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INFLUENCE OF INORGANIC FERTILIZERS ON YIELD AND QUALITY OF BROCCOLI (*Brassica oleracea* var. *italica* L)

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Abstract

Experiments in field and laboratory of Horticulture Department of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, were conducted during 10 October 2007 to 28th February 2008, to study the growth, yield and quality of broccoli under different fertilizer treatment combinations. There were 13 treatments in the experiment comprising four levels each of N, P, K and Mo. The highest plant height (60.67 cm) and the maximum leaves/plant (14.67) were found in T_4 ($N_{135}P_{30}K_{50}M_{O0.3}$) treatment. The highest yield (16.67 t/ha) was obtained from T_4 which was statistically similar with T_7 ($NOP_{90}K_{50}MO0.3$) (15.29 t/ha). Dry matter content was the maximum (9.44%) in T_1 ($N_0P_0K_0M_{00}$) and the minimum (7.47%) in T_4. The highest ascorbic acid content (33.04 mg/100 g) and ß-carotene (0.49 mg/100 g) were recorded in T_1 (control) where no fertilizer was applied, but the minimum value was noted in T_4 ($N_{135}P_{30}K_{50}M_{O0.3}$).

Keywords: Broccoli, yield, nutritional qualities, inorganic fertilizers.

Introduction

Broccoli (*Brassica oleracea var. italica* L.) is one of the winter vegetable crops belong to the family cruciferae which was introduced in Bangladesh several years ago. But its cultivation the country is limited and its average yield is only about 7.5 metric tons per hectares (Anon, 1998). Vegetables play an important role in human nutrition. It provides carbohydrates, fat, minerals, vitamins and fibres, which constitute the essentials of a balanced diet. But vegetable consumption in Bangladesh is very low and only 32g per person per day against the minimum recommended quantity of 200g per day (FAO, 1986). The total vegetable production is far below the requirement. In 2007-08, the vegetable produced in 285020 hectares of land with a production of 2.01 million tons. To fulfill the nutritional requirement total production as well as number of vegetables should be

increased. Broccoli is a nutritious vegetable than any other Cole crops (Nieuwhof, 1969). Per pound of edible portion of broccoli contains protein 9.10 g, fat 0.60 g, carbohydrate 15.20 g, calcium 360.00 mg, phosphorus 211.0 mg, iron 3.60mg, vitamin-A 970.00 I.U., ascorbic acid 327.00mg, riboflavin 0.59 mg and thiamine 0.26 mg (Thompson and Kelly, 1985). Devouring broccoli enriched in antioxidants can reduce the risk of some forms of cancer and heart disease. Thus broccoli can play a vital role in improving the nutritional status of the people of Bangladesh.

Broccoli can be grown on a variety of soils. Broccoli demands a soil with a good moisture supply, ranging from light sand to heavy loam that are well supplied with organic matter (Katayal, 1977). Broccoli is presumely rather salt tolerant (Nieuwhof, 1969). Successful production of Broccoli largely depends on fertilizer management. Broccoli responds greatly to major essential elements like, nitrogen, phosphorus, potassium and molybdenum in respect of its growth and yield (Macmillan, 1962). The early and rapid vegetative growth of the plant is necessary for obtaining higher yield and quality crop which is greatly influenced by different doses of nitrogenous fertilizer (Pieters, 1976; Thompson and Kelly, 1985). Earliness and yield of broccoli is affected by phosphatic fertilizers supplied to the soil, potash improve to the inflorescence and diameter of the curd significantly by different molybdenum level (Cutcliffe and Murno, 1976). Information on growth, yield, fertilizer requirements and quality of broccoli is scanty. Thus, the present study was undertaken to determine the optimum dose of nitrogen, phosphorus, potassium and molybdenum for growth, yield and quality of broccoli.

