EFFECT OF SULPHUR ON YIELD AND YIELD ATTRIBUTES OF MUSTARD

A THESIS

BY

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Approved as to style and content
by

.....
Prof. Dr. Md. Yasin Ali
(Supervisor)

.....
Dr. Md. Sarwar Jahan
(Cosupervisor)

.....
Prof. Dr. Md. Yasin Ali
Chairman
Examination Committee

DEDICATED TO

MY BELOVED PARENTS
AND
ELDEST BROTHER

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ABSTRACT

A field experiment was conducted at the Agrotechnology Field Laboratory, Khulna University, Khulna during the *rabi* season from November, 2006 to February, 2007 to evaluate the effect of sulphur on yield and yield attributes of mustard. The study consisted of four levels of sulphur *viz.* 0, 15, 30 and 45 kg S ha^{-1} and three mustard varieties *viz.* Sonali sarisha, BARI sarisha-9 and BARI sarisha-11. The experiment was laid out in the randomized complete block design with two factors. The results showed that among the tested varieties, BARI sarisha-9 performed well in cases of 1000 seed wt. (2.19 g), seed yield (2.36 t ha^{-1}) and harvest index (48.62 %). Application of 45 kg S ha^{-1} produced highest number of siliqua $plant^{-1}$ (244.20), 1000 seed wt. (2.27 g) and seed yield (2.46 t ha^{-1}) but highest harvest index (43.36 %) was produced by application of 30 kg S ha^{-1} which was statistically similar to 45 kg S ha^{-1}. The interaction effect of sulphur and variety was varied significantly at all parameters of yield and yield attributes except no. of seeds $siliqua^{-1}$. BARI sarisha-9 produced highest number of siliqua $plant^{-1}$ (294.86) and seed yield (2.75 t ha^{-1}) by the application of 45 kg S ha^{-1} but 1000 seed wt. (2.44 g) and harvest index (50.67 %) by application of 30 kg S ha^{-1}.

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CHAPTER I

INTRODUCTION

Mustard and rapeseed called 'Sarisha' in the local term are the major oilseed crops of Bangladesh. The mustard plant is herbaceous one, which belongs to the family crucifereae.

Oilseed crops play an important role in the economy of Bangladesh. Mustard is the top ranking oilseed crop. It covers about 78% of the total oilseeds acreage and 62% of the total production (BBS, 2004). Optimum dietary allowance (ODA) is estimated to be 35 g oils and fats $head^{-1}$ day^{-1}. The oilseed crop occupied 5% of the total cropped area. Among these areas 73% is covered by rapeseed and mustard, 18% by sesame and 9% by groundnut (BBS, 2004). Total cultivated land of mustard is 0.352 million hectare and total production is 0.334 million metric ton and yield 1.5-2.0 ton ha^{-1} (AIS, 2007). Rapeseed and mustard production should be increased to fulfill the consumption need and at the same time to save our foreign currency.

Sulphur is an essential element for plant development and growth since it is a constituent of S-containing amino acids and enzymes required for the synthesis of proteins, chlorophyll, oil and vitamins. Plant requires 3-5 ppm of $SO_4^=$ in the soil solution. In S- deficient soils, the level of $SO_4^=$ is usually less than 5-10 ppm. The influence of S on the protein and oil contents of rapeseed- mustard has been observed in a number of studies (Finlayson *et al.*, 1990). Sulphur deficiency is also known to affect N metabolism in plant (Dev *et al.*, 1981). When plant S is limiting, protein synthesis decreases, whereby N is not fully utilized resulting in accumulation of non-protein N in the plants. Sulphur fertilizer improves nutritive value of several crops. So application of sulphur containing fertilizers to the crop field is essential to fulfill the sulphur deficiency of soils and it is important to maintain the appropriate dose for better growth and higher yield of crops.

The yield of mustard can be augmented with the use of high yielding varieties and appropriate agronomic practices. Fertilizer is the most important input to boost the production of the crop. Among the fertilizer elements sulphur plays a key role in augmenting the production of oil seeds. The oil seed crops need comparatively higher amounts of sulphur for proper growth and higher yield (Singh *et al.*, 1988a). Response of mustard to sulphur in addition to major nutrients has been reported by many workers (Singh and Singh, 1984a; Pathak and Tripathi, 1979; Paul and Sarker, 1989). Sulphur is absolutely essential in order to obtain high yield from improved varieties of mustard. Mustard needs larger amount of sulphur for maximizing production as sulphur plays a vital role in the physiology of mustard (Betrand, 1927).

It is now apprehended that the present S deficient soils comprise a total of as much as 3.95 million ha (BARC, 1988). An intensive cropping system removes 30-70 kg S ha^{-1} $year^{-1}$ from soil in Bangladesh (Hussain, 1990). When oilseeds are included in the rotation of cropping, the removal of sulphur increases (Joshi *et al.*, 1983). Increased crop yields remove large amount of sulphur. The total removal of sulphur from the soil of different crops is estimated 64,349 ton and about 7.5% of the total sulphur is removed by oilseeds. Rapeseed and mustard have been reported to remove as much as 17.27 kg S ton^{-1} grain production (Jain *et al.*, 1984). The present experiment was undertaken with the following objectives:

1. To observe the effect of varieties on the yield and yield attributes of mustard.
2. To observe the effect of sulphur level on the yield and yield attributes of mustard.
3. To observe the interaction effect of varieties and sulphur level on the yield and yield attributes of mustard.

CHAPTER II

REVIEW OF LITERATURE

Mustard (*Brassica spp.*) is one of the most important oilseed crops in our country. Its growth and yield as well as quality are essentially influenced by the proper fertilizer management especially nitrogen and sulphur fertilizers. Sulphur is an essential plant nutrient. Sulphur requirement of oil seeds on an average, is quite large. An attempt has been made in this chapter to present a brief review of the pertinent works on effect of sulphur on mustard done by different researchers under separate heads.

Studer (1969) observed from an experiment on winter rapes by applying N, P, K and S. Production of dry matter was more or less constant in 3 years (10-11 t ha^{-1} on average). During these year's seed yield ranged from 1.75 to 2.66 t ha^{-1}. Phosphorus and sulphur uptake remained uniform during the whole growth period. He noted that suitable amounts of fertilizers for winter rapes were 180-220 kg N, 65-75 kg P_2O_5, 120-150 kg K_2O and 40-60 kg S ha^{-1}. Maximum seed yield obtained when fertilized with 40-60 kg S ha^{-1} with other fertilizers.

Johanson (1970) conducted an experiment on winter rapeseed while the crop yielded 1.39 t ha^{-1} and increased plant height and growth with the application of 25 kg S ha^{-1} and the control gave 1.08 t ha^{-1}. Application of 60 kg S ha^{-1} gave a further increase of 1.45 t ha^{-1}. According to this scientist, sulphur requirement of oilseed crops is very high and the crop responds fairly to the application of sulphur, particularly in the form of gypsum.

Saalbach (1973) and Colemon (1957) reported that without visible symptoms, sulphur deficiency reduced crop yields by 10 to 34 %, when sulphur was in shorter supply then no sulphur containing amino acids like asparagine, glutamine and arginine were accumulated.

Lazareva (1977) performed an experiment on derno–podzolic soil in Moscow Province, sulphur was applied as phosphogypsum. It increased the growth and seed yields of mustard (*B. juncea*). So, he suggested to apply sulphur fertilizer regularly to winter rapeseed.

Mazur and coworkers (1977) conducted an experiment on winter rapeseed with different doses of sulphur (30, 60 and 90 kg S ha^{-1}) to determine the effect of seed yield. Seed yield of winter rapeseed increased from 1.01 to 1.75 t ha^{-1}. There was no significant difference among the rates of sulphur fertilizers and their effect on seed yield.

