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Effect of sulphur containing fertilizer and poultry manure on the growth and yield of BARI Sarisha 15 in HSTU soil

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ABSTRACT

An experiment was conducted at the Soil Science research field of Hajee Mohammad Danesh Science and Technology University, Dinajpur during the period of September 2016 to February 2017 in order to investigate the effects of different levels of sulphur (S) and poultry manure (PM) on the yield and yield attributes of mustard (BARI sarisha 15). Four different levels of sulphur and three different levels of poultry manure were used as treatment viz. T_1 = 0 kg S + 0 t PM ha^{-1}, T_2 = 20 kg S + 0 t PM ha^{-1}, T_3 = 30 kg S+ 0 t PM ha^{-1},T_4 = 40 kg S + 0 t PM ha^{-1},T_5= 0 kg S + 5 t PM ha^{-1},T_6= 20 kg S + 5 t PM ha^{-1},T_7= 30 kg S + 5 t PM ha^{-1},T_8 = 40 kg S + 5 t PM ha^{-1},T_9 = 0 kg S + 10 t PM ha^{-1},T_{10} = 20 kg S + 10 t PM ha^{-1},T_{11} = 30 kg S + 10 t PM ha^{-1} and T_{12} = 40 kg S + 10 t PM ha^{-1}. The experimental results revealed that plant height, branches $plant^{-1}$, pod number, pod length, 1000-seeds weight, seed yield, stover yield, nitrogen content and sulphur content in the plant were significantly influenced by S and PM. The highest plant height (94.47cm) was observed in T_{11} treatment and the lowest (50.57cm) was found in the control treatment. The maximum number of branches (7.26) was produced in the treatment T_{11} and minimum number of branches (2.83) was found in the treatment T_1. The highest number of pod (19.37) was found in the treatment T_{12} which was statistically identical with T_{11} treatment. The lowest number of pod (8.53) was observed in the control treatment. Seed yield and stover yield of mustard plants were significantly influenced with the application of S along with PM. It was found that the application of 30 kg S ha^{-1} with 10 t PM ha^{-1} produced the highest seed and stover yield(418.33 kg ha^{-1}) and (506.33 kg ha^{-1}), respectively. The control treatment produced the lowest seed and stover yield (105.23 kg ha^{-1}) and (103.9 kg ha^{-1}), respectively. The findings of the study showed that the performance of the treatment T_{11} was the best among other treatments in respects of plant height, branches $plant^{-1}$, number of pod $plant^{-1}$, pod length, seed yield and stover yield of mustard. Therefore, 30kg S ha^{-1} with 10 t PM ha^{-1} is recommended for mustard cultivation.

Key words: BARI Sarisha 15, poultry manure, S containing fertilizer and stover yield

INTRODUCTION

Mustard is a major oil seed crop of Bangladesh. It is commonly known as 'sharisha' and is being cultivated throughout Bangladesh during winter season. Its seeds contain 40-45% oil and 20-25% protein (Hasanuzzaman et al. 2008). Edible oil plays a key role as a source of high energy component of food in human nutrition. Vegetable fats obtained from plant sources are safe for consumption for its cholesterol free nature. Mustard seed oil is not only rich source of energy (about 9kcalg^{-1}) but also rich in soluble vitamins A, D, E and K (Sharif et al. 2017). Mustard oil plays an important role as a fat substitute in our daily diet. This oil is widely used in cooking and medical ingredients. Moreover, mustard oilcake is used as feed for cattle and fish and also as good manure. Per capital oil and fat supply for the people of Bangladesh is only 7.5 kg per year (FAO 2010).

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Unfortunately its yield is only 0.735 t ha^{-1} which is very low. In Bangladesh about 3% of the total cropped area is used for edible oil seed with annual production of 23,23,000 metric tons, covering 3,03,249 hectares of land (BBS 2008). The country has to import more or less 1.9 million tons of edible oil. In 2007-08, around 1, 35, 328 million taka was spent for the import of 1.92 million tons of edible oil. Among the edible oil cultivation in 2015-16, mustard seed occupies 66% of the total oilseed area being the largest oilseed crop. It is possible to increase the yield per unit area by the use of high yielding variety coupled with an application of balance fertilizers.

