Response of Nitrogen and Sulphur Fertilizers on Yield, Yield Components and Protein Content of Oilseed Mustard (*Brassica* spp)

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Abstract

An experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, to observe the effect of different levels of nitrogen and sulphur on growth, yield, yield contributing characters and protein content in seed of mustard (SAU Sharisha-1). The experiment consists of four levels of nitrogen i.e. fertilizer treatments consisted of 4 levels of nitrogen (0, 40, 80 and 120 kg N ha^{-1} designated as N_0, N_1, N_2 and N_3, respectively) and 4 levels of sulphur (0, 8, 16 and 24 kg S ha^{-1} designated as S_0, S_1, S_2 and S_3 respectively).The experiment was laid out in the two factors RCBD with three replications. The plant height, the number of branches plant^{-1}, the number of siliqua plant^{-1}, seed and shoot yield increased with increasing N level up to 80 kg N ha^{-1}. Further increasing in N level i.e. 120 kg N ha^{-1} had a negative effect on seed yield. On the other hand , with increasing S levels plant height, slilqua plant^{-1}, 1000 seed weight increased significantly up to 16 kg S ha^{-1}. However, the number of branches plant^{-1} and seed yield and shoot yield increased up to the highest dose of S (24 kg S ha^{-1}). Considering the combined effect of N and S, the treatment combination N_2S_3 produced the maximum seed yield (1738 kg ha^{-1}). Protein content increased from 19.38% to 21.81% as S rate was increased from 0 to 16 kg ha^{-1}. The highest N level resulted in the highest values for protein (22.31%).

1. Introduction

Mustard (*Brassica* spp) has a remarkable demand for edible oil in Bangladesh. Mustard tops the list among the oil seed crops grown in this country in respect of both production and acreage (BBS, 2004). In the year of 2003-04 it covered 1.79 lakhs ha land and the production was 2.11 lakhs mt, whereas the total oilseed production was 4.07 lakhs mt and total area covered by oilseed corps was 3.89 lakhs ha. In the year of 2004-05 it covered 3.95 lakhs ha land and the production was 3.79 lakhs mt (BBS, 2005). Edible oil is an essential integral part of the daily diet of the people in Bangladesh. Bangladesh is suffering from acute shortage of edible oil in terms of domestic production. About two thirds of the total edible oil consumed in the country is imported. Although the domestic production has considerably increased the deficiency has not reduced due to increased requirement of edible oil. Mustard plant belongs to the genus *Brassica* under the family cruciferae. The *brassica* has three species that produce edible oil, *B. napus*, *B. campestris*, *B. juncea*. Of these *B. napus* and *B. campestries* have the greatest importance in the world's oilseed trade. In this subcontinent, *B. juncea* is also an important oilseed crop. Until recently, mustard varieties such as Tori-7, sampad (both are *B. campesties*) and Doulat B. juncea were mainly grown in this country. Recently MM-2-16-98. MM-34-7, MM-38-6-98, MM-49-3-98, Binasarisha-4 are high yielding mutants/varieties have been developed by the scientist of Bangladesh institute of nuclear agriculture (BINA). Very recently, a new variety of mustard named SAU-sharisha has been developed in Sher-e-Bangla Agricultural University. Mustard oil is being used as a medium of cooking from time immemorial (Khaleque, 1985). However; the production of mustard is hampered due to many reasons of which suitable varieties, inadequate use of fertilizers such as nitrogen and sulphur fertilizer are very important for the cultivation of mustard in Bangladesh. The importance of NPK for increasing production is well recognized but sulphur which is ranking third or fourth in the mineral composition of plants and is essential for the synthesis of proteins, vitamins and sulphur containing amino acid has been ignored (Kanwar, 1984). Nitrogen is the most spectacular of all essential nutrients in its effect on plant growth and yield of this crop. The literature shows that nitrogen has significant effect on plant height, branches plant^{-1}, pods plant^{-1} and other growth factors and yield of mustard (Mondal and Gaffer; 1983; Allen and Morgan; 1972). Nitrogen increases the vegetative growth and delayed maturity of plants. Excessive use of this element may produce too much of vegetative growth, thus fruit production may be impaired (Sheppard and Bates, 1980; Singh et al.; 1972). Moreover, nitrogen and sulphur are closely related with one another because both of these elements are required for protein synthesis and their amount in plant tissue always maintained at constant ratio (Dijshorn et al., 1960). In addition, the fertilizer requirement for maximum growth and yield of newly developed mustard variety SAU-Sharisha is not much investigated. With a view to determine the nitrogen and sulphur requirement of this new variety a field study was conducted with the objective to observe the growth and yield performance of SAU mustard variety by using different levels of nitrogen and sulphur.

