced by the plant under control treatment, T_{14} (N_0 P_0 K_0 S_0 kg/ha). The results indicated that optimum levels of NPK and S application led to a linear increase in number of leaves of broccoli plant. Optimum level of fertilizers combination might have influenced

Table 1. Effect of different levels of NPK and S on number of leaves per plant of broccoli at different days after transplanting

Treatments	No. of leaves per plant at different days after transplanting				
	20 DAT	40 DAT	60 DAT	80 DAT	100 DAT
T_1	5.11 g	9.84 ef	10.94 gh	7.17 de	4.67 cd
T_2	5.31 fg	10.74 def	12.82 fg	8.67 cd	5.07 c
T_3	7.18 a	15.09 a	20.02 a	13.03 a	8.00 a
T_4	6.54 b	14.21 ab	17.76 b	11.80 ab	7.60 a
T_5	5.16 g	10.83 def	14.34 ef	8.07 cd	5.13 c
T_6	5.77 def	11.45 cde	15.46 cde	8.70 cd	6.70 b
T_7	6.12 bcd	12.78 bcd	17.02 bcd	10.17 bc	4.93 c
T_8	5.53 efg	9.89 ef	15.15 de	9.10 cd	4.90 c
T_9	5.98 cde	10.89 def	16.04 b-e	8.97 cd	4.17 de
T_{10}	6.30 bc	13.79 ab	17.44 bc	9.67 bc	4.80 cd
T_{11}	5.80 de	11.17 def	14.92 def	8.00 cd	4.20 de
T_{12}	6.22 bcd	12.01 b-e	16.01 b-e	7.30 de	3.77 ef
T_{13}	6.33 bc	13.70 abc	16.79 bcd	9.13 cd	4.70 cd
T_{14}	4.45h	9.02 f	10.13h	5.60 e	3.13 f
LSD at 5%	0.474	2.249	2.216	2.316	0.660
CV%	4.85	11.34	8.60	15.41	7.67

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_1: N_0 P_{100} K_{140} S_{20} T_2: N_{60} P_{100} K_{140} S_{20} T_3: N_{120} P_{100} K_{140} S_{20} T_4: N_{180} P_{100} K_{140} S_{20}
T_5: N_{120} P_0 K_{140} S_{20} T_6: N_{120} P_{50} K_{140} S_{20} T_7: N_{120} P_{150} K_{140} S_{20} T_8: N_{120} P_{100} K_0 S_{20}
T_9: N_{120} P_{100} K_{70} S_{20} T_{10}: N_{120} P_{100} K_{210} S_{20} T_{11}: N_{120} P_{100} K_{140} S_0 T_{12}: N_{120} P_{100} K_{140} S_{10}
T_{13}: N_{120} P_{100} K_{140} S_{30} T_{14}: N_0 P_0 K_0 S_0

better performance of the crop and ultimately produced more leaves per plant in this study. Randhawa and Bhail (1976) also reported about the effect of nitrogen at the rate of 120 to 180 kg per hectare producing the maximum number of leaves of cauliflower per plant. Balyan *et al.* (1988) observed that the nitrogen fertilizer improved the number of leaves per plant and leaf size index over the control. Number of leaves per plant was increased up to 20 DAT to 60 DAT. After attaining maximum number of leaves per plant at 60 DAT it began decreased with the senescence of the plant. After certain stage when plant go to mature stage and for this reason water loss of leaf was increased than supply, leaves cell was loose, die and dropping of basal leaf. The length of leaf per plant was significantly influenced by different treatments of N, P, K and S fertilizers (Table 2) revealed that length of leaf gradually

increased up to 60 DAT and then slowly decreased in all the treatments till last harvest of secondary curd at 100 DAT with the senescence of the plant. The maximum leaf length (55.68 cm) was attained

Table 2. Effect of different levels of NPK and S on maximum length of leaf per plant of broccoli at different days after transplanting