The yield of mustard is very poor in Bangladesh as compared to other countries like India, Nepal, Canada, China and USA due to various factors (World Bank 2019). The competition of rice with other grains has shifted the cultivation of mustard to marginal land of poor productivity. In view of population growth the requirement of edible oil is increasing day by day. It is therefore, highly expected that the production of edible oil should be increased considerably to fulfill the demand.

Sulphur (S) is a secondary macro-nutrient, required for plant growth as in the same order as that phosphorus (Zhao et al. 1987). It is an important element for the cultivation of mustard and is directly or indirectly involved in several physiological and biochemical processes during plant growth (Sharma 2006). Several physiological and biochemical functions of plants such as water resolution, ion absorption, IAA (Indole Acetic Acid) metabolism, sugar translocation, cell division, photosynthesis, fruit and seed development is associated with S. The seed yield also noticeably increased up to 1.5 kg S ha^{-1} and beyond that the increment of S level the seed yield decreased steadily with the irrespective of variety tested. The seed yield of mustard increased from 15.5-68.55% due to S application (Chatterjee et al. 1985). Crops differ in their sensitivity to S deficiency. *Brassica* crops in general have a high S requirement (Hossain et al. 2011). The need for S fertilizers depends on the balance between inputs and losses by leaching and other pathways of removal from agriculture systems. Mustard is highly susceptible to S shortage and responds well to S fertilization (Hoque 2002). Good soil health depends on the application of organic manure and balance fertilizer in the field. But the farmers of Bangladesh normally use only the NPK fertilizers in the field but don't use the S containing fertilizer which plays a vital role to increase the yield by improving yield components, including the oil content (Dubey and khan 1991). Further, S nutrition of a crop often has a strong influence on the quality of the produce because of its essential role in the synthesis of amino acids (e.g. Cystine, Cysteine and Methionine), coenzymes (e.g. Biotin, coenzyme A, Thiamine, Pyrophosphate and Lipoic acid) and some secondary metabolites. S is responsible for characteristic taste and smell of mustard (Tisdale et al. 1984). S application increased an average oil content of seed from 40.46 to 45.05%. But in general, about 97% soils of Bangladesh are deficient in S and this deficiency is becoming acute day by day due to extensive use of S free fertilizers and intensive crop production (Begum 2012).

Poultry manure (PM) is a good source of organic nutrients, containing both macro and micronutrients, and its application can improve soil carbon content (Fronning et al. 2008) and further improve soil physical and chemical properties. At the same time, PM application could have some environmental issues, including antibiotics (Gao and Pedersen 2009), N, P and salt leaching into surface or groundwater (Jacob 1995) and the risk of spreading weed seed (Larney and Blackshaw 2003). PM is also an organic fertilizer that can apply in any type of soil. It is eco-friendly and has no toxicity. PM is also a good source of micronutrients which are very useful for mustard. In Bangladesh, farmers use only S fertilizers without PM. It is essential for mustard to use S fertilizer including PM. Therefore, the present study was undertaken to investigate the effect of S and PM on the growth and yield of mustard and to find out the optimum doses of S and PM on the yield of mustard.

MATERIALS AND METHODOLOGY

A field experiment was conducted in the Soil Science research field, Department of Soil Science in HSTU during November, 2016 to February, 2017. The field is located at 25.13° N latitude and 88.23°E longitudes at a height of 37.5m above the main sea level. The land was medium high belonging to the Old Himalayan Piedmont Plain (AEZ 1), which falls into Non Calcareous Brown Floodplain soils (UNDP and FAO 1988).The general characteristics of the soil are presented in Table 1.

The test crop under the study was mustard BARI sarisha 15. This variety has gained popularity among the farmers of Bangladesh for its high yield potential. Healthy, vigorous, plumy and well-matured seeds were selected for sowing. There were twelve treatments comprising two factors. The factors are -

Factor A- 4 levels of S (S_0, S_{20}, S_{30} and S_{40} kg ha^{-1})
Factor B- 3 levels of PM (PM_0, PM_5 and PM_{10} t ha^{-1})
Treatment combination will be as follows:
Here, $T_1=PM_0S_0$, $T_2=PM_0S_{20}$, $T_3=PM_0S_{30}$, $T_4=PM_0S_{40}$, $T_5=PM_5S_0$, $T_6=PM_5S_{20}$, $T_7=PM_5S_{30}$, $T_8=PM_5S_{40}$, $T_9=PM_{10}S_0$, $T_{10}=PM_{10}S_{20}$, $T_{11}=PM_{10}S_{30}$, $T_{12}=PM_{10}S_{40}$,
PM= Poultry manure and S= sulphur