2. Materials and Methods

The experiment was conducted at the Research farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during November 2006 to February 2007.The experimental site was located at $23^0 77'$ N latitude and $90^0 3'$ E longitude with an elevation of 1.0 meter from sea level. Primary soil samples were collected from the experimental plots to a depth of 0-15 cm from the surface before initiation of the experiment and analyzed in the laboratory. The initial soil texture was Clay loam, Soil pH - 5.81, Organic carbon (%) 5.8, Total N (%) 0.08, C: N ratio 9.75: 1, Available P (ppm) 35, Exchangeable K (me 100 g^{-1} soil) 0.18, Available S (ppm) 40, Available B (ppm) 0.34.The experimental area has sub tropical climate characterized by heavy rainfall during May to September and scantly rainfall during rest of the year. The annual precipitation of the site was 2152 mm and potential evapotranspiration was 1297 mm, the average maximum temperature was 30.34^0C and average minimum temperature is 21.21^0C. The average mean temperature was 25.17^0C. The humidity varies from 61.72% to 70.45%.

SAU Sharisha-1 (*Brassica campestris*) was used as a test crop which is a medium yielding and short duration mustard variety.The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications of each fertilizer treatment combinations. Fertilizer treatments consisted of 4 levels of N (0, 40, 80 and 120 kg N ha^{-1} designated as N_0, N_1, N_2 and N_3 respectively) and 4 levels of S (0, 8, 16 and 24 kg S ha^{-1} designated as S_0, S_1, S_2 and S_3 respectively). There were 16 treatment combinations. Each block consisted of 16 plots and individual plot was 2.5 m × 2m i.e. 5 sq. m in size. The row-to-row and seed to seed distance were 30 and 5 cm respectively accommodating 250 plants in each plot. The adjacent block and neighboring plots were separated by 1.0 m and 0.5 m, respectively.

The land was first ploughed with a tractor drawn disc plough after that the soil was brought into desirable tilth condition by four operations of ploughing and harrowing with country plough and ladder. The stubbles of the previous crops and weeds were removed. The individual plots were made by making ridges (20 cm high) around each plot to restrict lateral runoff of irrigation water.

The P K and Zn fertilizer were applied at the rate of 20, 50 and 2 kg ha^{-1} according to Fertilizer Recommendation Guide (BARC, 2005) through Triple super phosphate (TSP), Murate of potash (MOP) and Zinc oxide, respectively. One third of whole amount of Urea and full amount of MOP, TSP and Zinc oxide were applied at the time of final land preparation. The remaining Urea was top dressed in two equal installments- at 25 days after sowing (DAS) and 40 DAS respectively.

Seeds were sown continuously @ 7 kg ha^{-1} on 8^{th} November 2006 by hand as uniform as possible in the 30 cm apart lines. A strip of the same crop was established around the experimental field as border crop. Plant population was kept 200 $plot^{-1}$. After sowing the seeds were covered with soil and slightly pressed by laddering.

Different types of weeds were removed manually for the first time and at 10 days of sowing. The final weeding and thinning were done after 25 DAS. Care was taken to maintain constant plant population $plot^{-1}$.