Treatments	Maximum length (cm) of leaf per plant at different days after transplanting				
	20 DAT	40 DAT	60 DAT	80 DAT	100 DAT
T_1	14.29i	39.21cd	43.28ef	40.43f	37.70ef
T_2	17.21h	42.36bc	45.21cdef	42.50def	39.81cdef
T_3	23.62ab	48.34ab	53.62a	50.75ab	47.93ab
T_4	25.76a	51.58a	55.68a	52.47a	49.53a
T_5	20.42defg	43.18bc	45.13cdef	42.43def	39.64cdef
T_6	21.65bcde	43.54bc	45.64cdef	43.04cdef	40.72bcdef
T_7	22.44bcd	46.42ab	53.11ab	49.93abc	47.31abc
T_8	18.26gh	42.92bc	42.97f	40.31f	38.10ef
T_9	19.76efg	43.94bc	44.02def	41.20ef	38.90def
T_{10}	22.71bc	47.35ab	51.57abc	48.96abcd	46.28abcd
T_{11}	19.22fgh	44.89abc	46.62bcdef	43.83bcdef	41.41bcdef
T_{12}	20.50cdefg	45.69abc	50.07abcde	47.61abcde	45.05abcde
T_{13}	21.33cdef	47.24ab	50.16abcd	47.87abcde	45.34abcde
T_{14}	12.95i	35.22d	41.20f	39.06f	36.71f
LSD at 5%	2.280	6.697	6.810	7.164	7.847
CV%	6.79	8.98	8.50	9.48	11.01

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_1: $N_0 P_{100} K_{140} S_{20}$ T_2: $N_{60} P_{100} K_{140} S_{20}$ T_3: $N_{120} P_{100} K_{140} S_{20}$ T_4: $N_{180} P_{100} K_{140} S_{20}$
T_5: $N_{120} P_0 K_{140} S_{20}$ T_6: $N_{120} P_{50} K_{140} S_{20}$ T_7: $N_{120} P_{150} K_{140} S_{20}$ T_8: $N_{120} P_{100} K_0 S_{20}$
T_9: $N_{120} P_{100} K_{70} S_{20}$ T_{10}: $N_{120} P_{100} K_{210} S_{20}$ T_{11}: $N_{120} P_{100} K_{140} S_0$ T_{12}: $N_{120} P_{100} K_{140} S_{10}$
T_{13}: $N_{120} P_{100} K_{140} S_{30}$ T_{14}: $N_0 P_0 K_0 S_0$

with the application of T_4 treatment ($N_{180} P_{100} K_{140} S_{20}$ kg/ha) at 60 DAT which was statically identical (53.62 cm, 53.11cm,) to that of T_3 ($N_{120} P_{100} K_{140} S_{20}$ kg/ha) and T_7 ($N_{120} P_{150} K_{140} S_{20}$kg/ha) treatment combination of the same 60 DAT and it was the lowest (42.97 cm ,) and (41.20 cm)at 60 DAT in control treatment T_{14} ($N_0 P_0 K_0 S_0$ kg/ha). The length of leaves were increased with the increasing rate of nitrogen fertilizer .The results of the present experiment were also in agreement with the observation of Haque *et al.* (1996) and Trembaly (1984).The combined effect of N, P, K and S fertilizers on breadth of leaf was significant (Table 3). The maximum breadth of leaf per plant (21.81 cm) was observed from the treatment combination of T_4 ($N_{180} P_{100} K_{140} S_{20}$ kg/ha) and the lowest (14.95 cm) was obtained from the T_{14} ($N_0 P_0 K_0 S_0$ kg/ha) treatment. The results indicated that the breadth of leaf was increased gradually with the increase in dose of nitrogen with optimum level of P K and S fertilizers. The higher nitrogen levels might have encouraged better physiological activity in plants with the production of higher breadth of leaf. The present result was similar to that obtained by Boojit *et al.* (1996), who stated that the highest dose of nitrogen expand the leaf of Brussels sprout. (Table 3) revealed that breadth of leaf gradually increased up to 60 DAT and then slowly decreased with the senescence of the plant. A good spread of plant indicates good growth and development of broccoli is directly related to yield. There was significant difference in crown spread of plant among different treatments at 20, 40, and 60 DAT (Table 4). At 60 DAT maximum crown spread of plant (87.51 cm) was found from the treatment T_4 ($N_{180} P_{100} K_{140} S_{20}$ kg/ha) which was followed by (74.29 cm) with T_3 ($N_{120} P_{100} K_{140} S_{20}$ kg/ha) treatment and the minimum crown spread (47.90 cm) was observed from the control T_{14} ($N_0 P_0$