Rahman and associates (1978) reported that the application of sulphur was favourable for the production of more seeds $siliqua^{-1}$ and mature seeds $siliqua^{-1}$.

Uziak and Szymanska (1979) performed an experiment in sand culture on summer rapes (*B. napus*), the pots were fertilized with 120, 240 and 510 mg of N from NH_4NO_3 and 2.5, 10 and 50 mg of S from K_2SO_4 singly and in combinations. They showed that increases in applied sulphur increased top growth at each installment of N and dry matter weights of above ground parts were highest with 150 mg N and 50 mg S treatment.

Singh and Bairathi (1980) reported that interaction of sulphur and selenium influenced the growth of mustard plants.

Welter (1980) stated that rapeseed and mustard required large amount of sulphur for high seed yield. Seed yield increased with the increasing rates of sulphur.

Hoveland and associates (1981) concluded that rapeseed required 45 lb N ac^{-1} in autumn and 60 lb N ac^{-1} in spring. Sandy soils required 10 lb S ac^{-1} annually.

Courapron and colleagues (1982) conducted a field experiment on rapeseed. The plots were fertilized with 50 kg S ha^{-1} in February or April or 50 kg S in February + 50 kg S in April. Sulphur 50 kg ha^{-1} in February gave the highest seed yield (2.32 t ha^{-1}).

BARI (1982) reported that the application of sulphur was favourable for the production of more seeds $siliqua^{-1}$ in comparison to plants not fertilized with sulphur.

Shukla and coworkers (1983) concluded that the application of sulphur and zinc significantly increased the concentration and uptake of these elements. Seed yield was significantly increased by their application either alone or in combination.

Joshi and colleagues (1983) performed a pot trial on mustard (*B. juncea*), the pots were fertilized with 0, 25, 50 and 75 kg P_2O_5 and S ha^{-1}. Sulphur and P_2O_5 were used separately or in combination. Seed yield increased with the increasing doses of P_2O_5 with sulphur. The highest yield of 8.89 g pot^{-1} was obtained with the application of S and P in the same pot. The yield given by control treatment was 4.25 g pot^{-1}.

Samui and colleagues (1983) reported that when $ZnSO_4$ was applied, it increased number of siliqua $plant^{-1}$, seeds $siliqua^{-1}$, siliqua length, 1000 seed weight and seed yield of mustard.

Sing (1984) observed that application of sulphuric acid to the soil was more effective in the initial stage of mustard, but elemental sulphur was more stable and gave 16.9, 15.3, 17.2 and 16.7 % more yield when applied at 25, 45, 60 and 75 days after sowing respectively over the control.

Singh and Singh (1984a) reported that yield response of 7-8 kg grain kg^{-1} S used has most commonly been obtained under field condition.

Rahman and coworkers (1984) reported that mustard crop was fertilized with S under irrigated condition; a maximum seed yield of 1.99 t ha^{-1} was obtained at 20 kg S ha^{-1} against 1.06 and 1.85 t ha^{-1} with no S application and 30 kg S ha^{-1}, respectively.

Singh and Singh (1984b) found that there was no effect of S on yield attributes of toria probably due to the fact that the amount of S present in the soil was adequate to sustain the optimum plant growth and development.

Janzen and Bettany (1984) concluded that timely application of sulphur influenced the maturity of mustard plants.

BARI (1985) reported that the number of filled siliqua $plant^{-1}$ of mustard and plant height increased significantly due to the application of sulphur.

It has been observed in the investigation of Chatterjee and associates (1985) that maximum number of siliqua $plant^{-1}$, 1000 seed weight and 29 % higher yield, when mustard is provided with 20 kg S ha^{-1} in combination with borax.

In a study on sandy loam soil of the Gangetic flood plain of West Bengal, it was found that application of S at the rate of 20 kg ha^{-1} increased 39 % seed yield over control of mustard (Chatterjee *et al.*, 1985).

Mazid (1986) summarized from the seed yield experiments of mustard and observed that 45 % higher seed yield could be obtained at 20 kg S ha^{-1} in Bangladesh.

Tandon (1986) reported that plants deficient in S exhibit many symptoms which resemble those of N deficiency such a light green to yellowish leaves, small plants, retarded growth and poor branching.

Singh and Gangasarma (1987) reported that application of 30 kg S ha^{-1} increased plant height, branch number and siliqua per plant and 1000 seed weight, consequently produced significant seed yield of mustard.

Aulakh and Pasricha (1987) conducted a pot trial with rapeseed (*Brassica napus* var. toria) of improved toria. It was grown on an arid brown soil, low in available S and K and given combinations of 0.25 and 50 ppm S, Mg and K. Vegetative growth and seed yields were significantly increased by sulphur application alone or in combination with K. Sulphur content of vegetative parts and seed yield increased with increasing S or K application. Sulphur and K showed synergistic effect; S content significantly decreased with Mg application. Total S uptake by seed and vegetative parts showed similar trends. Sulphur and Mg interaction was significant and S x K interaction was positive for the parameters under study.

Singh and Saran (1987) reported that application of 30 kg S ha^{-1} in Indian rapeseed gave yields of 1.61 ton compared with 1.00 ton without sulphur. Yield was not further increased with 60 kg S ha^{-1}.

Tarafdar (1987) conducted a field experiment during the *rabi* season of 1984-85 at the Field experiment of Bangladesh Agricultural Research Institute, Joydevpur, Gazipur. The plots were fertilized with 0, 15, 30, 45 and 60 kg S ha^{-1}. All other fertilizer was applied as basal doses. There was no significant yield improvement from control in mustard due to the application of sulphur alone. Yield increased when 40 kg N ha^{-1} was added along with 30 kg S ha^{-1}. Application of 200 kg N ha^{-1} along with 30 kg S ha^{-1} produced 1.25 t ha^{-1}. When the rate of sulphur was reduced to 25 kg ha^{-1}, the yield declined to 0.958 t ha^{-1}. Gradual increase in yield was found, when sulphur doses were raised from 15-60 kg S ha^{-1} along with 120 kg N ha^{-1}.

Singh and Singh (1987) performed an experiment on (*B. juncea*) in a sulphur deficient soil when the plots were fertilized with 0.12 ppm sulphur. Application of

sulphur up to 90 ppm increased plant dry matter, seed yields and 1000-seed weight but 120 ppm sulphur $plot^{-1}$ decreased these parameters. Sulphur content increased with applied sulphur up to 120 ppm in 50 days old plants and 90 ppm in matured plants.

Sawrker and associates (1987) noted that increasing doses of applied sulphur (as ammonium sulphate) from 0-45 kg ha^{-1} increased the seed yields from 1.46 to 1.82 t ha^{-1} in (*B. juncea* cv.) varuna and from 1.36 to 1.77 in cv. RW 351; Sulphur @ 60 kg ha^{-1} slightly decreased seed yields.

Singh and coworkers (1988a) found that when S was the limiting factor, protein synthesis decreased and N was not fully utilized resulting in accumulation of non-protein N in plant.

Somani and colleagues (1988) showed the effect of 5-200 ppm S on yield and oil quality of *B. juncea* in a green house experiment. Increasing levels of sulphur up to 50 ppm increased S-uptake, grain and straw yields. Higher levels of sulphur decreased grain and straw yields.

Singh and coworkers (1988b) conducted a long time experiment with two doses of gypsum (10 and 14.5 kg ha^{-1}) on crop growth and observed a continued higher plant height.

A yield response of 7-8 kg grain kg^{-1} S used has most commonly been obtained under field condition (Gupta and Saini, 1988; Aulakh and Pasricha, 1988).

Aulakh and Pasricha (1988) also reported that S applicatoin increased seed yield of rapeseed and mustard from 12 to 48 % under irrigated and 17 to 20 % under rainfed conditions.

