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YIELD AND YIELD ATTRIBUTES OF SHORT DURATION MUSTARD AS INFLUENCED BY NUTRIENT RATES

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Abstract

Mustard (*Brassica napus)*is the important principal edible oil-producing crop in Bangladesh. However, the nutrient requirement of mustard especially for the short duration variety is very much important to obtain higher yield. A field experiment was conducted to assess the requirement of major nutrients (N, P, K, and S), and to recommend fertilizers for short-duration mustard variety BARI Sarisha-14. There were 8 treatments T_1=100% soil test based (STB) nutrients (N, P, K, S, Zn & B @ 90, 25, 60, 15, 2 & 1 kg ha^{-1}, respectively) as per Fertilizer Recommendation Guide (FRG,2012), $T_2=T_1$+ 25% N of FRG, $T_3=T_1$+ 25% NP of FRG, $T_4=T_1$+ 25% NK of FRG, $T_5=T_1$+ 25% PK of FRG, $T_6=T_1$+ 25% NPK of FRG, T_7=75% of T_1 and T_8= native nutrient (control). The experiment was laid out in Randomized Complete Block Design with 3 replications. The results revealed that yield and yield parameters of mustard weresignificantly influenced by the nutrient levels. The highest value of almost all the yield components and yield were obtained in T6 among the treatments. The highest seed yield (1.68 t ha^{-1}) and the maximum stover yield (2.96 t ha^{-1}) were obtained from the treatment (T_6) containing 100% STB nutrients with additional 25% NPK among the fertilizer treatments. The seed yield value was statistically higher than all other treatments except the treatment where100% STB nutrients with additional 25% NP were used (T_3). The highest seed yield and stover production were attributed tothe yield contributing parameters. The highest amount of all the nutrients content was found in the treatment T_6 that was followed by T_3 and $_{T4}$ and the lowest in T_8. The highest amount of N, P, K, and S content in seed of the treatment T_6 was 3.75, 0.97, 0.96 and 0.78%, respectively. The highest yield was accredited to the highest amount of nutrient content in seed. It could be concluded that the treatment T6 (STB fertilizer dose + 25% NPK of FRG) would suitable for short duration Mustard (BARI Sarisha-14) for getting higher yield and better performance.

Introduction

Mustard (*Brassica napus* A.) belonging to the family Brassicaceaeis one of the most important oilseed crops throughout the world after soybean (S.N.) and groundnut (S.N.). Among the oilseed crops grown in Bangladesh mustard holds the first position in terms of both total cultivation area and production. A total area of 3,36,542ha in Bangladesh is used for mustard production with an annual production of about 3,62,860 metric ton (BBS, 2018). It is cultivated in Bangladesh and covers a good acreage; however, the yield is not satisfactory due to low yield as well as nutrient mining, depletion of soil organic matter, imbalanced fertilization, scanty use of bio and organic fertilizers, and poor management practices (Miah and Karim, 1995).

The correct application of nutrients is essential for the maximization of farm income, economic and quality product, and environmental improvement. The amount of fertilizers applied should be based on diagnostic methods. Any fertilizer recommendation should consider the cost of fertilizer and its application, as well as the value of the product (Sawedaet *al.*, 2017).The fertility status of Bangladesh soil is most uneven and it varies considerably even between two adjacent plots. Fertilization of farm plots through soil analysis might be aneffective way to achieve maximum yield goal with economic benefit, to maintain soil fertility, and to avoid environmental pollution.

Bangladesh Agricultural Research Institute (BARI) has recently developed a short-duration mustard variety (BARI Sarisha-14) having a life spell of about 75 to 80 days with seed yield is about 1.4-1.6 t ha^{-1} which can be fitted easily in the existing cropping pattern. As such Soil Science Division of BARI is trying to fit this mustard variety in the Mustard-Mungbean-T.*Aus*-T.*Aman* cropping pattern. As a result assessment of its nutrient requirement for optimum yield through soil test based (STB) is of utmost importance. Therefore, the study was undertaken to investigate the nutrient requirement based on soil test and to recommend fertilizer recommendation for short-duration mustard var.BARI Sarisha-14.