Table 1. Morphological, physical and chemical characteristics of the soils of Soil Science research field of HSTU

Morphological characteristics	
Location	HSTU research field
AEZ	Old Himalayan Piedmont Plain
General soil type	Non Calcareous Brown Floodplain Soil
Drainage	Well drained
Topography	Medium high land
Textural class	Sandy loam
Chemical characteristics	
pH (soil: water = 1:2.5)	5.87
Organic matter (%)	1.719
Total N (%)	0.085
Available P (µg g^{-1})	14.60
Exchangeable K (meq 100g $^{-1}$ soil)	0.20
Available S (µg g^{-1} soil)	12.36

Land preparation was started 7 days before seed sowing. The land was first opened by a tractor and the land was prepared thoroughly by ploughing and cross ploughing with a power tiller. Every ploughing was followed by laddering to obtain a good tilth. Weeds and stubbles were collected and removed from the field. Field lay out was done on 15th October 2016, according to the design adopted. Finally individual plots were prepared with spade on 5th November 2016.

Sulphur containing fertilizer gypsum ($CaSO_4.2H_2O$) and poultry manure (PM) were applied as per design and treatments and all other fertilizers were applied according to the fertilizer recommendation guide (BARC 2003). The full amount of phosphorus, potassium and sulphur and one half of the nitrogen were applied during final land preparation in the form of triple super phosphate, muriate of potash, gypsum and urea, respectively. Another rest one half of nitrogen was applied 35 days after sowing (DAS).

Seeds were sown at the rate of 7 kg ha^{-1} (BINA 1998). Seeds were sown in the plots on 10th November, 2016. Sowing was made continuously in lines and seeds were covered by soil. The spacing between lines was 25 cm. Germination of seeds started from 4th day of sowing. On the 6th to 7th day all the seeds were germinated. Thinning and gap filling were done simultaneously at 16 and 30 days after sowing. Irrigation was given twice on 1st December 2016 and 25th December 2016 in order to maintain enough moisture in the field. The crop was harvested at maturity on 7th February 2017. The sample plants from each unit plot were uprooted at random prior to harvest, which were dried properly for collecting data on yield components. Per plot yields of seed and stover were recorded after drying the plants in the sun followed by threshing and cleaning.

Collection of plant samples: Plant samples were collected from the plot during harvesting. Ten plants from each plot were carefully uprooted through random selections with the help of a nirani. The fresh weight of plant samples were recorded and then dried in air followed by oven drying at 60^0 C for 48 hours and the dry weight of the plants were noted.

Shoot dry weight: The sun dried weight of shoots was recorded and the mean values were determined.

Preparation of plant and soil samples for chemical analysis: Seed and stover samples of all crops were separated and collected at the time of threshing. The plant (seed and stover) samples were oven dried at 65-70^{0}C for 72 hours. The dried plant samples were finely ground by using a Willy- Mill with stainless contact points to pass through a 60-mesh sieve. The initial and post-harvest soil samples were stored for analysis of pH, organic matter, N, P, K and S contents. The plant samples were stored for analysis of N, and S contents. The standard methods used for plant and soil samples analysis were as follows:

Elements	Methods
N	Micro-Kjeldahl method: The plant sample was digested with conc. H_2S0_4 in presence of catalyst mixture (K_2SO_4: $CuSO_4$: Se = 10: 1: 0.1). Nitrogen in the digest was estimated by distillation with 10N NaOH followed by titration of the distillate trapped in H_3BO_3indicator solution with 0.01 N H_2S0_4).
P	Available phosphorus was extracted from the soil with 0.5 M sodium bicarbonate solution, pH 8.5 (Olsen et al. 1954). Phosphorus in the extract was then determined by developing blue color with $SnCl_2$ reduction of phosphomolybdate complex and the color intensity was measured colorimetrically at 660 nm wave lengths (Page et al.1989).
K	Exchangeable potassium was determined from the ammonium acetate extract using flame photometer as described by Page et al. (1989).
S	Available sulfur was determined by extracting the soil sample with 0.01M $Ca(H_2P0_4)_2$. The S content in the extract was estimated turbid metrically and the intensity of turbid was measured by spectrophotometer at 420 nm wavelength.