An experiment at Non- calcaleoous Dark Grey Floodplain soils in Bangladesh using different combination of N, P, K, S and Zn fertilizers, Ali and associates

(1988) found that yield of mustard was 300% more at 40 kg S ha^{-1} over S-control plots. Increase in yield due to S doses of 20 kg and 60 kg ha^{-1} were 226 and 317%, respectively.

Rathore and Manohar (1989) conducted trials in 1984-85 with mustard (*B. juncea*) grown on a sulphur deficient loamy sand soil. Application of 400 kg elemental sulphur increased seed yield, number of branches $plant^{-1}$ and dry matter production compared with the control, the effects increased significantly as sulphur doses increased up to 160 kg ha^{-1}.

Koti and coworkers (1989) conducted field trials at Dharwad in 1989. Mustard was given 0-22 kg S ha^{-1} at sowing time. Average pod yield ranged from 1.83 t ha^{-1} without sulphur to 2.31 t ha^{-1} with 18 kg ha^{-1} applied sulphur. Siliqua yield was significantly affected by the application of sulphur.

A large number of experiments from different parts of the world now conclusively proved that S is absolutely essential in order to obtain high crop yields from improved varieties of rapeseed-mustard both under rainfed and irrigated conditions (Virmani and Gulati, 1971; Ali *et al.*, 1976, Saran and Giri, 1990).

Finlayson and associates (1990) carried out an experiment on rapes grown on sulphur deficient soil low in nitrogen and potassium, using (a) no fertilizer (b) 44.8 kg N ha^{-1} (c) 44.8 kg N + 22.4 kg P_2O_5 ha^{-1} (d) 44.8 kg N + 22.4 kg P_2O_5 + 205.1 kg K_2O + 89.6 kg S ha^{-1} at sowing. The yield in (d) was 2.50 t ha^{-1} compared with 2.1, 1.7 and 2.1 t ha^{-1} in (a), (b) and (c) respectively. Thousand seed weight was not affected by fertilizer treatments.

Saran and Giri (1990) observed that plant height and primary branches $plant^{-1}$, number of siliqua $plant^{-1}$, length of pod, number of seeds $siliqua^{-1}$ and 1000 seed weight were increased significantly with 60 kg S ha^{-1} and seed yield $plant^{-1}$ increased with 30 kg S ha^{-1}.

On Farm Research Division (OFRD) (1990) in BARI, summarized the effect of sulphur along with various levels N, P, K and concluded that the maximum yield of mustard varied with the sulphur application (20 to 40 kg ha^{-1}) in different location of Bangladesh.

Islam and associates (1990) reported that sulphur application significantly increased the grain and straw yield of BR2 rice. They also reported that application of sulphur increased the content of sulphur both in grain and straw.

Caenio and Mamaril (1991) reported that application of S significantly enhanced plant height and tiller number of rice.

Chowdhury and coworkers (1992) conducted a field experiment with Varuna mustard during 1988-89. The treatments comprising 4 levels of nitrogen (20, 40, 60 and 80 kg N ha^{-1}) and 3 levels of sulphur (0, 25 and 50 kg S ha^{-1}). All the yield contributing characters except 1000 seed weight were influenced significantly up to the highest level of nitrogen (80 kg N ha^{-1}). Sulphur increased plant height, number of seeds $siliqua^{-1}$, seed weight $plant^{-1}$ and ultimately seed yield t ha^{-1}. Maximum seed yield was noted at the highest S level which was significantly superior to 0 and 25 kg S ha^{-1}.

Dubey and Khan (1991) reported that sulphur up to 30 kg ha^{-1} significantly increased seed yield of mustard.

Khandkar and colleagues (1991) showed that *B. juncea cv.* varuna grown at Mandsaur, Madhya Pradesh in *rabi* season applying 20, 40, 60 or 80 kg N and 0, 20, 40 or 60 kg S ha^{-1}, yield or economic return was highest with application of 60 kg N and 60 kg S ha^{-1}.

Babuchowski (1992) reported that the application of higher doses of sulphur decreased seed weight, seed oil content and ultimately harvest index of rapeseed.

Khanpara and coworkers (1992) observed that sulphur significantly affected the growth character of mustard such as plant height, primary and secondary branches plant^{-1} and these characters were significantly increased up to 100 kg S ha^{-1}.

Mohan and Sharma (1992) conducted a field experiment during winters of 1984-85 and 1985-86 to study the effect of nitrogen and sulphur on seed and oil yields of Indian mustard. Sulphur at the rate of 50 kg ha^{-1} increased the plant height and dry matter production significantly. An application of 75 kg S ha^{-1} significantly increased the functional leaves and number of branches plant^{-1} and 1000 seed weight in both years and only leaf area index during 1984-85.

Sarker and associates (1993) worked with four high yielding varieties of mustard viz. BAU-M/12 (Sampad), BAU-M/248 (Sambal), M-257 and SS-75 (Sonali Sarisha). They applied five levels of sulphur viz. 0, 10, 20, 30 and 40 kg ha^{-1} to the crop and found that BAU-M/248 (Sambal) gave the maximum seed yield @ 40 kg S ha^{-1} and the variety Sampad followed Sambal in respect of seed yield at the same level of sulpphur. Both the varieties M-257 and SS-75 gave the maximum seed yield when the S dose is 30 kg ha^{-1}.

Jahiruddin and colleagues (1994) reported that application of 25 kg S ha^{-1} increased the number of tillers hill^{-1} in rice varieties.

Sarker (1997) reported that the highest plant height and number of branches plant^{-1}, seed yield recorded by the application of sulphur 45 kg ha^{-1}. He also reported that the number of siliqua plant^{-1} and number of seeds siliqua^{-1} also increased by sulphur fertilization and was significant up to 30 kg S ha^{-1} and then reduced with highest level of sulphur.

Khalil (1997) reported that, highest number of siliquas plant^{-1} and number of seeds siliqua^{-1}, maximum 1000-seed weight, harvest index, maximum number of branches plant^{-1}, seed yield were produced by 60 kg S ha^{-1}.

Sen and coworkers (2002) carried out an experiment on application of sulphur through single super phosphate in a sulphur deficient area of Murshidabad district in a rice-mustard cropping system. They recorded significant yield increase in rice with application of sulphur at 30 kg ha^{-1}.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Agrotechnology Field Laboratory, Khulna University, Khulna, during November 2006 to February 2007. The study was made to evaluate the effect of sulphur on the yield and yield attributes of mustard.

Location

Experimental site is located at the latitude of 22°47′ N and longitude of 89°34′ E. It belongs to the Agroecological Zone of Ganges Tidal Flood Plain (AEZ-13a) with an elevation of 4 m from the mean sea level.

Climate

The region is on the sub-tropics where rainfall is maximum during the *Kharif* season (April-September) and the rainfall is scanty in association with moderately low temperature and plenty of sunshine in the *Rabi* season (October-March). The meteorological data are presented in appendix 2.

Soil

Soil samples were collected from ten different spots of experimental sites before first ploughing. Soil samples were collected from plough depth (0- 15cm) of soil profile and after that these were mixed with each other as well as stored in polythene bag for laboratory analysis. The land was medium high with having sandy loam texture. The detail information about chemical characteristics of soils is presented in appendix 1.

Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design with two factors. The experimental area was divided into three blocks and each block was divided into twelve plots. Four levels of sulphur and three varieties of mustard were used. The total number of experimental units was 4 x 3 x 3 =36. The unit plot

size was 3m x 2m. Block to block and plot to plot distance was maintained by 0.5 m. The treatments were distributed randomly in each block.