The first irrigation was given in the field at 25 days after sowing (DAS) through irrigation channel. The second irrigation was given at the stage of maximum flowering (35DAS). The final irrigation was given at the stage of seed formation (50 DAS). The crop was infested with aphids (*Lipaphi erysimi*) at the time of siliqua filling. The insects were controlled successfully by spraying Malathion 50 EC @ 2ml l^{-1} water. The insecticide was sprayed thrice. The crop was kept under constant observations from sowing to harvesting.

Ten (10) plants from each plot were selected at random and were tagged for the data collection. Some data were collected from sowing to harvesting with 15 days interval and some data were collected at harvesting stage. The sample plants were uprooted prior to harvest and dried properly in the sun. The crop was harvested plot wise when 90% siliquae were matured; harvesting was done on 08 February 2007. The seed yield and stover yield $plot^{-1}$ were recorded after cleaning and drying those properly in the sun. Data were collected on the following parameters:1) Plant height (cm) , 2) Number of primary branch $plant^{-1}$, 3) Number of siliquae $plant^{-1}$, 4) Number of seeds $siliqua^{-1}$, 5) Weight of 1000-seeds (g) , 6) Seed yield (t ha^{-1}), 7) Stover yield (t ha^{-1}), 8) Protein content in seed. Particle size analysis of the soil was done by hydrometer method (Bouyoucos, 1927). The textural class was determined using

Marshell's Triangular co-ordinate as designated by USDA (1951). Soil organic carbon was estimated by Walkley and Black's wet oxidation method, Jackson (1973).The C/N ratio was calculated from the percentage of organic carbon and total N. Soil organic matter content was calculated by multiplying the percent value of organic carbon with the Van Bemmelen factor, 1.724 as described by Piper (1942). The pH of the soil was determined with the help of a glass electrode pH meter using soil: water ratio being 1:2.5 (Jackson, 1973). Total nitrogen content in soil was determined by Kjeldahl method by digesting the soil was sample with conc. H_2SO_4, 30% H_2O_2 and catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se = 10:1:0.1) followed by distillation with 40% NaOH and by titration of the distillate trapped in H_3BO_3 with 0.01 N H_2SO_4 (Black, 1965). Available S in soil was determined by extracting the soil samples with 0.15% $CaCl_2$ solution (Page et al., 1982). The S content in the extract was determined turbidimetrically and the intensity of turbid was measured by spectrophotometer at 420 nm wavelength. Available phosphorus was extracted from the soil with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen et al., 1954). Phosphorus in the extract was measured by spectrophotometrically after development of blue color (Black, 1965).Exchangeable potassium (K) content of the soil sample was determined by flame photometer on the NH_4Oac extract (Black, 1965). For determination of N content in seed the sample were first digested with acid and determination of elements in the digest was performed by titration.

For N, digestion was done with conc. H_2SO_4 and digest was distilled over following the appropriate procedure (Black, 1965). Protein content in seeds was estimated by multiplying N (%) in seeds with 6.25.

The collected data were statistically analyzed by using the ANOVA technique. The test of significance of all parameters was done. The Duncan`s Multiple Range Test (DMRT) with Least Significant Difference value was determined with appropriate levels of significance and the means were tabulated. The mean comparison was carried out by DMRT technique (Gomez and Gomez, 1984).

3. Results and Discussion

1.1. Plant height

Effect of nitrogen showed a statistically significant variation for plant height of mustard under the present trial (table 1). The tallest plant (88.0 cm) was recorded from N_2 treatment which was statistically similar (85.7 cm) with the treatment N_3. The plant height increased significantly with increasing levels of N up to 80 kg N ha^{-1} (N_2). Probably 80 kg N ha^{-1} ensured the other nutrients and favorable condition for growth of mustard plant and the ultimate results is the tallest plant. Ali et al. (1990), Mondal and Gaffer (1983), Gaffer and Razzaque (1983), Asaduzzaman and Shamsuddin (1986) also reported the similar results from their experiment. They reported that different levels of nitrogen significantly increased plant height of mustard.