Estimationof total nitrogen from soil: The total nitrogen of each sample was estimated by the Micro-kjeldahl method through the digestion of organic matter by concentrated sulphuric acid (H_2S0_4) which was then mixed with sodium hydroxide (NaOH) for distillation. The distilled ammonia was received in boric acid (H_3BO_3) and mixed indicator solution of bromocessol green ($C_{21}H_{14}Br_4O_3S$) and methyl red ($C_{15}H_{15}N_3O_2$) and was titrated against a standard H_2SO_4 until the end point appeared from green to pink (PCARR 1980). The amount of N was calculated by using the following formula:

$$\% N = (T - B) \times N \times 1.4 / S$$

Where, T =Sample titration mL standard H_2SO_4.
B =Blank titration mL standard H_2SO_4.
N=Normality of H_2SO_4.
S=Sample weight.

Statistical analysis: All the collected data were subjected to statistical analysis following the ANOVA technique and the mean were compared by Duncan's New Multiple Range Test.

RESULTS AND DISCUSSION

Effect of sulphur (S) and poultry manure (PM) on the growth of mustard: The height of mustard plant was influenced significantly by different treatments (Table2). The application of S and PM increased the plant heights of mustard compared to that found in control. Different levels of S and PM produced the different plant height at maturity stage. Probably PM ensure nutrients and favorable condition for plant growth of mustard and ultimate result of tallest plant height. The plant height increased progressively with the application of increasing level of S and PM. The highest plant height (94.47 cm) was recorded in T_{11} with the application of 30 kg S ha^{-1} along with 10 t ha^{-1} PM which was statistically identical toT_5, T_{10} and T_{12}. This might be due to the high membrane permeability of S (Eichert and Goldbach2010) which is important in cell elongation, cell division and transpiration (Azza et al. 2006). The lowest plant height (50.57cm) was recorded in control T_1 (without any S and PM application). This decrease in plant height in control might be due to the S deficiency.

The effect of different levels of S and PM was significant as observed on number of branches plant^{-1}. The number of branches per plant increased with increasing S and PM levels. The maximum number of branches per plant (7.267) was obtained with T_{11}treatment which was closely followed by the treatment T_{10}.The lowest number of branches (2.83cm) was obtained with T_1treatment (Table 2). S and PM ensure favorable growth condition for mustard and ultimate result was the maximum number of branches. Rana et al. (2001) found that application of 40 kg S ha^{-1} significantly increased the number of primary branches in taramira cultivar. Piri et al. (2012) explained that the increase in number of primary branches of plant with 45 kg S ha^{-1} may be enhanced photosynthesis, as S is involved in the formation of chlorophyll and activation of enzymes.

Length of pod showed considerable increases with the increment of S and PM (Table 2). The highest length 4.64 cm was recorded in the treatment combination of T_{12} which was statistically similar to T_{10} and T_{11}. On the other hand the lowest length 2.98 cm obtained in the treatment T_1.This was probably due to the effect of S and PM on the length of pod. Similar results were reported by (Khalid et al. 2009). McGrath and Zhao (2002) reported that sulphur is mainly responsible for enhancing the reproductive growth and the proportion of the reproductive tissues (inflorescences and pods) in total dry matter content in rapeseed.

Pod plant^{-1} showed variation for different level of S and PM (Table2). The number of pod per plant enhanced with increasing doses of S and PM. The maximum pod per plant (20.00) was obtained with T_{10}which was statistically identical to $T_{11}$and T_{12}. The lowest pod number was found in the control treatment T_1.

S and PM influenced on the 1000 seed weight of mustard (Table2). The weight of 1000 seed increased with increasing levels of S up to 30 kg ha^{-1}and PM up to 10 t ha^{-1}. The highest 1000 seed weight (2.857g per plant) was recorded from the treatment T_{11} which was identical to the treatment T_{10}. The lowest weight (0.86g per plant) was recorded under control treatment. This might be due to the S role in translocation of photo assimilates from vegetative to reproductive parts of the crop and also its role in fruit and seed development that was supported by Agrawal and Gupta (2009).