Experimental treatment

Two factors included in the experiment were as follows

Factor A. Sulphur dose: 4

S_0 = 0 kg S ha^{-1}

S_{15} = 15 kg S ha^{-1}

S_{30} = 30 kg S ha^{-1}

S_{45} = 45 kg S ha^{-1}

Factor B. Variety: 3

V_1= Sonali sarisha (*Brassica campestris*)

V_2= BARI sarisha-9 (*Brassica juncea*)

V_3= BARI sarisha-11 (*Brassica juncea*)

Land preparation

The land was ploughed two times with a tractor drawn disk plough. The ploughed soil was then brought into desirable fine tilth by four operations of ploughing and harrowing with country plough and ladder. The previous crop residues and all kinds of weeds were removed from the experimental area. The first plouging and final land preparation were done on 8th and 16th November, 2006, respectively. The experimental plots were laid out in the field on 17th November, 2006.

Fertilizer application

The experimental plots were uniformly fertilized with 275, 175, 90, 6 and 12 kg ha^{-1} urea, TSP, MP, $ZnSO_4$ and H_3BO_4 respectively. Sulphur fertilizers were applied to the plots as per treatment in the form of Gypsum (18% S). Half part of the urea and full amount of other fertilizers were applied on the experimental plots

and thoroughly incorporated in to the soil at the time of final land preparation. The remaining portion of urea was applied at 31 days after sowing (DAS).

Seed sowing

The seed rate 9 kg ha^{-1} were sown after fertilizer application on 18th November, 2006. Line sowing method was followed and 30 cm distance was maintained from line to line. After sowing, the seeds were covered with soil and slightly pressed by laddering. Sowing was done at 'Jo' condition of soil which ensured satisfactory germination of seeds. The seeds were germinated within 3- 4 days after sowing (DAS).

Intercultural operation

Weeding was done two times at 20 and 35 days after sowing (DAS) as well as the field was kept weed free all the time during the experimentation. Thinning was done at 21 DAS and 10cm distance was maintained from plant to plant for better plant growth and development.

Light irrigation was provided at 10 DAS due to lack of 'Jo' condition in the field during seed sowing. Irrigation was also provided two times at 32 and 54 DAS in order to maintain enough moisture in the field during experimentation. Besides, watering was done sometimes on a number of few plots to maintain uniformity of plant growth. Data on rainfall was given in Appendix 2.

Mustard plants were infested by caterpillar and aphid. To control caterpillar, Diazinon 60 EC @ 2 ml L^{-1} was applied at 26 DAS. Diazinon 60 EC @ 2 ml L^{-1} was also applied two times against aphid at 50 and 66 DAS. Mustard plant was also affected by alternaria leaf blight disease. To control this disease, Dithane M-45 @ 2 g L^{-1} was applied two times at 42 and 60 DAS.

General observation

All plots of experimental field were frequently observed and noted down on research note book at any change of plant growth and other characters. Flowering commenced at 27, 33 and 35 DAS by BARI sarisha-9, Sonali sarisha and BARI sarisha-11 respectively. Siliqua initiation was started at 34, 40 and 42 DAS by BARI sarisha-9, Sonali sarisha and BARI sarisha-11, respectively.

Harvesting

The crop was taken to be mature when stem and siliqua become yellow. Harvesting was done two times in this experiment because three varieties were matured at different times. At first, BARI sarisha-9 was harvested at 76 DAS and another two varieties were harvested at 86 DAS. The harvesting of crop was done within one day. Before harvesting, 5 plants were uprooted randomly from each plot for determination of yield components. The harvested crop of each plot was bundled separately, tagged properly and carried to the data collection room of Agrotechnology Field Laboratory. Yield data were taken as full plot basis.

Collection of Experimental Data

The following data were recorded:

1. Plant height (cm): The height of the plants was measured from the ground level to the tip of the top most siliqua.

2. Number of branches plant^{-1}: The number of branches plant^{-1} was counted.

3. Number of siliqua plant^{-1}: The number of siliqua of each plant was counted.

4. Length of siliqua (cm): Ten siliqua plant^{-1} were selected randomly. Siliqua length was measured from the base of the siliqua to the below of the stalk of each siliqua and mean value was calculated.

5. Number of seeds siliqua^{-1}: The number of seeds siliqua^{-1} was counted by splitting five siliqua plant^{-1}.

6. 1000- seed weight (g): Thousand seeds of each plot were counted randomly three times and weighed with a fine electric balance separately. The mean value was recorded.

7. Seed yield plant^{-1} (g): The seed yield plant^{-1} was counted by using the following formula:
Seed yield plant^{-1} (g) = Number of plant x number of siliqua plant^{-1} x number of seed siliqua^{-1} x individual weight of seed.

8. Straw yield plant^{-1} (g): Harvested plant was dried in oven at 72^{0}C for 72 hours and after that weighed was taken by fine electric balance.

9. Biological yield plant^{-1} (g): The summation of seed yield plant^{-1} and straw yield plant^{-1} was considered as biological yield plant^{-1}.

10. Seed yield (t ha^{-1}): Seed yield counted as plot basis which was converted into t ha^{-1}. The following formula was used to calculate the seed yield:

Seed yield (t ha^{-1}) = Number of plant unit area^{-1} x number of siliqua plant^{-1} x number of seed siliqua^{-1} x individual weight of seed.

11. Straw yield (t ha^{-1}): Total straw yield of the harvested area of each plot was determined and then it was converted into t ha^{-1}.

12. Biological yield (t ha^{-1}): Seed yield and straw yield were all together regarded as biological yield. It was calculated by using the following formula:
Biological yield (t ha^{-1}): Seed yield (t ha^{-1}) + straw yield (t ha^{-1})

After recording data from five plant samples, the sample yield was included with the respective plot yield and finally converted to hectare yield.

13. Harvest index (%): The harvest index was computed as the ratio of seed yield to the biological yield.

Harvest index (%) = Seed yield / biological yield x 100.

Statistical analysis

All the collected data were analyzed following the analysis of variance (ANOVA) technique and mean differences were adjusted by Duncan's New Multiple Range Test (DMRT) (Gomez and Gomez, 1984) using a computer operated program named MSTAT-C. Regression analysis was done between growth factors and yield attributes. Functional relationships were also developed between sulphur doses and yield as well as yield attributes.

CHAPTER IV

RESULTS AND DISCUSSION

Results of the present study regarding the influence of sulphur fertilizer (gypsum) on crop characters, yield and yield attributes of mustard have been presented and discussed in this chapter.

Varietal differences in yield and yield components of mustard

Plant height differed significantly among the mustard of tested varieties. Plant height of the mustard varieties ranged from 109.85 to 138.80 cm. The tallest plant was found in the variety BARI Sarisha-11 (138.80 cm) which differed significantly from other varieties (Table 1). The variable effect of variety on plant height was found by Sarker (1997).

Number of branches plant^{-1} varied significantly and ranged from 7.91 to 11.71. The highest number of branches plant^{-1} was recorded from the variety BARI Sarisha-11 (11.71) and the lowest was found in Sonali sarisha (7.91). Almost similar result was obtained by Khalil (1997).

Number of siliqua plant^{-1} was significantly influenced and varied from 138.89 to 263.44. The maximum number of siliqua plant^{-1} was found in BARI Sarisha-11 (263.44) which differed significantly from other varieties (Table 1). This has contributed to higher yield. The variable effect of variety on number of siliqua plant^{-1} was observed by Khalil (1997).

Length of siliqua of the tested mustard varieties varied widely and ranged from 3.72 to 4.51 cm. The longest siliqua was found in the variety Sonali Sarisha (4.51 cm) which was statistically similar to BARI Sarisha-9 (4.46 cm). Almost similar result was found by Singh and colleagues (1982).

Number of seeds siliqua^{-1} of the tested mustard varieties ranged from 11.42 to 25.79 which differed significantly at 1% level. The maximum number of seed siliqua^{-1} was observed in the variety Sonali sarisha (25.79) which was best performed than other two varieties (Table1). The results are in agreement with Rahman and associates (1988).