Materials and Methods

The experiment was conducted at the Horticultural Research Farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur during the period from 10 October, 2007 to 28th February, 2008. The experimental site is located at the centre of Madhupur Tract 24.09 N latitude and 90.26 E longitudes and at 8.5 meter above the sea level (Anonymous, 1989). Broccoli (*Brassica oleracea var. italica*) cv. Premium was used as plant material. There were 13 treatments in the experiment comprising four levels of N (0, 45, 90 and 135 kg/ha), four levels of P (0, 30, 60 and 90 kg/ha), four levels of K (0, 25, 50 and 75 kg/ha) and four levels of Mo (0, 0.1, 0.3 and 0.5 kg/ha). Cowdung applied 10 t/ha as per

recommended doses. N, P, K and Mo were applied as Urea, TSP. MP and ammonium molybdate respectively. Total quantity of Cowdung, TSP and ammonium molybdate were applied as broadcast and incorporated during final land preparation in individual plot as per treatment. Urea and MP were applied in three installments as 50% at the time of land preparation and rest 50% were applied at 15 and 30 days after transplanting. The field experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The treatments were randomly allotted in each block. In each plot 18 plants were accommodated. Block to block and plot to plot distance were 0.75 m. The size of each unit plot was 3 m 1.8 m = 5.4 m2. The plants were spaced with 60 x 50 cm spacing (Rashid, 1983 and Anonymous,1991). During the experimental period normal cultivation procedures such as manure and fertilizer application, mulching, weeding, irrigation and others application were followed. The crop was harvested during 10 January to 30 January, 2008. The Broccoli curd was harvested before the buds opened (Thompson and Kelly, 1985). The data were recorded on individual plant basis from the selected plants on plant height (cm), leaves per plant, stem diameter (mm) ,days to curd initiation [1st & 50%], percentage (%) of non-curding, main curd diameter (cm) ,main curd length (cm), secondary curds/plant, main curd weight/plant (g), secondary curds weight /plant (g), yield/plant (g), yield (t/ha). The harvested crops were used for biochemical analysis. Following data were recorded immediate after harvesting - water content (%), dry matter (%), ascorbic acid (mg/100 g), ß-Carotene (mg/100 g)

Estimation of Ascorbic acid: The ascorbic acid content was determined as per the procedure described by Pleshkov (1976). For estimating free ascorbic acid 10 ml of prepared extract was taken in a conical flask. Five ml 5% KI, 2 ml 2% starch solution, 2 ml glacial acetic acid were added to the extract. Finally it was titrated with 0.001N KIO3 solution. Free ascorbic acid was quantified by using the following formula:

$$\text{Ascorbic acid content (mg/100g)} = \frac{TFV}{vW} \times 100$$

Where, T =Titrated volume of KIO3 (ml), F = 0.088 mg of ascorbic acid per ml of 0.001N KIO3, V = Total volume of sample extracted (ml), v = Volume of the extract (ml) taken for titration, W = Weight of the sample taken.

Estimation of ß-Carotene: One gram of sample was crushed and mixed thoroughly with 10 ml acetone: hexane (4:6) solution. This sample was centrifuged and optical density of the

supernatant was measured by spectrophotometer (Model 200-20, Hitachi, Japan) at 663 ?m, 645 ?m, 505 ?m and 453 ?m. Calculation was done by the following formula (Nagata *et al.*, 1992).

ß-Carotene (mg/100g) = 0.216 (**OD_{663}**) + 0.452 (**OD_{453}**) - 1.22 (**OD_{645}**) - 0.304 (**OD_{505}**)

Where, bold figure indicates optical density.

The laboratory experiment was laid out in Completely Randomized Design (CRD) with three replications. The collected data were statistically analyzed and the treatments mean were compared by DMRT.

Results and Discussion

Growth and yield of broccoli

Plant height at harvest was significantly influenced by different fertilizers treatment combinations (Table 1). Maximum plant height at harvest was recorded in T_4 (60.67 cm) which was statistically identical to other treatments except T_5, T_2 and T_1. The minimum plant height at harvest was observed in absolute control treatment (T_1) (46.60 cm). It was also observed that plant height increased with the increasing rates of nitrogen at constant rate of phosphorus, potassium and molybdenum. The plant height of broccoli increased by 30.19% over the control treatment (T_1). The results also revealed that different levels of P, K, and MO had no significantly influence on plant height of broccoli. The plant height increased with increased rate of nitrogen also reported by Ram and Sharma (1969) and Rajput and Singh (1975).

The result revealed that there was a significant variation in number of leaves per plant among the treatments (Table 1). The maximum numbers of leaves were found in T_4 treatment (14.67) which was statistically similar T_7, T_{13}, T_{10}, T_9 T_{12} and T_3 treatments. The minimum numbers of leaves/plant were found in control treatment (10.55) followed by T_1 treatment (11.00). The results indicated the positive effect of nitrogen on number of leaves per plant (Karim *et al.*, 1987). It was also observed that P had significant influence on number of leaves per plant but K and Mo did not. Similar results also reported by Ram and Sharma (1969).The diameter of broccoli stem significantly influenced by different fertilizer combinations (Table 1). The maximum diameter was recorded in T_4 (37.23 cm) which was statistically identical with T_7, T_6, T_{10}, T_{13} and T_3. The minimum stem diameter was noted in control treatment T_1 (27.98 cm).