The grain yield was significantly influenced by the treatments. Application of PM along with different levels of S showed the variation for seed yield per plant (Figure 1). The highest seed yield (418.33 kg ha^{-1}) was obtained in the treatment T_{11} which was closely identical to the treatment T_7. The lowest seed yield (105.23 kg ha^{-1}) was recorded in the control treatment. Many researchers stated that S and PM performed many functions in plant during growth, development and seed development (Marschner 1995). The seed weight per plant produced that is similar with the findings of Islam and Anwar (1994), they reported that application of S and PM increased significantly the number of pod plant^{-1}, number of seeds pod^{-1} and seed weight of mustard.

Table 2. Effect of sulphur (S) and poultry manure (PM) on yield and yield contributing characters of mustard (BARI Sarisha 15)

Treatment	Plant height (cm)	No. of Branches plant^{-1}	No of pod plant^{-1}	Pod length (cm)	1000 Seed weight (g)	Seed weight (g) plant^{-1}	Stover weight (g) plant^{-1}
T_1	50.57 c	2.83 e	8.53 e	2.98 f	0.86 c	1.25 d	0.83 d
T_2	61.47 bc	3.46 de	12.33 de	3.45 ef	1.14 c	1.50 d	1.14 d
T_3	67.13 bc	3.86 de	16.27ad	3.84 cde	1.31 c	1.69 cd	1.64 cd
T_4	74.83 abc	4.80 be	17.50 abc	3.97 be	1.66 bc	2.14 bcd	1.44 cd
T_5	78.27 ab	6.06 ab	18.50 ab	4.25 abc	1.62 bc	2.10 bcd	1.82 bcd
T_6	69.57 abc	4.40 be	14.07 bcd	4.06 bcd	1.10 c	1.39 d	1.01 d
T_7	66.97 bc	4.90 bcd	17.50 abc	4.01 be	1.69 bc	2.15 bcd	1.67 cd
T_8	61.90 bc	4.03 cde	14.17 bcd	3.567 de	1.61 bc	2.21 bcd	1.60 cd
T_9	57.37 bc	4.13 be	13.67 cd	3.49 def	1.18 c	1.68 cd	1.10 d
T_{10}	93.17 a	7.03 a	20.00 a	4.517 ab	2.53 a	2.90 b	2.29 bc
T_{11}	94.47 a	7.26 a	18.70 ab	4.31 abc	2.85 a	4.55 a	3.73 a
T_{12}	94.07 a	5.93 abc	19.37 a	4.64 a	2.28 ab	2.82 bc	2.70 b
LSD	23.00	1.74	4.15	0.53	0.76	1.01	0.92
CV %	18.72	21.00	15.44	7.98	27.45	27.10	31.17

In the column, figures having similar letter(s) do not differ significantly at 5% level of probability. Here, $T_1=PM_0S_0$, $T_2=PM_0S_{20}$, $T_3=PM_0S_{30}$, $T_4=PM_0S_{40}$, $T_5=PM_5S_0$, $T_6=PM_5S_{20}$, $T_7=PM_5S_{30}$, $T_8=PM_5S_{40}$, $T_9=PM_{10}S_0$, $T_{10}=PM_{10}S_{20}$, $T_{11}=PM_{10}S_{30}$, $T_{12}=PM_{10}S_{40}$, PM= Poultry manure and S= sulphur