K_0 S_0 kg /ha) treatment. It was revealed from this result, that higher levels of nitrogen with optimum levels of P, K and S increased vegetative growth of plant by increasing photosynthetic rate and

Table 3. Effect of different levels of NPK and S on maximum breadth of leaf per plant of broccoli at different days after transplanting

Treatments	Maximum breadth (cm) of leaf per plant at different days after transplanting				
	20 DAT	40 DAT	60 DAT	80 DAT	100 DAT
T_1	6.19f	11.14de	16.60de	14.22fg	11.89de
T_2	6.85de	11.87cde	17.22bcde	15.19cdef	13.01bcd
T_3	9.06a	15.20ab	19.41ab	17.10b	14.72b
T_4	9.38a	16.34a	21.81a	19.58a	16.93a
T_5	6.47ef	12.00cde	16.99bcde	14.68efg	12.46cde
T_6	7.03cd	12.68bcd	17.80bcd	15.41bcdef	13.35bcd
T_7	8.92a	14.25abc	18.78bcd	16.52bcde	14.60b
T_8	6.82de	11.77cde	16.87cde	14.48fg	12.60cde
T_9	7.37c	13.09bcd	16.76cde	14.75defg	12.59cde
T_{10}	8.24b	15.10ab	19.16bc	16.99bc	14.78b
T_{11}	6.91cde	12.86bcd	17.28bcde	14.80defg	12.57cde
T_{12}	8.05b	12.85bcd	18.03bcd	15.79bcdef	13.78bc
T_{13}	8.94a	14.94ab	18.95bcd	16.55bcd	14.60b
T_{14}	4.97g	9.95e	14.95e	13.04g	10.95e
LSD at 5%	0.474	2.692	2.501	1.856	1.784
CV%	3.76	12.20	8.32	7.07	7.88

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_1: $N_0 P_{100} K_{140} S_{20}$ T_2: $N_{60} P_{100} K_{140} S_{20}$ T_3: $N_{120} P_{100} K_{140} S_{20}$ T_4: $N_{180} P_{100} K_{140} S_{20}$
T_5: $N_{120} P_0 K_{140} S_{20}$ T_6: $N_{120} P_{50} K_{140} S_{20}$ T_7: $N_{120} P_{150} K_{140} S_{20}$ T_8: $N_{120} P_{100} K_0 S_{20}$
T_9: $N_{120} P_{100} K_{70} S_{20}$ T_{10}: $N_{120} P_{100} K_{210} S_{20}$ T_{11}: $N_{120} P_{100} K_{140} S_0$ T_{12}: $N_{120} P_{100} K_{140} S_{10}$
T_{13}: $N_{120} P_{100} K_{140} S_{30}$ T_{14}: $N_0 P_0 K_0 S_0$