Stem diameter increased with increased in N, P, K and Mo. The findings were in agreement with the findings of Dufault (1988) who reported increased diameter with increasing nitrogen doses.

Table 1. Influence of different fertilizer on growth characters and days to curding

Treatment (kg/ha)	Plant height (cm)	Leaves/ plant	Stem diameter (mm)	Days to curd initiation	
				1st	50%
T_1 (N0P0K0 M0 0)	46.60 c	10.55 f	27.98 c	50.67 a	54.00 a
T_2 (N45P30K50M0 0.3)	51.00 bc	11.00 ef	31.08 bc	48.00 ab	53.00 ab
T_3 (N90P30K50M0 0.3)	55.63 ab	13.11 a-d	33.31 ab	46.67 bcd	49.67 bc
T_4 (N135P30K50M0 0.3)	60.67 a	14.67 a	37.23 a	44.00 d	47.33 c
T_5 (N90P0K50M0 0.3)	53.37 b	11.33 def	31.72 bc	48.00 ab	50.00 bc
T_6 (N90P60K50M0 0.3)	56.87ab	12. 66 b-e	34.94 ab	45.33 bcd	48.00 c
T_7 (N90P90K50M0 0.3)	58.03 ab	14.00 ab	35.69 ab	44.33 cd	47.33 c
T_8 (N90P30K0M0 0.3)	53.57 ab	11.89 c-f	31.30 bc	47.67 abc	49.67 bc
T_9 (N90P30K25M0 0.3)	54.73 ab	13.33 abc	31.90 bc	47.33 a-d	50.33 bc
T_{10} (N90P30K75M0 0.3)	56.13 ab	13.44 abc	33.68 ab	45.67 bcd	48.33 c
T_{11} (N90P30K50M0 0)	53.67 ab	12.55 b-e	31.49 bc	47.33 a-d	50.67bc
T_{12} (N90P30K50M0 0.1)	55.33 ab	13.11 a-d	32.20 bc	47.00 bcd	52.00 ab
T_{13} (N90P30K50M00.5)	56.00 ab	13.66 abc	33.47ab	45.67bcd	50.00 bc
Level of significance	*	**	*	*	**
CV%	6.77	7.99	7.45	4.96	3.61

In a column, means followed by common letter(s) are not significantly different from each other at 5% or 1% level of probability by DMRT.
*- significant at 5% level
**-significant at 1% level

Days to first curd initiation varied significantly due to the influence of different nutrient elements (Table 1). The minimum time required to first curd initiation was recorded in T_4 (44 days) which was statistically identical to all except T_8, T_5, T_2 and T_1. The maximum time (50.67 days) required to first curd initiation was noted in control treatment (T1) which was statistically similar to T_2 T_5 and T_8. Significant variations were observed in days to

50% curd initiation (Table 1). The shortest period required to 50% curd initiation in T_4 (47.33 days) which was statistically identical to other treatments except T_{12}, T_2 and T_1. The longest period required to 50% curd initiation was observed in absolute control treatment (T1) (54.00 days).

The yield of broccoli is directly influenced by the formation of curd. Percentage of non-curding varied significantly due to the influence of different fertilizer treatments (Fig.1).The minimum percentage of non-curding were recorded in T_4 treatment (4.46) which was followed by T_7, T_6 and T_{10} treatment. The maximum non-curding was found in control treatment (44.40%). The lower percentage of non-curding in T_4 and T_7 might be due to the fact that the plants under these treatments received the optimum quantity of macro and micro nutrients released from inorganic and organic manure.