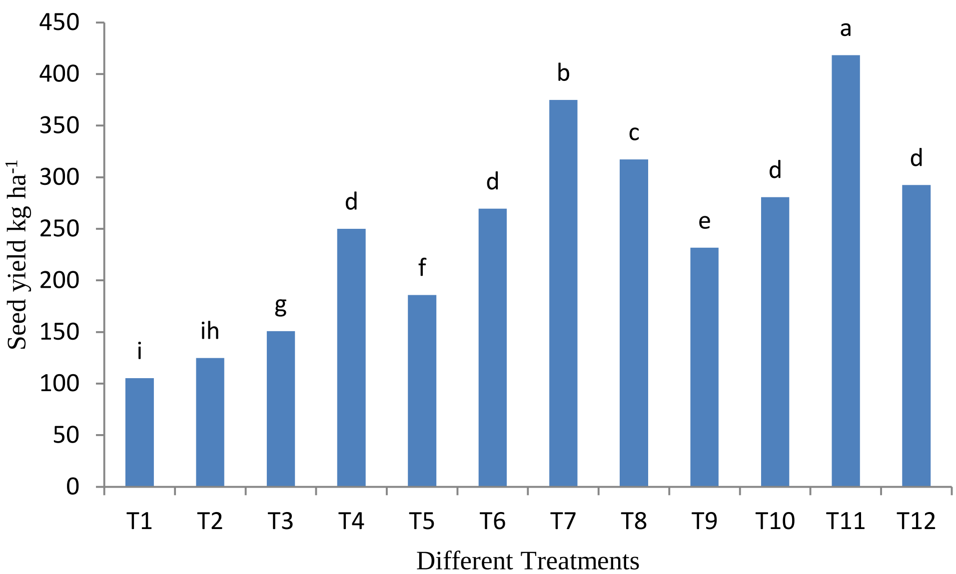

Figure 1. Effects of sulphur (S) and poultry manure (PM) on the seed yield of BARI sarisha 15, Here, $T_1=PM_0S_0$, $T_2=PM_0S_{20}$, $T_3=PM_0S_{30}$, $T_4=PM_0S_{40}$, $T_5=PM_5S_0$, $T_6=PM_5S_{20}$, $T_7=PM_5S_{30}$, $T_8=PM_5S_{40}$, $T_9=PM_{10}S_0$, $T_{10}=PM_{10}S_{20}$, $T_{11}=PM_{10}S_{30}$, $T_{12}=PM_{10}S_{40}$, PM= Poultry manure and S= sulphur

The effects of S and PM fertilizers on stover yield were significant (Figure 2). Application of S and PM at different levels showed the variation for stover yield per hectare. Like grain yield, stover yield was also significantly influenced by S and PM fertilization up to 40 kg ha^{-1}. The increased stover yield might be accounted for the luxuriant growth of plant as well as increased number of primary branches per plant. The highest stover yield (506.33 kg ha^{-1}) of mustard was observed in T_{11} which was statistically superior to other treatments. However, the lowest stover yield (103.9 kg ha^{-1}) was recorded in the control treatment. The results obtained in the present study are in agreement with the findings of Jaggi and Sharma (1997). Different levels of S and PM with respect to stover yield accumulation were also showed the same trend, as did the grain yield. The accumulation of higher stover yield at 30 kg S ha^{-1} and 10 t PM ha^{-1} might be due to the fact that primarily S is used to encourage above ground vegetative growth. S-deficiency in plants resulted in a decrease in leaf area than at S- supplied plants are supported by the finding of Tiwari et al. (1994). Sulphur deficiency induced inhibition of stover yield accumulation may be due to S-deficiency induced decrease in carbohydrate synthesis. This view is supported by the finding of S-deficient leaves fixed 25% less $C0_2$ than the normal plants which might result in a decrease in the accumulation of stover yield. The application of S and PM favored the highest level of stover yield.