Materials and Methods

The experiment was conducted at the central research farm of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur(24.09° N latitude and 90.26° E longitude and 8.4 m altitude) during Rabi season of 2013-2014 to find out the requirement of nutrient such as N, P, K, S for BARI Sarisha-14. The experimental site belongs to the Agro-ecological Zone (AEZ) 28 which is characterized by clay within 50 cm from the surface and is acidic and it belongs to Chhiata series and has been classified as Grey Terrace Soils (FRG, 2018). The nutritional status of the experimental field is presented in Table 1.It is characterized by comparatively high rainfall, high humidity, high temperature, relatively long day period during April to September and scanty rainfall, low humidity, low temperature, and short-day period fromOctober to March.The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 4m×3m and the seeds were sown continuouslyat the rate of8 kg ha^{-1}in rows. Row to row spacing was 30 cm. Eight treatmentsT_1 = 100% soil test based (STB) nutrients as per Fertilizer Recommendation Guide (FRG, 2018), $T_2 = T_1$ + 25% N of FRG, $T_3 = T_1$ + 25% NPof FRG, $T_4 = T_1$ + 25% NKof FRG, $T_5 = T_1$ + 25% PKof FRG, $T_6 = T_1$ + 25% NPKof FRG, T_7 = 75% of T_1 and T_8 = Native fertility (Control) were tested in the experiment. The whole amount of P, K, S, Zn, and half of N were applied at the time of final land preparation and the remaining N was applied 20 days after the sowing of mustard seeds. The amount of nutrients used in the treatment combination is given in Table 2.

Table 1. Native fertility status of the experimental plot (composite topsoil (0-30 cm) samples collected from the experimental plots at the Central Research Farm, BARI, Gazipur

pH	TOC (%)	TSN (%)	P_{Olsen} (ppm)	$K_{exch.}$ (cmol kg^{-1})	S (µg g^{-1})
5.9	1.41	0.089	8.4	0.21	9.4

NB: TOC=Total organic carbon and TSN=Total soil nitrogen

The crop was harvested at 80 days after sowing when the pods showed ripening signs. Ten plants were selected randomly from each plot in such a way that the border effect was avoided for the higher level of precision.Data on plant height (cm), number of branches $plant^{-1}$, number of siliqua$plant^{-1}$, weight of fresh plant (g), weight of fresh stem (g), weight of dry stem (g), weight of fresh siliqua (g), weight of dry siliqua (g), weight of 100 pod (siliqua) (g), 1000-seedweight, stover yield and seedyield were collected following standard methods.Seedand stover weight was taken from the 6-m^2 area from the center of each plot excluding border area. After threshing and cleaning, the weight was taken by fine-tuning electric balance and converted to kilogram (kg) in a dry weight basis.

Table 2.Treatment combinations of different nutrients in the experimental field at the Central Research Farm,BARI, Gazipur

Treatments	Treatment combination					
	N	P	K	S	Zn	B
	Kgha^{-1}					
T_1	90	25	60	15	2	1
T_2	112.5	25	60	15	2	1
T_3	112.5	31.25	60	15	2	1
T_4	112.5	25	75	15	2	1
T_5	90	31.25	75	15	2	1
T_6	112.5	31.25	75	15	2	1
T_7	68	19	45	11.25	1.5	0.75
T_8	Native fertility					

Chemical analysis of seedand stover

Preparation of samples: Seedand stover samples were dried in an oven at 65^{o}C for 48 hours and then ground by a grinding machine to pass through a 20 mesh sieve and stored in small paper bags into desiccators. Then the samples were analyzed for N, P, K, and S content.

Digestion of samples with nitricperchloric acid

Half gram dried sample was transferred into a dry clean 100 ml Kjeldahl flask. A 10 ml of di-acid (HNO_3: $HClO_4$) in the ratio of 2: 1 was added. After leaving for a while, the flask was heated at a temperature slowly to rise to 200^{o}C. Heating was momentarily stopped when the dense white fumes of $HClO_4$ occurred and after cooling, 6 ml of 6N HCl was added to it. The contents of the flask were boiled until they became sufficiently clean and colorless. P, K, and S contents of the flask were determined from this digest.

Digestion of samples with sulfuric acid

An amount of 100 mg oven-dry ground sample was taken in a 100 ml Kjeldahl flask and 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$ $5H_2O$: selenium) in the ratio (10: 1: 0.1), 2 ml 30% H_2O_2 and 3 ml conc. H_2SO_4 was added into the flask. The flask was swirled and allowed to stand for about 10 minutes. After that, the flask was heated and continued heating until the digest became colorless. After cooling, the digest was transferred into a 100 ml volumetric flask and made up to the mark with distilled water. A blank sample with requisite reagents was prepared in similarly. This digest was used for the estimation of total N following standard procedure.