Different levels of sulphur also exhibited statistically significant differences for plant height (table 2). With increasing the doses of S, the plant height increased significantly up to the highest dose 24 kg S ha^{-1} (S_3) and the maximum plant height was 83.9 cm. These findings are comparable with Tomer et al. (1997) who reported that plant height, number of branches increased significantly with the increasing levels of sulphur fertilizers. On the other hand the shortest plant height (79.6 cm) was recorded from S_0 treatment i.e. control condition under the present trial.

Significant interaction effect was also observed between nitrogen and sulphur in consideration of plant height under the present experiment (table 3). The tallest plant (93.0 cm) was recorded from the treatment combination N_2S_3 comprising of 80 kg N ha^{-1} + 24 kg S ha^{-1}, while the shortest plant (72.0 cm) was recorded from N_0S_0 i.e. no nitrogen no sulphur.

3.2. Branches plant^{-1}

A statistically significant variation for branches plant^{-1} of mustard was recorded for the effect of nitrogen. The number of branches plant^{-1} increased significantly with increasing N levels upto the treatment N_2 comprising of 80 kg N and the maximum number of branches plant^{-1} (7.05) was obtained with this treat-

Table 1: Main effect of nitrogen on yield, yield contributing characters and protein content of mustard

Nitrogen	Plant height (cm)	Branches plant^{-1}	Siliqua plant^{-1}	Seed siliqua^{-1}	1000 seeds weight (g)	Seed yield (kg ha^{-1})	Shoot yield (kg ha^{-1})	Protein Content (%)
N_0	73.5 c	5.08 c	77.7 c	17.7 c	2.28 d	908 d	757d	17.81c
N_1	79.0 b	6.75 b	108 b	20.3 b	2.55 c	1098 c	1097c	20.50b
N_2	88.0 a	7.05 a	150 a	21.5 a	2.73 b	1535 a	1552a	22.18a
N_3	85.7 a	7.05 a	151 a	21.9 a	2.76 a	1431 b	1394b	22.31a
LSD (p=0.05)	2.576	0.112	1.930	0.966	0.026	18.01	21.2	0.431

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

Table 2: Main effect of sulphur on yield, yield contributing characters and protein content of mustard

Nitrogen	Plant height (cm)	Branches plant^{-1}	Siliqua plant^{-1}	Seed siliqua^{-1}	1000 seeds weight (g)	Seed yield (kg ha^{-1})	Shoot yield (kg ha^{-1})	Protein Content (%)
S_0	79.6 b	5.93 d	109 c	19.83 b	2.46 c	1078 d	1168d	19.38c
S_1	80.4 b	6.29 c	125 b	19.8 b	2.53 b	1161 c	1201c	20.19b
S_2	82.2 ab	6.79 b	126 ab	20.7 ab	2.67 a	1340 b	1369b	21.81a
S_3	83.9 a	6.93 a	127 a	21.2 a	2.65 a	1394 a	1236a	21.38a
LSD (p=0.05)	2.576	0.112	1.930	0.966	0.026	18.01	21.2	0.431

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

Table 3: Interaction effects of nitrogen and sulphur on yield, yield contributing characters and protein content of mustard