Weight of 1000-seed was varied highly significantly and ranged from 2.04 to 2.19 g. The maximum weight of 1000-seed was produced by BARI Sarisha-9 (2.19g) and the minimum was found in Sonali sarisha (2.04 g) (Table 1). The higher 1000-seed weight might be due to larger size of the seed. The variable weight of 1000-seed of different mustard varieties were also reported by Sawarker and coworkers (1987).

Seed yield of the tested mustard varieties was varied from 1.90 to 2.36 t ha^{-1}. The highest yield was produced by BARI Sarisha-9 (2.36 t ha^{-1}) which was significantly different from other two varieties (Table 1). The variable seed yield of different mustard varieties was also reported by Sawarker and associates (1987). The higher seed yield found in BARI Sarisha-9 might be due to more number of siliqua plant^{-1}, greater siliqua length, larger seed size and higher harvest index (Table 1).

Biological yield of the tested mustard varieties varied significantly and ranged from 4.87 to 6.33 t ha^{-1}. The highest biological yield was produced by BARI Sarisha-11 (6.33 t ha^{-1}) and the lowest was found in Sonali sarisha (4.93 t ha^{-1}) which was identical to BARI Sarisha-9.

Harvest index of the tested mustard varieties ranged from 30.36 to 48.62 %. The highest harvest index was recorded from the variety BARI Sarisha-9 (48.62 %) which was significantly different than other two varieties (Table 1).

Table 1. Varietal differences on the yield and yield attributes of mustard.

Variety	Plant height (cm)	Number of branches plant^{-1}	Number of siliqua plant^{-1}	Length of siliqua (cm)	Number of seeds siliqua^{-1}	1000-seed weight (g)	Seed yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1	109.85c	7.91c	138.89c	4.51a	25.79a	2.04b	2.10b	4.93b	42.47b
V_2	113.99b	9.66b	239.27b	4.46a	17.17b	2.19a	2.36a	4.87b	48.62a
V_3	138.80a	11.71a	263.44a	3.72b	11.42c	2.15ab	1.90c	6.33a	30.36c
Level of significance	**	**	**	**	**	**	**	**	**
CV (%)	1.16	7.41	0.74	2.84	6.06	3.26	2.86	2.28	2.70

In a column, figures having similar letter (s) do not differ significantly whereas figures having dissimilar letter (s) differ significantly.

Note: V_1 = Sonali sarisha, V_2 = BARI sarisha-9, V_3 = BARI sarisha-11

CV = Coefficient of variation

** = Significant at 1 % level

Effect of sulphur on yield and yield components of mustard

Variation in plant height was found among the sulphur treatments (Table 2). The plant height ranged from 117.95 to 123.95 cm. The longest plant height was produced by application of 45 kg S ha^{-1} (123.95 cm) which was statistically similar to 30 kg S ha^{-1} (122.13 cm). The shortest plant was produced by S_{15} treatment (117.95 cm) which was similar to the control treatment (119.47 cm). Johanson (1970) reported that application of 30 kg S ha^{-1} in the form of gypsum increased plant height.

The number of branches $plant^{-1}$ was also influenced by sulphur application. The maximum number of branches $plant^{-1}$ was recorded from the application of 45 kg S ha^{-1} (10.88) and the lowest (9.17) was found where sulphur was not applied which was identical to the application of 15 kg S ha^{-1}. The results showed that number of branches $plant^{-1}$ was increased with increasing rate of sulphur. Similar results have been reported by Rathore and Manohar (1989).

The number of siliqua $plant^{-1}$ was differed significantly due to sulphur application. The number of siliqua $plant^{-1}$ ranged from 193.29 to 244.20 (Table 2). The maximum number of siliqua $plant^{-1}$ (244.20) was obtained where 45 kg S ha^{-1} applied which was different from other treatments. The result showed that number of siliqua $plant^{-1}$ increased with the increasing rate of sulphur application. The result is supported by the findings of Rathore and Manohar (1989) and Koti and coworkers (1989).

Table 2. Effect of sulphur on the yield and yield attributes of mustard.

Sulphur	Plant height (cm)	Number of branches plant^{-1}	Number of siliqua plant^{-1}	Length of siliqua (cm)	Number of seeds siliqua^{-1}	1000-seed weight (g)	Seed yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
S_0	119.47b	9.17b	193.29d	4.16	18.80	1.80b	1.81d	5.09b	36.96c
S_{15}	117.95b	9.33b	203.81c	4.19	17.62	2.17a	1.96c	5.29b	39.81b
S_{30}	122.13a	9.66ab	214.16b	4.25	18.14	2.26a	2.23b	5.16b	43.36a
S_{45}	123.95a	10.88a	244.20a	4.32	17.95	2.27a	2.46a	5.96a	41.79a
Level of significance	**	**	**	NS	NS	**	**	**	**
CV (%)	1.16	7.41	0.74	2.84	6.06	3.26	2.86	2.28	2.70

In a column, figures having similar letter (s) do not differ significantly whereas figures having dissimilar letter (s) differ significantly.

Note: S_0 = 0 kg S ha^{-1}, S_{15} = 15 kg S ha^{-1}, S_{30} = 30 kg S ha^{-1}, S_{45} = 45 kg S ha^{-1}

CV = Coefficient of variation

** = Significant at 1 % level, NS = Not significant

Siliqua length was not found to be influenced by the application of sulphur. The siliqua length ranged from 4.16 to 4.32 cm (Table 2). The longest siliqua was produced by the application of 45 kg S ha^{-1} (4.32 cm) and the lowest (4.16 cm) was found in the control treatment. This result is supported by Sen and associates (1987).

The effect of sulphur on number of seeds $siliqua^{-1}$ was non significant. However, the number of seeds $siliqua^{-1}$ ranged from 17.62 to 18.80 (Table 2). The maximum number of seeds $siliqua^{-1}$ (18.80) was produced from the control treatment and the minimum was obtained where 15 kg S ha^{-1} applied. It might be concluded that application of higher levels of sulphur was not suitable for seed formation because the experimental area was not sulphur deficit.

The weight of 1000 seed ranged from 1.80 to 2.27 g (Table 2). The highest 1000 seed weight (2.27 g) came from where 45 kg S ha^{-1} was applied which was statistically similar to S_{15} and S_{30} treatments. The results showed that increasing rate of sulphur increased weight of 1000-seed gradually. This finding supported by Rathore and Manohar (1989) and Khalil (1997). Thousand seed weight also showed a positive and linear relationship with sulphur dose (Fig. 1). The maximum value (R^2= 0.7658) indicates that 76 % of the variation in 1000 seed weight could be defined by the variation in sulphur dose.

Seed yield varied significantly due to sulphur levels. It was observed that seed yield ranged from 1.81 to 2.46 t ha^{-1} (Table 2). The highest seed yield (2.46 t ha^{-1}) was obtained from the plot receiving the highest dose of sulphur (45 kg ha^{-1})and the lowest (1.81 t ha^{-1}) was found in the control treatment. The results showed that seed yield decreased with the decreasing rate of sulphur application. Khandkar and coworkers (1991) obtained similar results. They found that 60 kg S ha^{-1} produced the highest seed yield. Studer (1971) also observed that 40-60 kg S ha^{-1} produced highest seed yield. Seed yield showed a positive and linear relationship with

sulphur dose (Fig. 2). The higher value (R^2= 0.9884) suggests that over 95 % of the variation in yield could be explained by the variation in sulphur dose.

The effect of sulphur on biological yield was also significant which ranged from 5.09 to 5.96 t ha^{-1} (Table 2). The highest biological yield (5.96 t ha^{-1}) was produced by the application of 45 kg S ha^{-1}which differ significantly from other treatments. The lowest (5.09 t ha^{-1}) was found where sulphur was not applied.