maximum utilization of natural resources and also increased crown spread of plant. The results are also in partial agreement with the findings of Trembaly (1984). Who stated that increasing nitrogen rate has favored greater vegetative growth. In respect of days required to curd initiation of broccoli, the different treatment combinations had significant effect. The highest days required to curd initiation was noted in control T_{14} ($N_0 P_0 K_0 S_0$ kg/ha) treatment (63.34 DAT) (Table 4) while the lowest days required to curd initiation was recorded in T_3 ($N_{120} P_{100} K_{140} S_{20}$ kg/ha) treatment. It was probably due to the fact that proper amount of NPK and S fertilizers applied to the soil decreased the day required to curd initiation which has shown from T_3 ($N_{120} P_{100} K_{140} S_{20}$ kg/ha) treatment and the second lowest days required to curd initiation was recorded in T_4 ($N_{180} P_{100} K_{140} S_{20}$ kg/ha) treatment. The diameter of primary curd per plant was found to be highly significant due to different levels of NPK and S fertilizers (Table 4).The maximum diameter of primary curd (18.07cm) was found with the treatment combinations of T_4 ($N_{180} P_{100} K_{140} S_{20}$ kg / ha) which was statistically identical with T_3 ($N_{120} P_{100} K_{140} S_{20}$ kg/ha) and T_{10} ($N_{120} P_{100} K_{210} S_{20}$ kg/ ha) treatments in term of diameter of curd of broccoli. The lowest diameter of curd (8.18 cm) of broccoli was found in control treatment T_{14} ($N_0 P_0 K_0 S_0$ kg / ha). This result also supported by Brahma *et al.* (2002b). The formation of bigger curd with the application of higher NPK and S fertilizers dose may be due to higher synthesis of carbohydrate and their translocation to the sink i.e. broccoli curd which subsequently helped in the formation of larger and comparatively broader curd of broccoli . Significant variation among the different treatments was observed for diameter of stem in broccoli. The highest diameter of stem (4.31cm) was recorded in of T_4 ($N_{180} P_{100} K_{140} S_{20}$ kg / ha) which was followed by the treatment of T_3 ($N_{120} P_{100} K_{140} S_{20}$kg/ha) 3.79 cm and T_{10} ($N_{120} P_{100} K_{210} S_{20}$kg / ha) 3.75 cm. The lowest stem diameter (2.76) was obtained from the

control treatment T_{14} (N_0 P_0 K_0 S_0 kg /ha)(Table 4). The rest treatment combinations appeared to give lower influence on stem diameter. Dufault (1988) reported that stem diameter was increased with higher levels of nitrogen application, which supports the present result. The fresh weight of stem of broccoli varied significantly by the application of different levels of NPK and S fertilizers (Table 4). The maximum fresh weight of stem (253.62 g) was obtained from the treatment combination of T_4 (N_{180} P_{100} K_{140} S_{20} kg / ha) which was statistically identical with T_3 (233.76g), T_{13} (231.47g) and T_{10} (226.94g) treatment combinations respectively. The lowest fresh weight of stem (103.41 g) was

Table 4. Effect of different macronutrients (NPK and S) on yield and yield attributes of broccoli

Treatments	Canopy diameter (cm) at different DAT			Days required for curd initiation	Primary curd dia (cm)	Stem dia (cm)	Fresh weight of stem (g)
	20 DAT	40 DAT	60 DAT				
T_1	18.91g	37.92j	49.20h	60.51 ab	10.82 ef	3.23 bcd	137.50 de
T_2	21.84f	42.92hi	58.43g	55.01cd	12.45 de	3.02 cd	130.94 de
T_3	26.77b	53.84b	74.29b	48.72f	17.31ab	3.79 ab	233.76 a
T_4	29.47a	65.12a	87.51a	50.34ef	18.07a	4.31 a	253.62 a
T_5	23.21ef	40.60i	60.74efg	57.65bc	12.89 cde	2.97 cd	134.27de
T_6	25.36bcd	44.33gh	61.91def	57.17bc	14.28a-e	3.18 bcd	133.68 de
T_7	26.00bc	50.51cd	70.29c	51.83def	16.15a-d	3.69 b	193.62 b
T_8	23.27ef	42.18hi	59.75fg	56.74c	13.71b-e	3.21 bcd	133.66 de
T_9	24.23cde	45.83fg	61.16efg	55.32cd	15.23a-d	3.36 bcd	156.90 cd
T_{10}	25.73bc	52.22bc	71.76bc	52.18def	17.19ab	3.75 ab	226.94a
T_{11}	23.69de	47.07ef	63.03de	56.77c	15.11a-d	3.30 bcd	163.63 bcd
T_{12}	24.86cde	49.40de	64.70d	54.12 cd	15.39a-d	3.48 bc	173.55 bc
T_{13}	25.93bc	50.39cd	69.82c	52.61de	16.73abc	3.76 ab	231.47 a
T_{14}	16.77h	32.60k	47.09h	63.34a	8.18f	2.76 d	103.41 e
LSDat 0.05	1.641	2.550	2.864	3.255	3.520	0.549	32.04
CV%	2.13	9.51	8.87	3.62	15.30	9.60	11.33