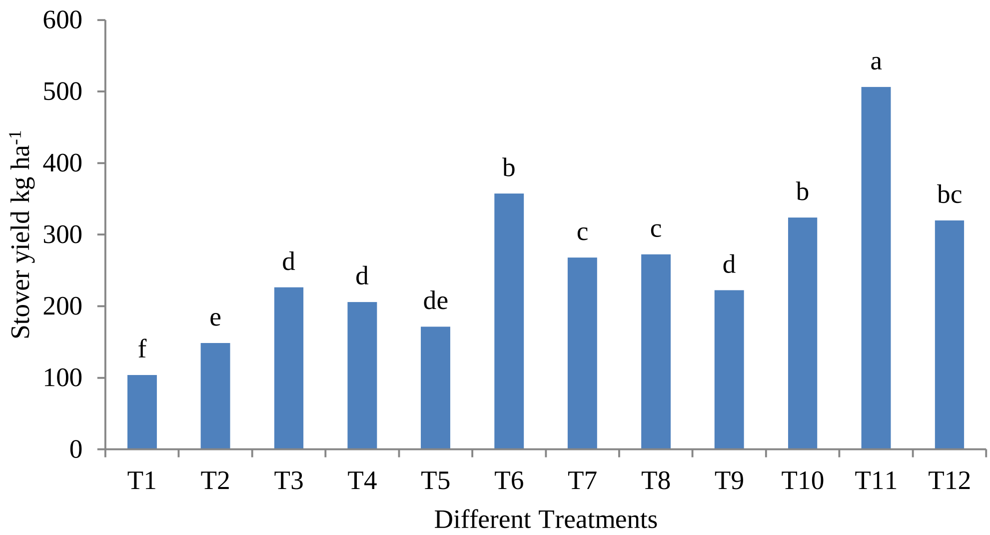

Figure 2. Effects of sulphur (S) and poultry manure (PM) on the stover yield of BARI sarisha 15, Here, $T_1=PM_0S_0$, $T_2=PM_0S_{20}$, $T_3=PM_0S_{30}$, $T_4=PM_0S_{40}$, $T5=PM_5S_0$, $T_6=PM_5S_{20}$, $T_7=PM_5S_{30}$, $T8=PM_5S_{40}$, $T9=PM_{10}S_0$, $T_{10}=PM_{10}S_{20}$, $T_{11}=PM_{10}S_{30}$, $T_{12}=PM_{10}S_{40}$, PM= Poultry manure and S= sulphur

Chemical Properties of the soil collected after harvesting: The post-harvest soil was slightly acidic, soil pH ranged from 5.89 to 6.85 (Table 3). The control treatment showed slightly increases in soil pH than the initial soil. There were no significant differences among the treatments of the post-harvest soil. The study proved that soil reaction remained more or less same in the post-harvest soils compared to initial soil.

The effect of S and PM was significant on organic matter (OM) content in the soil. The application of S and PM increased the organic matter status in the soil. Organic matter content of the post-harvest soil was balanced proportional to the initial soil (Table2). The treatments were statistically analogous except T_1.

The application of S and PM has a significant effect on total nitrogen in soil. S and PM increased the total soil N in different treatments. Soil N of the post-harvest soil was higher than the initial soil. The post-harvest soils have more or less same N percent. The highest soil N was found both in T_6 and T_7 treatments and the lowest soil N was found in the T_3 treatment soil (Table3).

The available phosphorus (P) content of the post-harvest soil varied significantly by different treatments (Table3). The maximum P content was found in the treatment T_{11}which was closely followed by T_{10} and T_{12} treatments. The lowest P content was observed in the control treatment (T_1). The P content in the treatments T_{10}, T_{11} and T_{12} were statistically identical.

The exchangeable potassium (K) content of the post-harvest soil was influenced by the different treatments. The values of the exchangeable K were traveling around from 0.31 to 0.47 meq100g^{-1} soil (Table3). The utmost value was observed in the treatment T_{11} which was identical to T_8, T_{10} and T_{12} treatment soil. The lowest value was found in the T_3 treatment.

The post-harvest soil which content available sulphur (S) was different for the different treatments. The available S content in the studied soil ranged from 32.48 to 91.51 µg g^{-1} soil (Table3). The highest S content (91.51 µg g^{-1}soil) was found in the treatment T_{11} which was statistically similar to those in T_8, T_{10} and T_{12} treatments. The lowest S (32.48µg g^{-1} soil) was observed in the treatment T_2.

Table 3. Effect of sulphur (S) and poultry manure (PM) on the soil pH, organic matter content, total N, available P, S and exchangeable K of the post-harvest soil

