Effects of irrigation and sulphur application on growth, yield and oil content of rapeseed (*Brassica napus*)

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Abstract

An experiment was conducted at the Agronomy Field of Sher-e-Bangla Agricultural University during October 2013 to February 2014 to evaluate the effect of irrigation and sulphur (S) application on the growth, yield and oil content of rapeseed (*Brassica napus*). There were three levels of irrigation viz. no irrigation, one irrigation at 25 days after sowing and two irrigation at 25 days after sowing and 53 days after sowing, and three levels of S viz. 15, 30 and 45 kg S ha^{-1} as gypsum .The experiment was laid out in a split plot design with three replications assigning irrigation in the main plots and S levels in the subplots. Irrigation and added S significantly influenced plant height, number of primary and secondary branches per plant, number of siliquae per plant, siliqua length, seeds per siliqua, seed yield and seed oil content. Seed yield was mainly influenced by number of siliquae per plant and seeds per siliqua. Two irrigations had better performances on all parameters under study. The highest seed yield (1527 kg ha^{-1}) was obtained with two irrigations coupled with application of 45 kg S ha^{-1} which was statistically similar to two irrigations with 30 kg S ha^{-1}. Sulphur application greatly influenced seed oil content showing the highest oil content due at 45 kg S ha^{-1}.

Keywords: Rapeseed, Irrigation, Sulphur, Yield and Oil content

Introduction

Rapeseed belongs to the family Cruciferae and it ranks as the world's third important oil crop in terms of area and production. Among the three species, *Brassica napus* is regarded as rapeseed. Rapeseed contains 40-45% oil and 20-25% protein. Edible oil is one of the basic requirements of people's daily diet. Bangladesh has been facing acute shortage of edible oil for the last several decades (BBS, 2012). On the basis of recommended dietary allowance (RDA), Bangladesh requires 0.29 million tons of oil to meet the demand of its people (FAO, 2008). About one-third of the total requirement of oil is met by local production of rapeseed and mustard (BBS, 2012). At present, about 0.25 million hectares of land is under rapeseed and mustard cultivation in Bangladesh with a production of 0.25 million tons (BBS, 2012). The average seed yield of rapeseed and mustard is around 1.0 t ha^{-1} in this country (BBS, 2012), which is far below compared to advanced countries like Belgium (4.7 t ha^{-1}), Denmark (3.6 t ha^{-1}), France (3.54 t ha^{-1}), Netherlands (3.47 t ha^{-1}), U.K. (2.89 t ha^{-1}), Germany (2.8 t ha^{-1}), Japan (2.16 t ha^{-1}) and Poland (1.86 t ha^{-1}) (FAO, 2012). The major reasons for such poor yield of mustard in Bangladesh may be attributed to lack of improved varieties and poor management practices in the farmers' field. On the contrary, the National Agricultural Research System, Institutes developed a number of *Brassica* oilseed varieties with high yield potentials and improved management practices, the yield range being between 1.4 and 2.1 t ha^{-1} (BARI, 2012). Therefore, there is a scope to increase the yield level by using High Yielding Variety (HYV) and adopting proper management practices like spacing, weeding, irrigation, seed rate, fertilizer application etc. In Bangladesh, both rapeseed and mustard are grown on the residual soil moisture in winter season (Kaul and Das, 1986). Irrigation is a vital factor for proper growth and development of rapeseed and mustard crops in dry season (Roy and Tripathi, 1985). Because requires water 60 to 169 mm water through its life cycle (Rahman, 1989; Sarkar et al., 1989). In fact, *Brassica* is an irrigated crop since its yields is greatly increased by the presence of adequate soil moisture in different growth stages (Prasad and Eshanullah, 1988). Saran and Giri (1988) reported that plant height was found to be highest when one irrigation at 30 days after sowing was

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applied. Rathore and Patel (1989) found the number of branches plan^{-1} of mustard increased with increased in irrigation frequency. Irrigation has been found to increase 1000 seed weight, number of siliquae plant^{-1}, number of seeds siliquae^{-1}, seed yield and harvest index (Shrivastava et al., 1988). Sharma and Kumar (1989b) found in another experiment with mustard that the number of siliquae plant^{-1} increased with increasing irrigation frequency. Siag *et al*. (1993) found that when two irrigations were given either at branching and siliquae development or at branching and flowering stages recorded a significant increase in siliqua plant^{-1}. Prasad and Ehsanullah (1988) reported that irrigation significantly increased the1000 seed weight. Irrigation has an effect in increasing nutrient uptake by crops thus increasing biomass, which ultimately increased yield. Sulphur has also been reported to influence productivity of oilseed (Singh *et al*., 1999). Because of rapeseed has a high demand of S, approximately 16 kg of S required to produce 1 ton of seeds containing 91% of dry matter (Zhao *et al*., 1993; Mc Grath *et al*., 1996). Sulphur as a micro nutrient, plays an important role in physiological functions like synthesis of cystine, methionine, chlorophyll and oil content of oilseed crops. It is also responsible for synthesis of certain vitamins (Vit B, Biotin and thiamine), metabolism of carbohydrates & proteins and oil formation in crucifers. *Brassica* has the highest S requirement owing to the presence of S rich glucosinolates.