Harvest index ranged from 36.96 to 43.36 %. Results presented in Table 2 which showed that 30 kg S ha^{-1} produced the highest harvest index (43.36 %) which was statistically similar to 45 kg S ha^{-1} (41.79%). The lowest (36.96%) was found in the control treatment which was dissimilar to other treatments. This relationship showed that seed yield was dependent on harvest index and over 67 % of the variation in yield could be defined from the variation in harvest index (Fig. 3).

Interaction effect of sulphur and variety on yield and yield components of mustard

Interaction effect of sulphur and variety on plant height was significant at 1 % level. Plant height ranged from 107.13 cm to 148.06 cm (Table 3). The tallest plant (148.06 cm) was obtained from the variety BARI Sarisha-11 fertilized with 45 kg S ha^{-1} and the shortest plant (107.13 cm) was recorded in Sonali sarisha where sulphur was not applied. The result is supported by Singh and Gangasarma (1987).

Number of branches $plant^{-1}$ was influenced by interaction effect of sulphur and variety. Number of branches $plant^{-1}$ ranged from 7.26 to 12.20 (Table 3). Maximum number of branches $plant^{-1}$ (12.20) was in BARI Sarisha-11 fertilized with 45 kg S ha^{-1} which was statistically similar to S_0V_3, $S_{15}V_3$, $S_{45}V_2$ and the minimum was produced by S_0V_1 (7.26). Similar finding was reported by Saran and Giri (1990) who observed that number of branches $plant^{-1}$ increased significantly with 45 kg S ha^{-1}.

Number of siliquas plant^{-1} was significantly affected by the interaction between sulphur and variety. Number of siliqua plant^{-1} ranged from 127.53 to 294.86 (Table 3). The maximum number of siliqua plant^{-1} (294.86) was recorded from the variety BARI Sarisha-9 fertilized with 45 kg S ha^{-1} and the minimum (127.53) was produced in $S_{15}V_1$. Chatterjee and coworkers (1985) and Sing and Gangasarma (1987) also recorded a maximum number of siliqua plant^{-1} with 30 and 45 kg S ha^{-1}, respectively. Simple linear regression showed that number of siliqua plant^{-1} was dependent on sulphur dose in all varieties (Fig. 4). From fig. 4 it can also be concluded that number of siliqua plant^{-1} increased with the suggest of sulphur dose and the regression models obtained are

Number of siliquas plant^{-1} (V1) = 121.21 + 0.7413 × sulphur dose (R^2 = 0.7708)
Number of siliquas plant^{-1} (V2) = 188.61 + 2.2512 × sulphur dose (R^2 = 0.8833)
Number of siliquas plant^{-1} (V3) = 256.79 + 0.2954 × sulphur dose (R^2 = 0.0785)

Length of siliqua was not significantly influenced by interaction effect of sulphur and variety. Length of siliqua ranged from 3.67 to 4.59 cm (Table 3). Numerically the longest and shortest siliqua length were recorded from $S_{45}V_1$ (4.59 cm) and $S_{15}V_3$ (3.67 cm) treatments, respectively. Similar result was found by Sen and colleagues (1987).

Number of seeds siliqua^{-1} was not influenced significantly by interaction between sulphur and variety. However number of seeds siliqua^{-1} ranged from 11.01 to 26.96 (Table 3). The highest number of seeds siliqua^{-1} (26.96) was obtained from the variety Sonali sarisha with not fertilized sulphur and the lowest (11.01) was produced by $S_{30}V_3$.

Weight of 1000 seed was significantly influenced by interaction between sulphur and variety which ranged from 1.47 to 2.44 g (Table 3). The highest 1000 seed weight (2.44 g) was produced from BARI Sarisha-9 fertilized with 30 kg S ha^{-1}

and the lowest was found in S_0V_1 (1.47g). The results are consistent with those of Chatterjee and associates (1985) who observed an increased weight of 1000 seed of mustard due to sulphur fertilization up to 30 kg ha^{-1}.

The interaction of sulphur and variety influenced the seed yield of mustard. Seed yield ranged from 1.59 to 2.75 t ha^{-1} (Table 3). The highest seed yield (2.75 t ha^{-1}) was produced from the variety BARI Sarisha-9 fertilized with 45 kg S ha^{-1} and the lowest (1.59 t ha^{-1}) was found in Sonali sarisha with no sulphur application. The result is in agreement with that of Sawarker and associates (1987) who obtained an increased seed yield due to sulphur fertilization up to 45 kg ha^{-1}. Simple linear regression showed that seed yield was dependent on sulphur dose in all varieties (Fig. 5). From fig. 5 it can also be concluded that seed yield increased with the suggest of sulphur dose and the regression models obtained are

Seed yield (V1) = 1.582 + 0.0228 × sulphur dose (R^2 = 0.9992)
Seed yield (V2) = 1.914 + 0.0196 × sulphur dose (R^2 = 0.8071)
Seed yield (V3) = 1.848 + 0.0022× sulphur dose (R^2 = 0.1092)

The interaction effect of sulphur and variety on biological yield was significant too. Biological yield ranged from 4.04 to 7.44 t ha^{-1} (Table 3). The highest and lowest biological yield was produced by $S_{15}V_3$ (7.44 t ha^{-1}) and $S_{15}V_2$ (4.04 t ha^{-1}) treatments, respectively.

Harvest index was significantly affected by interaction between sulphur and variety at 1 % level. Harvest index ranged from 26.79 to 50.67 % (Table 3). The highest harvest index (50.67 %) was obtained from the variety BARI Sarisha-9 fertilized with 30 kg S ha^{-1} and the lowest (26.79 %) was found in BARI Sarisha-11 fertilized with 15 kg S ha^{-1}. The results are supported by Freeman and Mossadeli (1972).

Table 3. Interaction effect of variety and sulphur on the yield and yield attributes of mustard.

Sulphur x Variety	Plant height (cm)	Number of branches plant^{-1}	Number of siliqua plant^{-1}	Length of siliqua (cm)	Number of seeds siliqua^{-1}	1000-seed weight (g)	Seed yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
S_0V_1	107.13f	7.26e	128.53k	4.39	26.96	1.47f	1.59g	4.83f	33.05e
S_0V_2	113.63de	8.60de	202.49g	4.40	17.37	2.00e	2.01d	4.15h	48.68b
S_0V_3	137.66b	11.67a	248.86e	3.69	12.06	1.93e	1.83ef	6.30b	29.15f
$S_{15}V_1$	108.60f	7.80de	127.53k	4.39	24.18	2.22bc	1.92de	4.40g	43.72d
$S_{15}V_2$	111.53e	8.40de	199.57h	4.50	17.29	2.04de	1.97d	4.04h	48.91ab
$S_{15}V_3$	133.73c	11.80a	284.33b	3.67	11.39	2.27bc	1.99d	7.44a	26.79g
$S_{30}V_1$	115.40d	7.80e	139.11j	4.67	26.73	2.19bc	2.25c	4.92f	45.80c
$S_{30}V_2$	115.26d	10.00bc	260.14d	4.37	16.68	2.44a	2.69ab	5.33e	50.67a
$S_{30}V_3$	135.73bc	11.20ab	243.23f	3.71	11.01	2.15cd	1.75f	5.22e	33.63e
$S_{45}V_1$	108.26f	8.800d	160.40i	4.59	25.30	2.29b	2.62b	5.55d	47.30bc
$S_{45}V_2$	115.53d	11.66a	294.86a	4.58	17.33	2.27bc	2.75a	5.96c	46.20c
$S_{45}V_3$	148.06a	12.20a	277.33c	3.79	11.22	2.24bc	2.02d	6.37b	31.87e
Level of significance	**	*	**	NS	NS	**	**	**	**
CV (%)	1.16	7.41	0.74	2.84	6.06	3.26	2.86	2.28	2.70

In a column, figures having similar letter(s) do not differ significantly whereas figures having dissimilar letter(s) differ significantly.