Nitrogen × Sulphur	Plant height (cm)	Branches plant^{-1}	Siliqua plant^{-1}	Seed siliqua^{-1}	1000 seeds weight (g)	Seed yield (kg ha^{-1})	Shoot yield (kg ha^{-1})	Protein Content (%)
N_0S_0	72.0 h	4.77 h	71.3 l	16.0 g	2.10 i	850 i	918i	17.19i
N_0S_1	72.8 gh	4.80 h	72.0 l	16.7 fg	2.25 h	882 i	903i	17.93hi
N_0S_2	73.3 efg	5.22 g	77.3 k	18.1 ef	2.35 g	946 h	931h	18hi
N_0S_3	75.7 efgh	5.53 f	90.0 j	20.1 de	2.42 f	954 h	975h	18.125hi
N_1S_0	78.0 defg	6.40 de	96.0 i	20.7 cd	2.45 f	1038 g	1016g	18.44gh
N_1S_1	78.7 def	6.60 d	119 g	20.7 cd	2.47 f	962 h	981h	19.125g
N_1S_2	79.7 cde	7.00 c	110 h	20.0 de	2.65 d	1238 e	1226e	21.88de
N_1S_3	79.5 cde	7.00 c	107 h	20.0 de	2.63 de	1154 f	1165f	22.5cd
N_2S_0	85.0 bc	6.27 e	125 f	20.0 de	2.58 e	1262 e	1280e	20.31f
N_2S_1	85.1 bc	6.34 e	152 c	18.3 ef	2.68 cd	1500 c	1516c	20.63f
N_2S_2	88.85 ab	7.50 b	158 b	23.0 ab	2.80 b	1640 b	1663b	23.44d
N_2S_3	93.0 a	8.10 a	165 a	24.7 a	2.86 a	1738 a	1748a	24.38a
N_3S_0	83.2 bcd	6.27 e	142 e	22.7 abc	2.71 c	1161 f	1460f	21.56e
N_3S_1	85.2 bc	7.40 b	157 b	23.3 ab	2.71 c	1300 d	1404d	23.125bc
N_3S_2	87.0 b	7.43 b	158 b	21.7 bcd	2.88 a	1534 c	1656c	23.875ab
N_3S_3	87.3 b	7.10 c	146 d	20.0 de	2.72 c	1728 a	1055a	20.63f
LSD (p=0.05)	5.152	0.224	3.861	1.932	0.053	36.03	39.02	0.875

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

ment (Table 1). Probably 80 kg N ha^{-1} ensured the favorable condition for growth of mustard and the ultimate results is the maximum number of branches. Mondal and Guffer (1983), Gaffer and Razzaque (1983) also reported the similar results from their experiment. They reported that different levels of nitrogen significantly increased branches plant^{-1} of mustard. Number of branches plant^{-1} for different levels of sulphur also showed statistically significant variation (Table 2). The highest significant increase in number of branches plant^{-1} (6.93) was recorded from S_3 treatment containing 24 kg S ha^{-1}.

Interaction effect between nitrogen and sulphur showed a significant difference for the number of branches plant^{-1} under the present experiment. The maximum number of branches plant^{-1} (8.10) was observed from the treatment combination N_2S_3 having 80 kg N ha^{-1} + 24 kg S ha^{-1} (Table 3).

3.3. Siliqua plant^{-1}

In the present trial the difference nitrogen level showed a statistically significant variation on siliqua per plant which was enhanced with increasing the doses of N and the greatest significant number (150) was obtained with N_2 (80 kg N ha^{-1}). Further, increasing of N level, failed to increase the number of siliqua significantly (Table 1). Mondal and Gaffer (1983), Gaffer and Razzaque (1983) also reported the similar findings from their experiment. They reported that different levels of nitrogen significantly increased siliqua per plant of mustard ensuring proper growth of plant. Sharawat et al. (2002) recorded maximum number of siliquae/plant with 120 kg N ha^{-1}. These results indicated that higher dose of nitrogen favored higher number of siliqua formation in mustard. Different level of sulphur showed statistically significant differences for siliqua per plant. The maximum number of siliqua per plant (127) was observed from S_3 treatment comprising of 24 kg S ha^{-1} which was statistically identical (126) with S_2 treatment as 16 kg S ha^{-1} (Table 2). On the other hand the minimum number of siliqua per plant (109) was recorded from the S_0 treatment. These results are in accordance with the findings of the early workers, Singh and Gangasaran (1987) who also reported higher number of pods plant-1 when 30 kg S ha-1 was applied as compared to the treatment where no S was applied.

Nitrogen and sulphur showed a significant interaction effect for number of siliqua per plant (Table 3). The maximum number of siliqua per plant (165) was recorded from the treatment combination N_2S_3 (80 kg N ha^{-1} + 24 kg S ha^{-1}).