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_1: N_0 P_{100} K_{140} S_{20} T_2: N_{60} P_{100} K_{140} S_{20} T_3: N_{120} P_{100} K_{140} S_{20} T_4: N_{180} P_{100} K_{140} S_{20}
T_5: N_{120} P_0 K_{140} S_{20} T_6: N_{120} P_{50} K_{140} S_{20} T_7: N_{120} P_{150} K_{140} S_{20} T_8: N_{120} P_{100} K_0 S_{20}
T_9: N_{120} P_{100} K_{70} S_{20} T_{10}: N_{120} P_{100} K_{210} S_{20} T_{11}: N_{120} P_{100} K_{140} S_0 T_{12}: N_{120} P_{100} K_{140} S_{10}
T_{13}: N_{120} P_{100} K_{140} S_{30} T_{14}: N_0 P_0 K_0 S_0

obtained from the treatment combination of T_{14} (N_0 P_0 K_0 S_0 kg /ha). The maximum fresh weight of leaves (459.59 g) was obtained from the treatment combination of T_4 (N_{180} P_{100} K_{140} S_{20} kg /ha) which was statistically identical with T_3 (421.24g) and T_{10} (413.55g) treatment combinations respectively. The lowest fresh weight of leaves (161.84 g) was obtained from the treatment combination of T_{14} (N_0 P_0 K_0 S_0 kg /ha)(Table 2). In this study nitrogenous fertilizer along with potassium, phosphorus and sulfur fertilizers might have more absorption of nutrients resulting better performance of the crop and ultimately produced more fresh weight of leaves. The results on length of the stem as significantly influenced by different treatment combinations have been presented in Table-5. The highest length of the stem (23.88 cm) was found in of T_4 (N_{180} P_{100} K_{140} S_{20} kg / ha) which was statistically similar with T_3 (22.72 cm) and T_{10} (22.51cm) treatments. The lowest length of the stem (14.77 cm) was found in T_{14} (N_0 P_0 K_0 S_0 kg /ha) control treatment. It was observed higher stem length of broccoli increased with

higher dose of nitrogen. The similar results were observed by Mitra *et al.* (1990) who stated that application of nitrogen @ 135-225 kg /ha increased stem length. The maximum length of root (24.35cm) was recorded at T_7 (N_{120} P_{150} K_{140} S_{20} kg /ha) treatment combinations which is followed by T_{13} (22.49 cm), T_{10} (22.19cm) and T_3 (22.06 cm) treatments. The shortest root (17.57cm) was obtained at control treatment T_{14} (N_0 P_0 K_0 S_0 kg /ha), which was statically similar (17.85) with T_{12} (N_{120} P_{100} K_{140} S_{10}kg /ha) and other treatment combinations were appeared to give slight influence on root length (Table 5). The results are partially supported by Sumiati (1988), who stated maximum root length as observed in manure with NPK fertilizers. The secondary curds were those, which develop after harvest of the main curd. Number of secondary curd of broccoli plant is important for increasing total production. The effects of different levels of NPK and S fertilizers were significant on the number of secondary curds per plant of broccoli (Table 5). The maximum number of secondary curds per plant (7.30) was produced by the application of T_3 treatment which was followed by the T_4 treatment (7.09). The minimum number of secondary curds per plant (2.70) was obtained from the T_{14} (N_0 P_0 K_0 S_0 kg/ha) control treatment and the highest secondary curd weight (113.16 g) was recorded with T_3 (N_{120} P_{100} K_{140} S_{20} kg/ha) treatment. The minimum weight of secondary curds per plant (27.61g) was obtained from the T_{14} (N_0 P_0 K_0 S_0 kg/ha) control treatment. The rest treatment combination also affected the weight of secondary curds of broccoli (Table 5). Different treatments of NPK and S fertilizer showed a significant effect on the weight of primary curd of broccoli .The maximum curd weight (375.88g) was