Measurement of N, P, K and S contents in seed

Nitrogen determination

Nitrogen content of seedof plant was analyzed by Micro-kjeldahl method (Bremner and Mulvaney, 1982). Exactly 0.1 g sample was digested in a fume hood with 10 ml concentrated H_2SO_4 in presence of K_2SO_4 catalyst mixture (K_2SO_4: $CuSO_4$: Se = 10: 1: 1). The digest was then transferred to a distillation flask and 5 ml 40% NaOH was added. Nitrogen was estimated by titrating the distillate trapped in the H_3BO_3 indicator solution with 0.02N H_2SO_4.

Phosphorus determination

The total phosphorus content of different plant parts wasdetermined by using Vanadomolybdate method (Yoshida *et al*., 1972). Dried plant materials were digested with concentrated HNO_3 and $HClO_4$

(Nitric per-chloric acid) mixture for the determination of total P content. Total P content in the extract was determined by Jackson (1973) using a double beam spectrophotometer at 440nm wavelength.

Potassium determination

Total potassium was also determined by using the Per-chloric acid digestion assay method (Yamakawa, 1992). Dried plant materials were digested with concentrated HNO_3 and $HClO_4$ (Nitric perchloric acid) mixture for determination of total K content. The concentration of K was determined by the atomic absorption spectrophotometer at 766 nm wavelength.

Sulfur determination

Dried plant materials were digested with concentrated HNO_3 and $HClO_4$ (Nitric per-chloric acid) mixture for determination of total S content which is known as nitric per-chloric acid digestion method. Sulfur was estimated through theturbid metric method using $BaCl_2$. $2H_2O$ by double Beam Spectrophotometer at 420 nm wavelength.

Statistical analysis

Data recorded in the experiments were statistically analyzed following procedures described by Gomez and Gomez (1984). Analysis of variance (ANOVA) was conducted using statistical software MSTAT-C and Means were compared with the least significant difference (LSD) test.

Results and Discussion

The influences on the agronomic parameters, yield attributes,and yield; such as plant height, dry weight of stem, fresh weight of siliqua, dry weight of siliqua, 100-siliqua weight, 1000-seed weight, seedyield, stover yield are shown in different tables and figures below.

Plant height

The plant height of mustard was significantly influenced by different nutrition levels (Table 3). The maximum plant (91.07cm) was recorded in T_6 treatment (T_1+25% NPK i.e., recommendeddose+25% NPK chemical fertilizer) which was statistically similar to all treatments except $T_7$and control treatment (T_8) with lowest plant height (72.68 cm). Ali and Ullah (1995) reported that the tallest mustard plant was found with the application of 120 kg N ha^{-1}. The increase in plant height in these treatments was attributed to the availability of optimum nutrients throughout the growing season which might render the optimum and balanced nutrients from chemical fertilizer that reflected in plant height. However, the addition of extra N, P, and K had no significant effect on plant height.

Number of branches plant^{-1}

Nutrients rates had a significant influence to produce branches in plants (Table 3). The maximumnumber of branchesplant^{-1} (7.20) was recorded in T_6 treatment which was at par with T_2 (T_1+25% N) and T_5 (T_1+25% PK) but statistically higher from the other treatments. The lowest number of branches (3.92) was recorded in T_8 treatment where no nutrition was applied. The results are in agreement with the findings of Shukla*et al.* (2002) who found that the application of mixed fertilizer (NPKS) increased the number of branches in the mustard plant.The nutrient helps in initiating buds in plants. These buds ultimately become active branches from where leaves emerge as photosynthetic organs and the flowering nodes are developed. Thus it plays a vital role in increasing the crop yield.

Dry weight of stem plant^{-1}

As shown in Table 3, the nutrient response on stem dry weight was significant. The highest stem dry weight was observed in T_6 treatment (25.74 g plant^{-1}) which is statistically different from all other treatments. In contrast, the lowest value of stem dry weight (9.72 g plant^{-1}) was found in T_8 treatment.

The possible reason behind might be this due to an increase in nutrition level the photosynthesis rate increases as a result of more dry matter accumulation occurs and ultimately stem dry weight increases. The results were in alignment with Bhagawan*et al.* (1996).