3.4. Seeds siliqua^{-1}

Effect of nitrogen showed a statistically significant variation for seed per siliqua of mustard. The number of seed per siliqua increased with increasing N levels and maximum significant increase was found with the treatment N_2 (80kg N ha^{-1}) (Table 1). Application of 80 kg N ha^{-1} ensured the congenial condition for growth of mustard and also produced healthy silliqua and the ultimate result is the maximum number of siliqua. Mondal and Gaffer (1983), Gaffer and Razzaque (1983) also reported the similar results from their experiment. They reported that different levels of nitrogen significantly increased seed per siliqua of mustard. Similar result was also reported by Sharawat et al. (2002), Sen et al. (1977) and Allen and Morgan (1972). In this experiment statistically significant variation was recorded for different level of sulphur for seed per siliqua. The number of seeds per siliqua increased with increasing levels of S and the maximum number of seed per siliqua (21.2) was recorded from S_3 treatment as application of 24 kg S ha^{-1} which was statistically similar (20.7) with treatment S_2 as of 16 kg S ha^{-1} (Table 2). These results are in conformity with those of Islam and Sarker (1993), Dutta and Uddin (1983) who have observed increased number of siliquae/plant of mustard by increasing rate of sulphur. These results are quite in line with the early research work done by Ali et al. (1996) who reported maximum number of seeds pod-1 (31.19) at 30 kg S ha-1 against the lower rates of S application and control.

A significant interaction effect was also recorded between nitrogen and sulphur in consideration of number of seed per siliqua under the present experiment (Table 3). The maximum number of seeds per siliqua (24.7) was recorded from the treatment combination N_2S_3 comprising of 80 kg N ha^{-1} + 24 kg S ha^{-1}.

3.5. 1000 seed weight

Nitrogen showed statistically significant differences for 1000 seed weight of mustard under the present trial. The weight of 1000 seed increased with increasing levels of N upto N_3 (120 kg N ha^{-1}) (Table 1). The highest weight of 1000 of seeds (2.76 g) was recorded from N_3 treatment. Mondal and Guffer (1983), Gaffer and Razzaque (1983), Sharawat et al. (2002), Mudhokar and Ahlawat (1981) also reported the similar results from their experiment.

Different level of sulphur exhibited also statistically significant variation for 1000 seed weight. It increased significantly with higher levels of S with the highest (2.67 g) at S_2 treatment comprising of 16 kg S ha^{-1} which was statistically similar (2.65 g) with treatment S_3 comprising of 24 kg S ha^{-1} (Table 2). The results are supported by Singh and Gangasaran (1987), who reported that increased levels of sulphur produced the highest 1000-seed weight.

Interaction effect of nitrogen and sulphur showed a significant variation for 1000 seed weight under the present experiment. The highest weight of 1000 seed (2.86 g) was recorded from the treatment combination N_2S_3 comprising of 80 kg N ha^{-1} + 24 kg S ha^{-1} and the lowest (1.60 g) was recorded from N_0S_0 where no nitrogen and sulphur were applied (Table 3).

3.6. Seed yield

Application of nitrogen at different level showed a statistically significant variation for seed yield per hectare of mustard under the present trial (Table 1). With increasing the levels of nitrogen, the seed yield increased significantly upto 80 kg N ha^{-1}. However, the seed yield decreased significantly with the application of 120 kg N ha^{-1} (N_3) compared to 80 kg N ha^{-1}. The highest seed yield (1535 kg ha^{-1}) was recorded from N_2 treatment comprising of 80 kg N ha^{-1} which was closely followed (1431 kg ha^{-1}) with N_3 and the lowest seed yield (908 kg ha^{-1}) was recorded from N_0 treatment (control). These results are in conformity with that of Tomer et al. (1996), Mondal and Gaffer (1983), Singh and Rathi (1984), Narang and Singh (1985) who have observed increased seed yield of mustard by increasing rate of nitrogen. Statistically significant differences were observed for the application of sulphur at different level showed for seed yield per hectare. The application of S favored the seed yield of mudtard up to the highest level (24 kg S ha^{-1}) and the highest seed yield (1394 kg ha^{-1}) was recorded from this treatment (Table 2). On the other hand the lowest seed yield (1078 kg ha^{-1}) was recorded from the S_0 treatment (control). Banueles et al. (1990) recorded significant differences for different level of sulphur application.