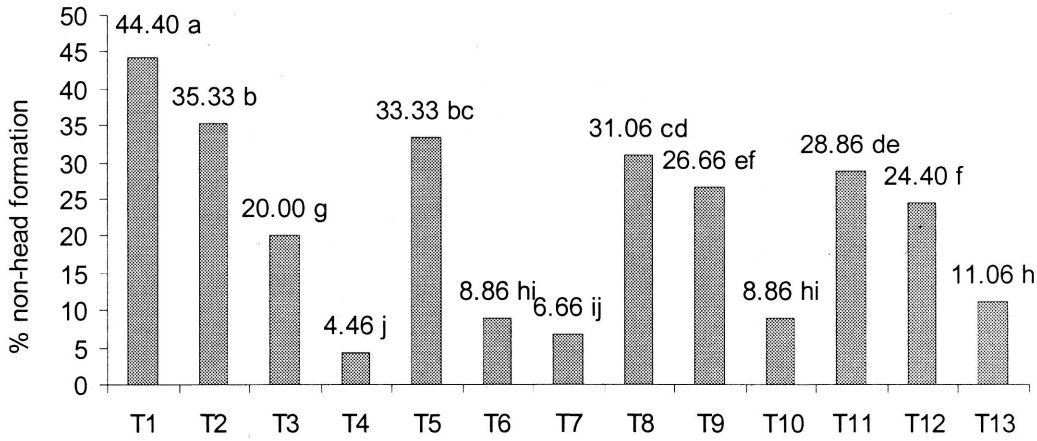

Fig.1. Effect of different fertilizer treatment on the percent of non-curding

Main curd diameter of broccoli significantly influenced by different fertilizer treatments (Table 2). The maximum diameter was recorded in T_4 treatment (20.35 cm) which was statistically identical to other treatments except T_2 and T_1 (Table 2). The minimum diameter was recorded in control treatment (15.53 cm). Application of different combinations of fertilizer led to increase in diameter of curd from 10.11% to 31.03% over the control treatment. The plants under T_4 produced the maximum number of leaves which increased the photosynthesis resulting bigger curd.

Gorski and Armstrong (1985) reported that broccoli head size increased with increasing N rate up to 224 kg/ha which corroborate the present findings. Marketable weight of broccoli depends on length of the curd. The length of the main curd significantly influenced by different fertilizers treatments (Table 2). The maximum length of the main curd was recorded in T_4 treatment (16.12 cm) which was statistically similar to others except T_1 treatment which produced the minimum length of curd T_1 (12.97cm).

Table 2. Effect of different fertilizer treatments on curd characters of broccoli

Treatment (kg/ha)	Main curd diameter (cm)	Main curd length (cm)	Secondary curds/plant
T1 (N0P0K0 Mo 0)	15.53 c	12.97 b	3.00 f
T2 (N45P30K50M0 0.3)	17.10 bc	14.23 ab	3.33 bcd
T3 (N90P30K50M0 0.3)	19.03 ab	15.53 a	4.21 b-e
T4 (N135P30K50M0 0.3)	20.35 a	16.12 a	5.33 a
T5 (N90P0K50M0 0.3)	18.33 ab	14.30 ab	3.66 def
T6 (N90P60K50M0 0.3)	19.87 a	15.93 a	4.66 abc
T7 (N90P90K50M0 0.3)	20.10 a	16.07 a	5.00 ab
T8 (N90P30K0M0 0.3)	18.40 ab	14.53ab	3.66 def
T9 (N90P30K25M0 0.3)	18.56 ab	15.03 a	4.00 cde
T10 (N90P30K75M0 0.3)	19.27 ab	15.80 a	4.33 bcd
T11 (N90P30K50M0 0)	18.53 ab	14.90 a	4.00 cde
T12 (N90P30K50M0 0.1)	19.00 ab	15.26 a	4.21 b-e
T13 (N90P30K50M00.5)	19.07 ab	15.80a	4.33 bcd
Level of significance	*	*	**
CV%	7.26	6.63	12.21

In a column, means followed by common letter (s) are not significantly different from each other at 5% or 1% level of probability by DMRT. *- significant at 5% level, **- significant at 1% level