Treatment	pH	Organic matter content (%)	Total N (%)	Available P (ppm)	Exchangeable K (meq100g^{-1} soil)	Available S (ppm)
T_1	6.80	1.79 bc	0.11 ab	34.61 g	0.32 ef	32.48 f
T_2	5.90	2.40 abc	0.12 ab	45.94 ef	0.36 def	38.85 d
T_3	5.89	2.21 abc	0.10 ab	44.10 ef	0.31 f	34.71 ef
T_4	6.78	2.41 abc	0.13 ab	42.40 f	0.37 de	36.12 def
T_5	6.85	2.49 abc	0.14 ab	47.14 ef	0.38 cd	39.15 d
T_6	6.64	2.50 abc	0.15 a	49.16 e	0.35 def	37.45 de
T_7	6.81	2.61 a	0.15 a	64.14 d	0.44 ab	74.23 c
T_8	6.70	2.58 ab	0.13 ab	71.62 c	0.46 a	89.21 a
T_9	6.54	2.47 abc	0.11 ab	76.23 bc	0.40 bcd	85.22 b
T_{10}	6.70	2.68 a	0.13 ab	81.62 ab	0.46 a	90.23 a
T_{11}	6.71	2.67 a	0.12 ab	82.71 a	0.47 a	91.51 a
T_{12}	6.68	2.58 ab	0.11 ab	80.15 ab	0.43 abc	89.95 a
LSD	1.36	0.70	0.05	5.81	0.05	3.65
CV %	12.40	16.02	15.22	6.11	10.00	3.76

In the column, figures having similar letter(s) do not differ significantly at 5% level of probability. Here, T_1=PM_0S_0, T_2=PM_0S_{20}, T_3=PM_0S_{30}, T_4=PM_0S_{40}, T_5=PM_5S_0, T_6 =PM_5S_{20}, T_7=PM_5S_{30}, T_8=PM_5S_{40}, T_9=$PM_{10}S_0$, T_{10}=$PM_{10}S_{20}$, T_{11}=$PM_{10}S_{30}$, T_{12}=$PM_{10}S_{40}$, PM= Poultry manure and S= sulphur

Chemical properties of the plant shoot after harvesting

Nitrogen (N) content in shoots: Nitrogen (N) content in the mustard plants was markedly influenced by the different treatments (Table4). The content of N by the mustard plants varied between 0.78 and 2.04%. The highest content of N was found in the treatment T_{11}which was closely associated with the value of T_{12}treatment. The lowest content of N was observed in the control treatment (T_1) which was significantly alike with T_3, T_6 and T_7 treatments. The shoots of the treatments $T_8$and T_9 content around similar nitrogen and the lowest was showed in treatment T_1.

Table4. Nitrogen (N) and sulphur (S) content in the shoots of mustard plants

Treatment	N content in shoot (%)	S content in shoot (%)
T_1	0.78 f	39.20 cd
T_2	1.62 b	39.00 cde
T_3	0.98 ef	47.30 ab
T_4	1.20 de	47.30 ab
T_5	1.26 cde	31.70 e
T_6	1.00 ef	39.41 cd
T_7	0.95 ef	36.87 de
T_8	1.45 bcd	40.56 bcd
T_9	1.47 bcd	38.62 de
T_{10}	1.54 bc	46.22 abc
T_{11}	2.04 a	49.86 a
T_{12}	2.01 a	38.00 de
LSD	0.28	6.64
CV %	12.56	9.53

In the column, figures having similar letter(s) do not differ significantly at 5% level of probability. Here, T_1=PM_0S_0, T_2=PM_0S_{20}, T_3=PM_0S_{30}, T_4=PM_0S_{40}, T_5=PM_5S_0, T_6 =PM_5S_{20} T_7=PM_5S_{30}, T_8=PM_5S_{40}, T_9=$PM_{10}S_0$, T_{10}=$PM_{10}S_{20}$, T_{11}=$PM_{10}S_{30}$, T_{12}=$PM_{10}S_{40}$, PM= Poultry manure and S= sulphur

Sulphur (S) content in shoots: The content of sulphur (S) in the plant shoots of mustard was different for the different treatments combination. The S content of the different treatments ranged from 31.70 to 49.86 % (Table4). The maximum content of S (49.86%) was found in the treatment T_{11} which was statistically similar to the T_3, T_4 and T_{10} treatments. The lowest S content (31.70%) in the shoots was found in the treatment T_5 which was closely identical to the T_7, T_9 and T_{12} treatments and showed the lowest in control treatment (T_1).

CONCLUSION

The treatment combination of $PM_{10}S_{30}$ followed by $PM_{10}S_{20}$ and $PM_{10}S_{40}$ of BARI sarisha 15 produced higher values of yield components, whereas the lowest yield was recorded in the treatment PM_0S_0 followed by PM_0S_{20}. However for maximizing the grain yield of mustard 30 kg S ha^{-1} and 10 t PM ha^{-1}could be applied.

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