Table 5. Effect of different macronutrients (NPK and S) on yield and yield attributes of broccoli

Treatments	Fresh weight of leaves (g)	Stem length (cm)	Root length (cm)	No of Secondary curd per plant	Primary curd weight per plant (i)	Secondary curd weight per plant (ii)	Yield g/plant) (i+ii)
T_1	207.31 efg	16.26 de	19.97 b-e	3.03g	197.03 fg	35.62 hi	232.65 g
T_2	197.12 fg	17.46 d	20.09 b-e	3.30 efg	258.77cde	42.90 gh	301.67 ef
T_3	421.24ab	22.72ab	22.06 ab	7.30 a	375.88a	113.16 a	485.04 a
T_4	459.59 a	23.88 a	19.06 cde	7.09a	308.15bc	75.52 d	423.67 b
T_5	206.93 efg	16.77 de	20.19 b-e	3.20 fg	242.13 def	50.20 fg	292.33 f
T_6	207.54efg	17.50 d	20.39bcd	4.02 def	287.75bcd	61.22 ef	348.97 de
T_7	385.22b	20.97 bc	24.35 a	6.50 ab	312.61bc	96.16 bc	410.77 bc
T_8	223.66ef	16.81 de	19.17 cde	3.42 efg	240.47 def	69.47 de	309.93 ef
T_9	278.70cd	16.74 de	20.70 bc	4.43 cd	285.12bcd	77.81 d	362.93 cd
T_{10}	413.55b	22.51 ab	22.19 ab	6.81ab	322.92b	104.70 ab	420.61 b
T_{11}	252.58de	17.37 de	17.45 e	4.20 cde	215.43 ef	76.36 d	297.79ef
T_{12}	304.87c	18.75 cd	17.85 de	4.93 c	304.32 bc	75.48 d	379.80 bcd
T_{13}	383.51 b	21.92ab	22.49 ab	6.11 b	309.49 bc	89.50 c	411.00 bc
T_{14}	161.84 g	14.77 e	17.57 de	2.70 g	152.76 g	27.61 i	180.37 h
LSD at 0.05	43.33	2.363	2.463	0.825	49.18	11.22	50.07
CV%	9.11	7.54	7.25	10.67	10.76	9.40	8.69

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_1: N_0 P_{100} K_{140} S_{20} T_2: N_{60} P_{100} K_{140} S_{20} T_3: N_{120} P_{100} K_{140} S_{20} T_4: N_{180} P_{100} K_{140} S_{20}
T_5: N_{120} P_0 K_{140} S_{20} T_6: N_{120} P_{50} K_{140} S_{20} T_7: N_{120} P_{150} K_{140} S_{20} T_8: N_{120} P_{100} K_0 S_{20}
T_9: N_{120} P_{100} K_{70} S_{20} T_{10}: N_{120} P_{100} K_{210} S_{20} T_{11}: N_{120} P_{100} K_{140} S_0 T_{12}: N_{120} P_{100} K_{140} S_{10}
T_{13}: N_{120} P_{100} K_{140} S_{30} T_{14}: N_0 P_0 K_0 S_0