The secondary curds are those which develop a leaf axil after harvesting of the main curd. The result revealed that there was significant variation in number of secondary curds produced by the plants of different fertilizer treatment (Table 2). The maximum number of secondary curds was

recorded in T_4 (5.33) which was statistically identical to T_7 (5.00) and T_6 (4.66) (Table 2). The minimum number of secondary curds was recorded in T_1 treatment (3.00). The phenomenon of more number of secondary curds might be due to unremitting discharge of nitrogenous element from bulky dose of N which influenced to increase chlorophyll content imparting dark green colour to foliage resulted more food reserves that promoted branching of plant which produced curd. The control treatment performed inferior in producing secondary curd. Weight of main curd varied significantly due to the influence of different fertilizer combinations (Table 3). The maximum curd weight was recorded in T_4 treatment (572.33 g) which was statistically similar to T_7 (537.33 g), T_6 (527.33g), T_{10} (498.67g), T_{13} (489.33 g) and T_3 (491.67 g). The minimum curd weight was found in control treatment (T1) (340.36 g) which was statistically identical to T_2 treatment. It was also observed that weight of curd increased with increasing rate of N, P and K but it increased with increase of Mo up to 0.3 kg/ha. The increasing N rate favored greater vegetative growth resulting higher curd yield (Trembly, 1989). The present findings were in agreement with the findings of Sigh *et al.* (1976) who reported that curd yields increased with increasing application of N and K2O each at 120 kg/ha. There was a great variation in weight of the secondary curd produced by the plants under different fertilizer treatments (Table 3). The highest weight was found in T_4 (148.98 g) which was identical with T_7 (146.95 g). The lowest curd weight obtained in control treatment (52.47 g) which was statistically similar to T_2 treatment. The yield of broccoli per plant varied significantly due to different fertilizer treatments (Table 3). The yield ranged from 392.83 to 721.31 g/plant. The highest yield was recorded in T_4 treatment (721.31 g/plant) which was statistically identical with T_7 treatment (684.28 g/plant). The lowest yield/plant was found in control treatment (392.83 g). The plants under T_4 treatment produced the maximum number of leaves which increased photosynthesis. Due to higher photosynthesis plants stored more photosynthates which helped the plant to produce heavier curd as well as higher number of secondary curds resulting higher total yield/plant. Kowalenko and Hall (1987) reported that broccoli yield increased with increasing application of N up to 200 kg/ha which corroborate the present findings. The yield of broccoli significantly varied due to different fertilizer treatments (Table 3). The yield

ranged from 5.55 to 16.67 t/ha. The highest yield was recorded from T_4 treatment (16.67 t/ha) which was statistically identical with T_7 treatment (15.29 t/ha). The lowest yield was recorded in control treatment (T1) 5.55 t/ha. The yield difference between the highest and the lowest yielding treatments was 200.36%. The results revealed that yield (t/ha) increased with increase rate of N, P, K and Mo. But the plants under T_4 (N135P30K50Mo0.3) treatment may be absorbed the nutrients in balanced form which helped to complete their optimum vegetative growth in time resulting higher yield.

Table 3. Effect of different fertilizer treatments on yield and yield attributes of broccoli.

Treatment (kg/ha)	Main curd weight (g)	Secondary curd weight (g)	Yield/plant (g)	Yield (t/ha)	Yield increase over control (%)
T1 (N0P0K0 M0 0)	340.36 h	52.47 f	392.83 h	5.55 j	-
T2 (N45P30K50M0 0.3)	371.16 gh	53.47 f	424.63 gh	7.00 ij	26.12
T3 (N90P30K50M0 0.3)	491.67 a-e	105.82 bcd	597.49 cd	11.77de	112.07
T4 (N135P30K50M0 0.3)	572.33 a	148.98 a	721.31 a	16.67 a	200.36
T5 (N90P0K50M0 0.3)	394.67 fgh	80.77 e	475.44 fg	7.86 hi	41.62
T6 (N90P60K50M0 0.3)	527.00 abc	119.15 b	646.15 bc	14.38 bc	159.09
T7 (N90P90K50M0 0.3)	537.33 ab	146.95 a	684.28 ab	15.29 ab	175.49
T8 (N90P30K0M0 0.3)	411.33e-h	82.81 e	494.14 fg	8.45 ghi	52.25
T9 (N90P30K25M0 0.3)	445.00 c-g	91.69 de	536.69 def	9.74 fg	75.49
T10 (N90P30K75M0 0.3)	498.67 a-d	108.97 bc	607.64 cd	13.51 c	143.42
T11 (N90P30K50M0 0)	416.67 d-h	93.54 cde	510.21 ef	8.93 fgh	60.90
T12 (N90P30K50M0 0.1)	462.33b-f	104.11 bcd	566.44 de	10.52 ef	89.54
T13 (N90P30K50M00.5)	489.33 a-e	108.12 bcd	597.45 cd	12.96 cd	133.51
Level of significance	**	**	**	**	
CV%	9.81	9.14	7.06	8.21	

In a column, means followed by common letter (s) are not significantly different from each other at 5% or 1% level of probability by DMRT. *- significant at 5% level, **- significant at 1% level.