Table 3. Effect of nutrient rates on agronomic parameters of the short duration mustard BARI Sarisha-14

Treatments	Plant height (cm)	Branches plant^{-1} (no.)	Dry weight of stem (g)	Fresh weight of siliqua (g)	Dry weight of siliqua (g)
T_1 =100% NPKS (STB)	83.53 ab	5.70 bc	20.26 bc	124.52d	23.61 d
T_2 =T_1+ 25% N	82.86 ab	6.03 abc	19.94bc	148.04 b	28.87 b
T_3 =T_1+ 25% NP	87.53 ab	5.86 bc	20.24bc	147.44 b	28.03 b
T_4 =T_1+ 25% NK	88.33 ab	5.17 c	20.35 b	137.46 c	25.17cd
T_5 =T_1+ 25% PK	91.00 a	6.73 ab	22.03 b	151.56 b	28.29 b
T_6 =T_1+ 25% NPK	91.07 a	7.20 a	25.74 a	180.25 a	33.31 a
T_7 =75% of T_1	79.40 bc	4.83 cd	17.37 c	105.57 e	17.39 e
T_8 =Control	72.68 c	3.92 d	9.72 d	50.24 f	10.23 f
CV (%)	6.08	4.71	8.64	3.12	5.15
SE	4.19	4.38	1.38	3.32	1.01

Means followed by a common letter(s) are not significant at 5% level by of probability

Fresh weight of siliqua plant^{-1}

The fresh weight of siliquaplant^{-1}at different nutrient levels showed a significant result (Table 3). The highest % relative fresh weight of siliqua was observed in T_6 (180.25 g plant^{-1}) where 100% recommended dose of fertilizer and an additional 25% NPK were used which is statistically different from all other treatments. In contrast, the lowest value of siliqua fresh weight (50.24 g plant^{-1}) was found in T_8 treatment. The results indicated that siliqua fresh weight increased in T_6 treatment, due to the higher amount of supplied nutrients which might encourage the photosynthesis rate. Similar outcomes were obtained earlier by Bhagawan*et al.* (1996) and Mondal*et al.* (1997).

Dry weight of siliquaplant^{-1}

It is proved from the results that different nutrition has a significant effect on the siliqua dry weight per plant. In Table 3it observed that the highest siliqua dry weight (33.31 g) was observed in T_6 treatment which is statistically different from all other treatments and T_8 showedthe lowest siliqua dry weight (10.23 g). The possible reason might be that due to less in nutrient level lessen the photosynthesis rate of the plant also decreases resulting in less accumulation of photosynthates and ultimately giving the lowest siliqua dry weight in T_8 treatment.

Number of siliquaeplant^{-1}

The number of siliquae plant^{-1} is one of the most important yield contributing characters in mustard. The number of siliquaplant^{-1}was significantly affected by different levels of fertilizers (Table 4). The higher number of total siliquaplant^{-1}(80.87) was recorded with plants grown under T_6 treatment which is statistically different fromall other treatments. In contrast, the lower number of total siliqua plant^{-1} (38.67) was recorded in plants grown under T_8 treatment. This might be since nitrogen in the presence of other nutrients plays a vital role in both cell division and cell enlargement which might occur in this study. The results confirmed the findings of Singh *et al.* (1985).

Seeds siliqua^{-1}

The effect of different levels of nutrition on the number of seeds siliqua^{-1} was statistically significant (Table 4). The highest number of seeds siliqua^{-1} (35.90) was obtained from the treatment T_6 that statistically similar toall treatments except T_4, T_5,and T_8. The lowest number of seeds seliqua^{-1} (29.60) was obtained from the T_8treatment. Additional nitrogen in the presence of other nutrients increased the leaves area which leads to higher total photosynthesis and higher translocation of assimilating from vegetative to reproductive part. These results were in alignment with Shukla*et al.* (2002)who found that increased fertility levels increased seedspersiliqua.

Table 4. Effect of nutrient rates on yield attributes and stover yield of mustard var. BARI Sarisha-14