recorded from the treatment combination of T_3 (N_{120} P_{100} K_{140} S_{20} kg/ha) which was followed by T_{10} (N_{120} P_{100} K_{210} S_{20}kg / ha) treatment (322.92g). It was probably due to the fact that higher doses of NPK and S required for proper growth of plant, helped in the production of large size of curd with maximum weight. The lowest of primary curd (152.76g) was obtained in the control treatment T_{14} (N_0 P_0 K_0 S_0 kg/ha) (Table 5). The results of present study is in partial agreement with Karim *et.al.*(1997) , who reported the significant effect due to different doses of NPK fertilizer as well as levels of irrigation on plant height, leaves per plant, weight of curd per plant of cauliflower. The curd yield per plant of broccoli showed highly significant influenced by the application of NPK and S fertilizer.The maximum yield per plant (485.04g) was produced by the plants grown with T_3 (N_{120} P_{100} K_{140} S_{20} kg/ha) treatment which was followed by T_4 (423.67g) and T_{10} (420.61g) treatments. The lowest yield per plant (180.37g) was found from the T_{14} (N_0 P_0 K_0 S_0 kg / ha) control treatment (Table 5). The highest curd yield per plot (9.17kg) was recorded from the treatment combination of T_3 (N_{120} P_{100} K_{140} S_{20} kg/ha) treatment which was statically identical with T_{10} (8.99kg) treatment and the lowest yield (3.61kg) was obtained from the T_{14} (N_0 P_0 K_0 S_0 kg / ha) control treatment (Table 6).The findings of the present study also corroborate with the findings of Ying *et al.* (1997) who reported that N, P and K application resulted in maximum curd yield of broccoli. It might be due to the fact that vegetative growth was influenced by N fertilizer. Root growth and development was influenced by K fertilizer. Phosphorus is essential to give the early curd formation. Therefore the combination of different proper levels of NPK and S fertilizer gave better results in respect of growth and yield of broccoli. The yield ton per hectare of broccoli had significantly influenced by different levels of NPK and S fertilizer treatment. More or less similar trend in yield per hectare was found with different levels of NPK and S fertilizers. The maximum yield (19.11t/ha) was recorded with the application of T_3 (N_{120} P_{100} K_{140} S_{20} kg/ha) treatment which was followed by 18.74 t / ha with T_{10} treatment. The lowest yield 7.52 t/ha was recorded with the control treatment T_{14} (N_0 P_0 K_0 S_0 kg / ha) (Fig. 2). The highest dry matter (11.08) percentage of curd was recorded with the optimum

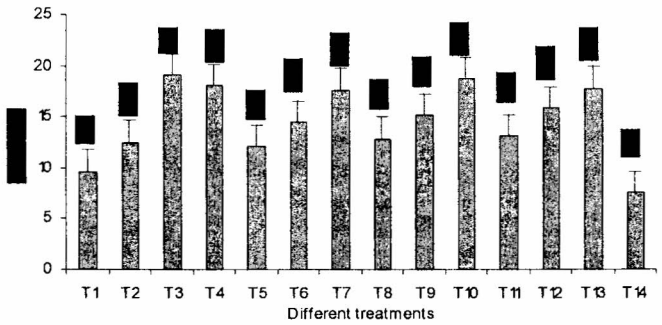

Fig. 2. Effect of different macro nutrients treatments (NPK and S) on yield of broccoli. The vertical bars represent by DMRT at 0.05 level of significance

level of NPK and S in T_3 ($N_{120}P_{100}K_{140}S_{20}$kg / ha) treatment which was statically identical with T_{13} (10.60) treatment combinations and the lowest dry weight of curd (6.64) was recorded at the control T_{14} (N_0 P_0 K_0 S_0 kg /ha) (Table 6). From the result it was indicated that optimum level of NPK and S increased the percent dry weight of curd. There is no significant effect in moisture content of curd of broccoli was observed due to different doses of NPK and S fertilizer (Table 6). The moisture content varied from 85.62 to 88.17 %, the highest moisture content of curd (88.17%) was recorded from the T_6 treatment and lowest moisture content of curd of broccoli (85.62 %) was recorded at T_{13} treatment. The highest ascorbic acid (117.67 mg / 100 gm) was found in the T_3 (N_{120} P_{100} K_{140} S_{20} kg / ha) treatment combination, which was statistically similar (116.00mg /100g, 115.67mg /100g, 115.67mg /100g) with the treatment combinations of T_{13}, T_4, and T_{10} respectively while it was the lowest ascorbic acid