Nutritional qualities of broccoli

The percentage of water content did not vary significantly due to the influence of different fertilizer treatments (Table 4). Numerically it varied from 90.65 to 92.62%. Significant variation in dry matter content of broccoli was found due to the different fertilizer treatments (Table 4). The highest dry matter was obtained in T_1 treatment (9.44%) which was statistically similar with T_2, T_5, T_8, T_{10}, T_{12} and T_{13}. The T_4 treatment recorded the lowest dry matter content (7.47%). Rembialkowska *et al.* (2003) reported that plants grown without fertilizer contained more dry matter compared to plants grown with inorganic fertilizer. Ascorbic acid content of broccoli varied significantly due to the influence of different fertilizer treatments (Table 4). It ranged from 17.79 to 33.04 mg/100g. The broccoli produced under T_1 treatment contained the maximum ascorbic acid (33.04 mg/100g) which was statistically identical to T_2, T_8 and T_5. The plant grown with the highest nitrogenous fertilizer (T_4) gave the lowest ascorbic acid (17.79 mg/100g). Plants grown without fertilizer gave more ascorbic acid may be due to containing higher dry matter. Significant variations in ß-carotene content were found due to the effect of different fertilizer treatments (Table 4). It varied from 0.33 to 0.49 mg/100g. The plants obtained from T_1 treatment contained the maximum ß -carotene (0.49 mg/100g) which was statistically similar to T_2 and T_5 treatments. The plants produced with T_4 treatment contained the lowest content of ß -carotene (0.33 mg/100g).The results are in agreement with the finding of Rembialkowska et al. (2003) who reported that application of inorganic fertilizer decrease ß -carotene in broccoli.

Conclusion: The combination of 135 kg N, 30 kg P, 50 kg K and 0.3 kg Mo /ha is recommended for cultivating broccoli with higher yield in shallow red brown terrace soil of Madhupur Tract.

Table 4. Effect of different fertilizer treatments on nutritional qualities of broccoli

Treatments (kg/ha)	Water content (%)	Dry matter content (%)	Ascorbic acid (mg/100g)	β-carotene (mg/100g)
T_1 (N_0P0K_0 M_{00})	90.65	9.44 a	33.04 a	0.49 a
T_2 ($N_{45}P_{30}K_{50}M_{00\cdot3}$)	91.10	8.99 ab	32.02 ab	0.45 abc
T_3 ($N_{90}P_{30}K_{50}M_{00\cdot3}$)	91.42	8.67 b	21.93 d	0.38 def
T_4 ($N_{135}P_{30}K_{50}M_{00\cdot3}$)	92.62	7.47 c	17.79 e	0.33 f
T_5 ($N_{90}P0K_{50}M_{00\cdot3}$)	91.12	8.97 ab	31.24 ab	0.47 ab
T_6 ($N_{90}P60K_{50}M_{00\cdot3}$)	91.57	8.52 b	18.39 e	0.35 ef
T_7 ($N_{90}P_{90}K_{50}M_{00\cdot3}$)	91.57	8.52 b	18.27 e	0.35 ef
T_8 ($N_{90}P_{30}K0M_{00\cdot3}$)	91.13	8.96 ab	31.28 ab	0.43 bcd
T_9 ($N_{90}P_{30}K_{25}M_{00\cdot3}$)	91.19	8.90 b	27.33 c	0.40 cde
T_{10} ($N_{90}P_{30}K_{75}M_{00\cdot3}$)	91.44	8.65 ab	18.89 e	0.37 ef
T_{11} ($N_{90}P_{30}K_{50}M_{00}$)	91.12	8.97 b	29.65 bc	0.40cde
T_{12} ($N_{90}P_{30}K_{50}M_{00\cdot1}$)	91.31	8.78 ab	22.19 d	0.39 def
T_{13} ($N_{90}P_{30}K_{50}M_{00\cdot5}$)	91.47	8.62 ab	19.87 de	0.37 def
Level of significance	NS	**	**	**
CV%	1.52	3.96	6.08	6.11

In a column, means followed by common letter (s) are not significantly different from each other at 5% or 1% level of probability by DMRT. *- significant at 5% level ,**- significant at 1% level and NS- Non-significant

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