Treatment	Siliquaeplant^{-1} (no.)	Seeds siliqua^{-1}(no.)	100-siliqua weight (g)	1000-seed weight (g)	Stover yield (t ha^{-1})
T_1=100% NPKS (STB)	70.20 b	32.60abc	22.67 bc	2.98 a	2.40 d
T_2 =T_1+ 25% N	66.20b	33.76 ab	21.67 bc	2.96 a	2.55 c
T_3 =T_1+ 25% NP	71.33b	32.20abc	23.33 b	3.12 a	2.40 d
T_4 =T_1+ 25% NK	56.13c	29.77 c	25.67 ab	2.94 a	2.31 e
T_5 =T_1+ 25% PK	62.07bc	32.17bc	25.67 ab	2.92 a	2.62 b
T_6 =T_1+ 25% NPK	80.87 a	35.90 a	26.67 a	3.16 a	2.96 a
T_7 =75% of T_1	55.80 c	32.60abc	21.33 c	2.82 ab	2.10 f
T_8 =Control	38.67 d	29.60c	21.00 c	2.52 b	1.40 g
CV (%)	4.71	6.58	5.04	5.89	11.62
$SE_{(0.05)}$	4.38	1.73	0.06	4.57	2.67

Means followed by a common letter(s) are not significant at 5% level by of probability

Siliqua weight

Different treatments showed significant variation in respect of 100-siliqua weight (Table 4). The maximum 100-siliqua weight (26.67 g) was observed in the case of T_6 treatment where more nutrition was added and which is statistically similar toT_4 and T_5 treatments but different from all other treatments. The lowest 100-siliqua weight (21.0 g)was observed in T_8 treatment. These results confirmed with the findings of Hossain*et al.* (1997).

Seed weight

It is noted that 1000-seed weight was significantly influenced by different levels of nutrients (Table 4). The highest 1000-seed weight (3.16 g) was recorded with T_6treatment which is statistically similar toall other treatments except T_7 and T_8 treatment. The lowest 1000-seed weight (2.52 g) was recorded in the control. Seed weight is genetically characteristics, however, it was influenced the nutrient rates. The results indicated that the 1000-seed weight of mustard increased with increased nutrient rates.These results were corroborating with findings of Singh *et al.* (1985) who found that 1000-seed weight was increased withthe applicationof additional nutrients.

Seed yield

The data regarding mustard seed yield as influenced by different fertilizer rates (Figure 1). The tested fertilizer treatments affected mustard seed yield significantly. The highest mustard seed yield (1.68t ha^{-1}) was produced from the treatment T_6 where 25% extra NPK was added over the 100% STB fertilizer rate. This yield value was statistically higher than all other treatments except theT_3 treatment which was statistically similar. The native nutrient treatment T_8produced the lowest mustard seed yield (0.89 t ha^{-1}). Due to enhanced growth attributes that crop diverted the photosynthates to reproductive organs for the formation of seeds of large size and number that ultimately increased the yield. These results were in corroborates with those reported by Tomar*et al.* (1997), Jagvir*et al.* (2004)and Rao *et al.* (2006).

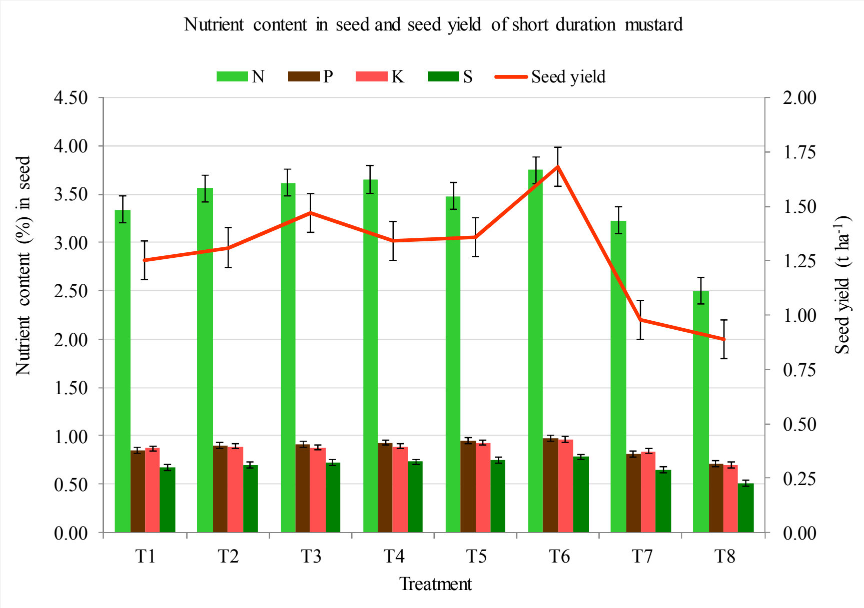

Fig. 1. Seed yield and nutrient contents in the seedof the short duration mustard var.BARI Sarisha-14 as influenced by nutrient rates.