Note: V_1 = Sonali sarisha, V_2 = BARI sarisha-9, V_3 = BARI sarisha-11

S_0 = 0 kg S ha^{-1}, S_{15} = 15 kg S ha^{-1}, S_{30} = 30 kg S ha^{-1}, S_{45} = 45 kg S ha^{-1},

CV = Coefficient of variation

** = Significant at 1 % level, * = Significant at 5 % level, NS = Not significant

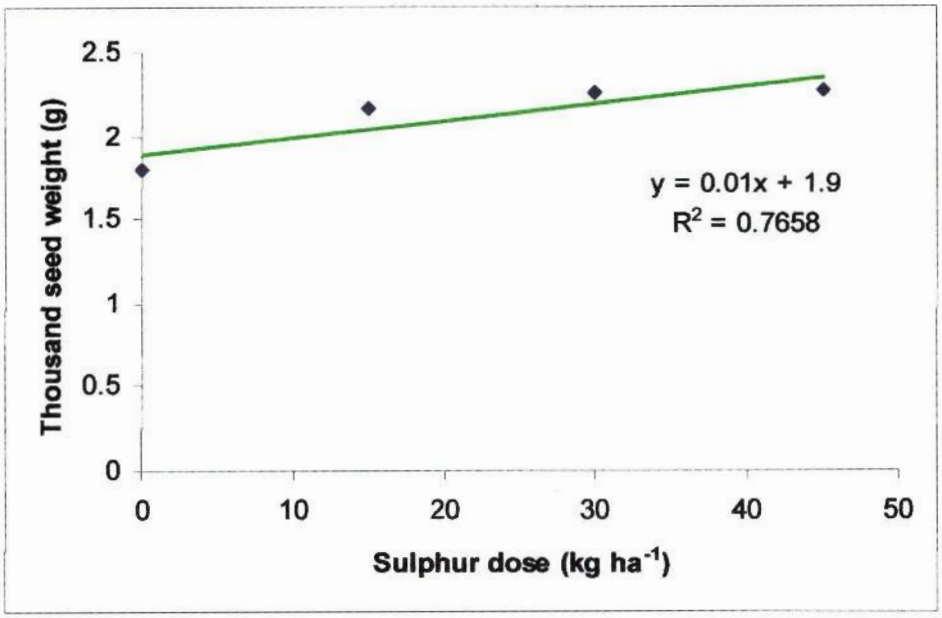

Fig.1. Functional relationship between sulphur dose and thousand seed weight in mustard.

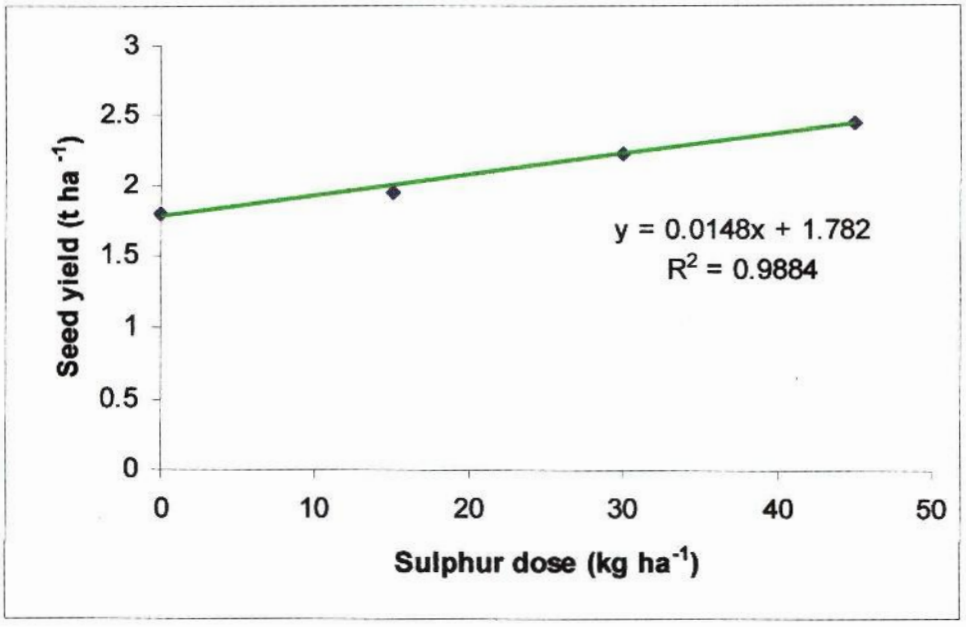

Fig. 2. Functional relationship between sulphur dose and seed yield in mustard.

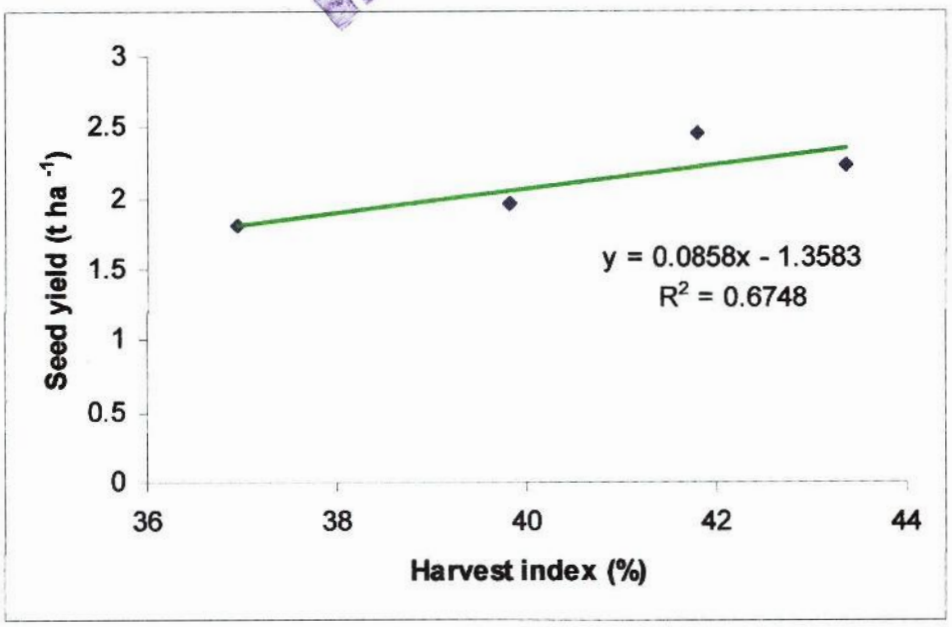

Fig. 3. Functional relationship between harvest index and seed yield in mustard.

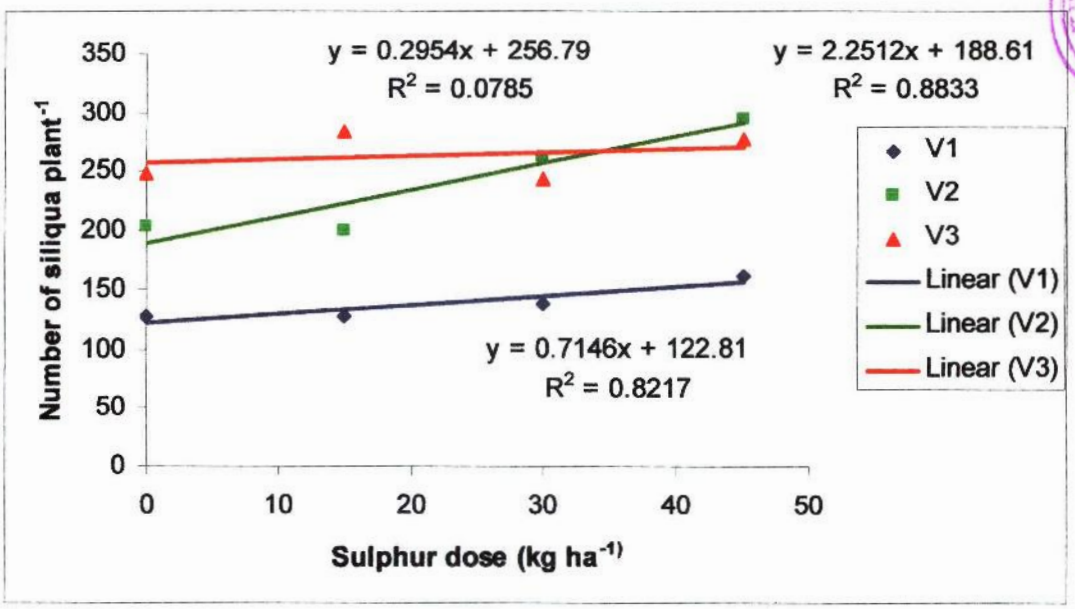

Fig. 4. Functional relationship between sulphur dose and number of siliqua plant^{-1} in mustard varieties.