Significant interaction effect was also recorded between nitrogen and sulphur for seed yield per hectare under the present experiment .The highest yield (1738 kg ha^{-1}) was recorded from the treatment combination N_2S_3 comprising of 80 kg N ha^{-1} + 24 kg S ha^{-1} and the lowest yield (850 kg ha^{-1}) was recorded from N_0S_0 where no nitrogen and sulphur was applied (Table 3).

3.7 Stover yield

Under the present trial, application of nitrogen at different level showed a statistically significant variation for stover yield per hectare of mustard (Table 1). With increasing the levels of nitrogen, the stover yield increased significantly up to 80 kg N ha^{-1}. However, the stover yield decreased significantly with the application of 120 kg N ha^{-1} (N_3) compared to 80 kg N ha^{-1}. The highest stover yield (1552 kg ha^{-1}) was recorded from N_2 treatment comprising of 80 kg N ha^{-1} which was closely followed (1394 kg ha^{-1}) with N_3 and the lowest stover yield (757 kg) was recorded from N_0 treatment (control). These results are in conformity with that of Tomer et al. (1996), Mondal and Gaffer (1983), Singh and Rathi (1984), Narang and Singh (1985) who have observed increased stover yield of mustard by increasing rate of nitrogen. Application of sulphur at different level showed statistically significant differences for stover yield per hectare. The application of S favored the stover yield of mustard up to the highest level (24 kg S ha^{-1}). The highest stover yield (1369 kg ha^{-1}) was recorded from S_3 treatment comprising of 24 kg S ha^{-1} (Table 2). On the other hand the lowest shoot yield (1168 kg ha^{-1}) was recorded from the S_0 treatment (control). Banueles et al. (1990) recorded significant differences for different level of sulphur application.

Significant interaction effect was also recorded between nitrogen and sulphur for stover yield per hectare under the present experiment. The highest stover yield (1748 ha^{-1}) was recorded from the treatment combination N_2S_3 comprising of 80 kg N ha^{-1} + 24 kg S ha^{-1} and the lowest (918 kg ha^{-1}) was recorded from N_0S_0 where no nitrogen and sulphur was applied (Table 3).

3.8. Protein content

Data regarding protein content of mustard as affected by N and S are shown in Table 1 and Table 2 respectively. The effects of N and S on protein content of mustard were significant. N rates revealed that seed protein contents enhanced progressively with increase in N rates and the highest protein content of 22.31 % which was statistically identical 22.18% , found at the level of 120 kg N ha^{-1} and 80 kg N ha^{-1} respectively. Similarly, seed protein content also had a positive response to the increasing S levels. Higher protein contents of 21.81% and 21.38% were recorded for the plots that received 16 to 24 kg S ha^{-1}, respectively. The lowest protein content of 19.38% was noted in the plots that received no S. The increase in seed protein content of SAU Sharisha-1 with the application of N and S could be due to the fact that N is an integral part of protein and the protein of rapeseed contains relatively large quantities of the S containing amino acids like methionine and cystine (Gardner et al., 1985). Significant interaction effect was also recorded between nitrogen and sulphur for protein content on seed ha^{-1} under the present experiment .The highest protein content (24.38%) was recorded from the treatment combination N_2S_3 comprising of 80 kg N ha^{-1} + 24 kg S ha^{-1} and the lowest was recorded from N_0S_0 where no nitrogen and sulphur was applied (Table 3).

4. Conclusion

Yield and yield contributing factors had increased with increasing N level up to 80 kg N ha^{-1}. S levels significantly increased plant height, slilqua plant^{-1}, 1000 seed weight upto 16 kg S ha^{-1} but the number of branches plant^{-1} and seed yield upto 24 kg ha^{-1}. Combination of $N_{80}S_{24}$ produced the maximum seed yield (1738 kg ha^{-1}). The highest N level resulted in the highest values for protein (22.31%).

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