(86.70mg / 100 gm) was noted from the T_{14} (N_0 P_0 K_0 S_0 kg / ha) control treatment (Table 6). The results indicated that all fertilizers (N P K and S) were used as standard which helped the plants to grow normally and hence produced the metabolites and other nutrients in the highest quantity. Kaniszewski and Rumpet (1983) found that nitrogen fertilization influenced vitamin c content. There is a significant effect in protein content of curd of broccoli was observed due to different doses of NPK and S fertilizer (Table 6). The highest protein content (4.43%) of broccoli curd observed from T_3

Table 6. Effect of different macronutrients (NPK and S) on yield and yield attributes of broccoli

Treatments	Yield kg/plot	Percent dry weight of curd	Moisture (%)^{NS}	Ascorbic acid content (values per 100g of edible portion) International units (mg)	Protein content (%)
T_1	4.65 g	7.15 cd (15.51)	87.98	98.33 bc	3.99b
T_2	6.03 ef	7.46 cd (15.85)	86.75	99.33 bc	4.20ab
T_3	9.17 a	11.08 a (19.44)	87.55	117.67 a	4.43a
T_4	8.67ab	8.16 c (16.59)	87.52	115.67 a	4.26ab
T_5	5.85 f	7.20 cd (15.56)	86.77	87.33 d	4.02b
T_6	6.98 cde	7.46 cd (15.85)	88.17	102.67 b	4.18ab
T_7	8.46ab	9.36 b (17.82)	87.51	109.33 ab	4.21ab
T_8	6.20 def	7.91 c (16.34)	86.46	89.33 cd	4.10ab
T_9	7.26 cd	8.02 c (16.45)	86.88	107.33 ab	4.08ab
T_{10}	8.99a	9.25 b (17.71)	85.82	115.67 a	4.23ab
T_{11}	6.31def	7.51 cd (15.91)	85.98	100.33 bc	4.07b
T_{12}	7.60 bc	8.01 c (16.44)	87.98	104.33 b	4.07ab
T_{13}	8.55a	10.60 a (19.00)	85.62	116.00 a	4.21ab
T_{14}	3.61 h	6.64 d (14.93)	86.25	86.67 b	3.55c
LSD at 0.05	1.001	0.975	-	10.22	0.363
CV%	8.69	7.03	3.94	5.82	5.26

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_1: N_0 P_{100} K_{140} S_{20} T_2: N_{60} P_{100} K_{140} S_{20} T_3: N_{120} P_{100} K_{140} S_{20} T_4: N_{180} P_{100} K_{140} S_{20}
T_5: N_{120} P_0 K_{140} S_{20} T_6: N_{120} P_{50} K_{140} S_{20} T_7: N_{120} P_{150} K_{140} S_{20} T_8: N_{120} P_{100} K_0 S_{20}
T_9: N_{120} P_{100} K_{70} S_{20} T_{10}: N_{120} P_{100} K_{210} S_{20} T_{11}: N_{120} P_{100} K_{140} S_0 T_{12}: N_{120} P_{100} K_{140} S_{10}
T_{13}: N_{120} P_{100} K_{140} S_{30} T_{14}: N_0 P_0 K_0 S_0

($N_{120}P_{100}K_{140}S_{20}$kg / ha) treatment which was followed by T_4 (4.26%), T_{10} (4.23%), T_7 (4.21%) and T_{13} (4.21%) *treatments. On the other hand, the lowest (3.55%) was found in* T_{14} (N_0 P_0 K_0 S_0 kg/ha) *control*

treatment. All fertilizers were used as standard which helped the plants to grow normally and hence produced the metabolites and other nutrients in the highest quantity. From the above result it showed that the treatment combination T_3 ($N_{120}P_{100}K_{140}S_{20}$ kg / ha) was found better for curd yield of broccoli. So it may be concluded that T_3 ($N_{120}P_{100}K_{140}S_{20}$ kg / ha) fertilizers combination is good for higher curd yield.

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