Sulphur deficiency results in reduced plant growth and chlorosis of the younger leaves, beginning with yellowing that gradually spreads over the entire leaf area. Sulphur is somewhat immobile in the plant, so deficiency symptoms tend to occur first in younger leaves and then older leaves. Plants may be small and spindly with short, slender stalks. Plants may flower but have reduced seed set as is the case for rapeseed. Sulphur increases plant dry matter. Mandal and Sinha (2004) reported that dry matter production and cumulative growth rate (CGR) significantly increased with increasing levels of S up to 20 kg S ha^{-1} and LAI up to 40 kg S ha^{-1}. The present study was undertaken with an objective to find out the number of irrigation and rate of S application for achieving higher and sustainable seed yield and oil content.

Materials and Methods

The experiment was conducted in the Modhupur Tract under Agro-Ecolological Zone 28 (AEZ-28). Experimental site was Sher-e-Bangla Agricultural University, Dhaka (90.2^{O} N latitude and 23.5^{0}E altitude) lies at an elevation of 8.2 m above the sea level. The terrace soils of Dhaka belongs to Tejgaon series under the agro ecological zone Madhupur Tract and texture is silty loam. The variety SAU SR-12 is a high yielding line (F_{12} progeny of SS-75 X Tori-7) under brown sarson group of *Brassica campestris*. Soil samples (0-20 cm), before initiation of the experiment, was analyzed for soil pH (Jackson, 1973), organic matter (Nelson and Sommers, 1982), total N (Bremner and Mulvaney, 1982), exchangeable K (Pratt, 1965), available P (Olsen & Sommers, 1982), available S (Fox *et al*., 1964) and available B (Page *et al*., 1982). The results of the soil properties are shown in Table 1.

Table 1. Soil properties of the experimental field

Location	pH	OM (%)	K meq. 100 g^{-1}	Total N (%)	P	S	B
					µg g^{-1}		
SAU, Dhaka	5.8	0.78	0.10	0.038	17	20	0.16
Critical level (FRG, 2012)	-	-	0.12	0.12	10	10	0.2

The experiment was laid in a split plot design with three replications. Irrigation treatments were imposed to the main plots and S treatments to the sub plots. Total number of main plots was 9 (3x3) and subplots was 27 (9x3). The unit subplot size was 6m^2 (4.0 m x 1.5 m). The distance among the main plots was 1m and among the subplots 0.5 m. The land was prepared thoroughly by country plough followed by laddering. Three irrigation treatments were I_1= no irrigation (control), I_2= one irrigation at 53 DAS, I_3= two irrigation at 25 and 53 DAS at per treatment. Three S fertilizer treatments in the experiment were S_1= 15 kg S ha^{-1}, S_2= 30 S kg ha^{-1}, S_3= 45 kg S ha^{-1}. Fertilizers were used as urea, TSP, MP, gypsum and boric acid to supply N, P, K, S and B, respectively. Seeds were sown on 12 November 2013. Ten mature plants were randomly selected from each plot on each replication for recording data on plant height (cm), number of branches plant^{-1}, pod length

(mm), siliquae plant^{-1}, seed siliqua^{-1}, grain yield (t ha^{-1}), oil content and N, protein, K, P, S, B content in rapeseed plant. Oil content of seed was determined by Soxhlet method and expressed in percentage (%), N content was determined by Kjeldahl method (Ranganna,1998), S content of plant extract by turbidometric method with the help of a spectrophotometer, set at 420 nm (Wolf, 1982), phosphorus content (diacid mixture extract) determined colorimetrically by ascorbic acid blue colour method at 660 nm (Olsen *el al* 1954), potassium (K) content (diacid mixture extract) by the help of the flame emission spectrophotometer. The samples were aspirated into a gas flame (Ghosh *et al*., 1983). Total N of each sample was estimated by the Macro kjeldahl method (PCARR, 1980). The data obtained from the experiment were analyzed statistically to find out the significance of the difference among the treatments. The mean values of all the characters were evaluated and analysis of variance was performed by the F (variance ratio) test. The significance of the differences between means was estimated by Least Significant Difference Test (LSD) at 5%.

Results and Discussion

The present experiment was conducted to determine the effect and interaction effect of different levels of irrigation and sulphur on yield and yield contributing characters of rapeseed. The analyses of variance (ANOVA) of the data results have been presented and discussed, and possible explanations have been given under the following headings.

Effect of irrigation and sulphur application on growth, yield and oil content parameters of mustard

Significant variation was found due to the interaction effect among irrigations and sulphur for eight characters of rapeseed (Table 2.). Significant variation was observed due to the effect and interaction effect among irrigations and sulphur on oil content of rapeseed (Table 2.).Variation was significant observed due to interaction effect among irrigation and sulphur on nitrogen, phosphorus, potassium, and sulphur content by rapeseed plant (Table 3.).