Nutrient content in seed

Nutrients (N, P, K, and S) content in seedof short duration mustard was significantly affected by the nutrient rates (Figure 1). The highest amount of all the nutrients content was found in the treatment T6 that was followed by T_3 and T_4. The highest amount of N, P, K, and S content in seedof the treatment T_6 was 3.75, 0.97, 0.96, and 0.78%, respectively. Nutrients content was the lowest in T_8 where fertilizers not applied and it was followed by T_7 where 25% less amount fertilizers applied from T_1 (STB). The lowest amount of N, P, K, and S content in seedof the treatment T8 was 2.50, 0.71, 0.70 and 0.51%, respectively. Nutrients content had a harmonic relationship withseedyield. The results revealed that a higher amount of nutrient addition positively influenced to accumulate a higher amount of nutrient in seed. These results confirmed with the findings of Yadav*et al.* (2017).

Stover yield

Stover yield of mustard was significantly influenced by the application of different doses of chemical fertilizers (Table 4). The higheststover yield (2.96 t ha^{-1}) was recorded in treatment T_6 receiving 25% extra NPK over the 100% STB fertilizer rate and the lowest stoveryield (1.40 t ha^{-1}) was recorded in T_8 treatment. This result was mainly because an optimum fertilizer facilitated maximum utilization of nutrients which enhanced total dry matter production and development of other yield contributing components. The results also confirmed the findings of Jagvir*et al.* (2004) which agreed well with the results of the present study.

Percent increase in yield of grain and stover over controltreatment

The seed yield of mustard increased significantly due to the application of different levels of nutrients. The increase of seed yield over control (Native fertility) ranges from 4.49 to 88.76 % (Figure 2) and the highest yield increase (88.76 %) showed in T_6 treatment receiving 25% extra NPK over 100% STB fertilizer rate and the lowest yieldincrease in T_7 treatment.In the case ofstover yield, percent increase over the control ranged from 50 to 111.42 %, and the highest stover yield increase was found in T_6 treatment (111.42%) and lowest in T_7 treatment (50%).

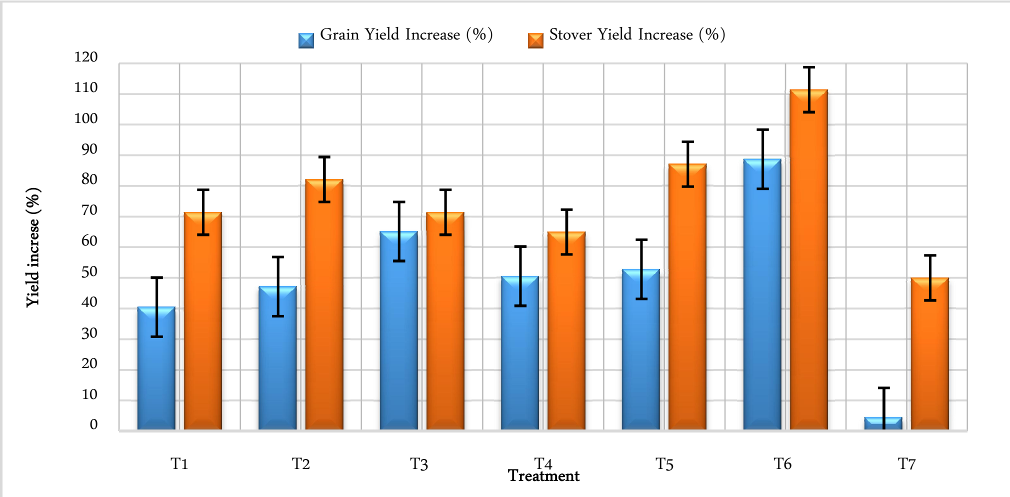

Fig.2.Seed (grain) and stover yield of mustard var. BARI Sarisha-14 increased (%) in the fertilized treatments (T_1 to T_7) over the controltreatment (T_8).

Conclusion

In the present study, it showed that the treatment T_6(100% recommended fertilizers based on soil test along with an additional dose of 25% NPK) gave the highest seed yield of short-duration mustard var. BARI Sarisha-14. Most of the growth parameters and yield components were also higher in this treatment which positively influenced seed and stover yields. Short-duration mustard var. BARI Sarisha-14 is one of the important crop components in the four-cropping pattern comprising Mustard-Mungbean-T.*aus*-T.*aman*. The findings concluded that an additional 25% NPK along withSTB fertilizer dose recommended for attaining better yield ofshort-duration mustard variety.

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