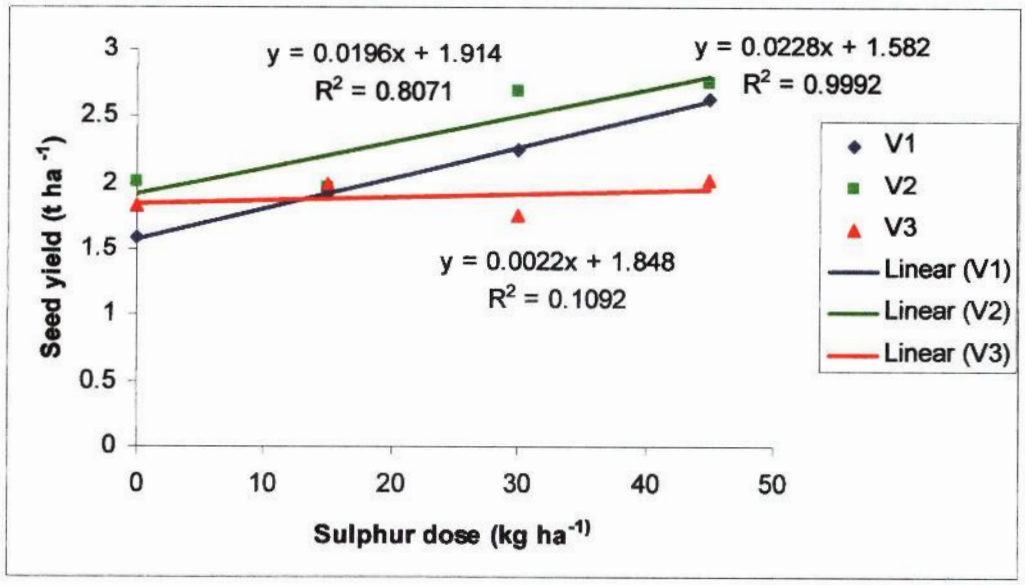

Fig. 5. Functional relationship between sulphur dose and seed yield in mustard varieties.

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted at the Agrotechnology Field Laboratory, Khulna University, Khulna during the *rabi* season from November, 2006 to February, 2007 to evaluate the effect of sulphur on yield and yield attributes of mustard. The experiment was laid out in a randomized complete block design with two factors. Four levels of sulphur *viz.*, S_0 = 0 kg S ha^{-1}, S_{15} = 15 kg S ha^{-1}, S_{30} = 30 kg S ha^{-1} and S_{45} = 45 kg S ha^{-1} as well as three varieties of mustard *viz.*, V_1= Sonali sarisha, V_2 = BARI sarisha-9 and V_3 = BARI sarisha-11 were used in this experiment. The total number of experimental units was 4 x 3 x 3 =36. The unit plot size was 3 m x 2 m. Block to block and plot to plot distance was maintained by 0.5 m. The experimental land was uniformly fertilized with 275, 175, 90, 6 and 12 kg ha^{-1} Urea, TSP, MP, $ZnSO_4$ and H_3BO_4, respectively. Seeds were sown @ 9 kg ha^{-1} on 18th November, 2006 manually in 30 cm apart lines. The seeds were germinated 4 days after sowing (DAS). Flowering commenced at 27, 33 and 35 DAS by BARI sarisha-9, Sonali sarisha and BARI sarisha- 11, respectively. BARI sarisha-9 was harvested at 76 DAS and another two varieties were harvested at 86 DAS. After harvesting data were recorded on plant height, number of branches $plant^{-1}$, number of siliquas $plant^{-1}$, number of seeds $siliqua^{-1}$, length of siliqua, 1000-seed weight, seed yield $plant^{-1}$, straw yield $plant^{-1}$, biological yield $plant^{-1}$, seed yield, straw yield, biological yield and harvest index.

The results revealed that varieties differed significantly for all the studied parameters. Among the tested varieties, BARI sarisha-11 produced highest plant height (138.80 cm), number of branches $plant^{-1}$ (11.71), number of siliqua $plant^{-1}$ (263.44) and biological yield (6.33 t ha^{-1}) than other varieties. The highest number of seeds $siliqua^{-1}$ (25.79) and length of siliqua (4.57 cm) were recorded from Sonali sarisha out of three varieties. BARI sarisha-9 performed well in 1000-seed weight (2.19g), seed yield (2.36 t ha^{-1}) and harvest index (48.62%).

Sulphur fertilization had significant effect on all parameters except number of seeds siliqua^{-1} and length of siliqua. The highest plant height (123.95 cm), number of branches plant^{-1} (10.88), number of siliqua plant^{-1} (244.20), 1000- seed weight (2.27 g), seed yield (2.46 t ha^{-1}), biological yield (5.96 t ha^{-1}) were found where sulphur was applied 45 kg ha^{-1}. But highest harvest index (43.36 %) was observed where sulphur was applied 30 kg ha^{-1}.

The interaction effect of sulphur and variety had significant effect on all parameters except number of seeds siliqua^{-1} and length of siliqua. The highest plant height (148.06 cm) and number of branches plant^{-1} (12.20) observed in BARI sarisha-11 when sulphur was applied 45 kg ha^{-1}. BARI sarisha-9 gave the highest number of siliqua plant^{-1} (294.86) and seed yield (2.75 t ha^{-1}) by the application of 45 kg S ha^{-1}.

It can be concluded that from the study, BARI sarisha-9 performed well in cases of 1000 seed wt. (2.19 g), seed yield (2.36 t ha^{-1}) and harvest index (48.62 %) than other two varieties. The highest number of siliqua plant^{-1} (244.20), 1000- seed weight (2.27 g) and seed yield (2.46 t ha^{-1}) was produced by the application of 45 kg S ha^{-1}. BARI sarisha-9 performed well than other varieties in such cases of number of siliqua plant^{-1} (294.86) and seed yield (2.75 t ha^{-1}) when sulphur was applied at 45 kg ha^{-1} but 1000-seed weight (2.440 g) and harvest index (50.67 %) produced by the application of 30 kg S ha^{-1} from the same variety. Further researches may be carried out with different varieties and different rates of sulphur at various agro-ecological zones of Bangladesh to arrive at a definite conclusion and to investigate the sulphur and oil content of seed.

CHAPTER VI

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APPENDICES

Appendix 1. Chemical characteristics of initial soil (0- 15 cm depth)

Sl. no.	Soil parameters	Analytical result	Comments
1.	p^H	6.2	Slightly acidic
2.	Salinity (dS m^{-1})	4.6	Slightly saline
3.	Organic matter (%)	4.32	High
4.	Potassium (me 100^{-1} g soil)	0.46	Very high
5.	Total Nitrogen (%)	0.250	Medium
6.	Phosphorus (µg g^{-1} soil)	2.78	Very low
7.	Sulphur (µg g^{-1} soil)	251.03	Very high

Source: Soil analyzed from Soil Resource Development Institute, Regional Laboratory, Doulatpur, Khulna.