Correlation and regression studies

Statistical relationship between seed yield and plant height, seed yield and effective siliquae plant^{-1}, seed yield and seeds siliquae^{-1}, seed oil content and S concentration in plant, seed yield and oil content of rapeseed has been found out. There is a direct significant and positive relationship between seed yield and plant height of rapeseed which has been confirmed with correlation co-efficient $r^2 = 0.987$.

Table 2. Interaction effect of irrigation and sulphur on yield contributing characters, yield and oil content of rapeseed

Treatment	Plant height	Primary branches plant^{-1} (No.)	Secondary branches plant^{-1} (No.)	Siliquae plant^{-1} (No.)	Length of siliquae (cm)	Seeds siliquae^{-1} (No.)	Seed yield (g plant^{-1})	Seed yield (kg ha^{-1})	Oil content (%)
I_0S_1	66	3	3	54	6	15	1.367	412.7	41.57
I_0S_2	66	3	3	53	6	15	1.360	409.7	42.20
I_0S_3	66	3	3	54	6	15	1.360	413	42.73
I_1S_1	86	6	7	122	7	18	4.683	996	42.33
I_1S_2	86	6	7	128	7	18	5.023	1059	43.13
I_1S_3	87	7	7	130	7	18	5.083	1055	43.67
I_2S_1	95	7	8	144	8	21	6.193	1463	42.27
I_2S_2	96	7	9	148	8	22	6.403	1526	43.60
I_2S_3	96	7	9	149	8	22	6.433	1527	44.40
$LSD_{0.05}$	3.12	0.23	0.44	2.16	0.23	0.55	0.19	27.55	0.47
CV (%)	0.42	2.25	2.51	1.11	1.88	1.69	2.45	1.39	0.62

Note: Means under a parameter, having a common letter separated by LSD test, do not differ significantly (p=0.05); I_0 = Control, I_1 = One Irrigation, I_1 = Two Irrigation, S_1 = 15 kg Sulphur ha^{-1}, S_2 = 30 kg Sulphur ha^{-1}and S_3 = 45 kg Sulphur ha^{-1}

Table 3. Interaction effect of irrigation and Sulphur on nitrogen, phosphorus, potassium, and Sulphur content by rapeseed plant

Irrigation x Sulphur	Content in plant (%)			
	N	P	K	S
I_0S_1	1.200 g	0.095 f	2.937 g	0.260 g
I_0S_2	1.237 fg	0.100 e	3.127 f	0.293 f
I_0S_3	1.273 f	0.097 f	3.157 f	0.330 e
I_1S_1	1.740 e	0.117 d	3.247e	0.360 d
I_1S_2	1.843 d	0.123 c	3.293 de	0.383 c
I_1S_3	1.930 c	0.121 c	3.337 d	0.400 b
I_2S_1	2.083 b	0.128 b	3.823 c	0.407 b
I_2S_2	2.127 ab	0.134 a	3.910 b	0.430 a
I_2S_3	2.140 a	0.130 b	4.147 a	0.440 a
LSD(0.05)	0.056	0.003	0.056	0.016
CV (%)	1.67	1.58	1.05	2.49

Note: I_0 = Control, I_1 = One Irrigation, I_1 = Two Irrigation, S_1 = 15 kg Sulphur ha^{-1}, S_2 = 30 kg Sulphur ha^{-1}and S_3 = 45 kg Sulphur ha^{-1}

The relationship was more evident by y = 36.01x – 1993.9 and also showing gradual increase of plant height. The seed yield was positively and significantly correlated with siliquae plant^{-1} (r^2 = 0.9489). The line of regression of y = 10.924x – 207.32 is found in analysis. The positive slope indicates that the seed yield and effective siliquae plant^{-1} are directly correlated i.e. increase in seed yield result in an increase in effective siliquae plant^{-1} of rapeseed. It was a direct significant and positive relationship between seed yield and seed siliquae^{-1} having y = 164.56x – 2049.7. The correlation co-efficient (r^2 = 0.9793) was found out significant at 5% level of probability. The positive slope is found and indicate that seed yield and seed siliquae^{-1} directly correlated i.e. increase in seed siliquae^{-1} result in an increase in seed yield. There is a direct, significant and positive relationship between oil content and S concentration of rapeseed which has been confirmed with correlation co-efficient r^2 = 0.6714. The relationship was more evident by y = 1.1846x + 38.53 and also showing gradual increase of S concentration.

Conclusions

Results revealed that main effect and interaction effect of irrigation and S was significant in respect of studied parameters. It may be concluded that irrigation and S influenced the growth, yield and yield components of rapeseed. Among the irrigation levels two irrigations at 25 and 53 Days after sowing (DAS) gave the best results, whereas, among the S treatments, 45 kg S ha^{-1} gave the best result and it was statistically similar with 30 kg S ha^{-1}. So, the interaction effects of two irrigations with 30 kg S ha^{-1} were found most effective in respect of mustard seed yield.

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