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Growth and Yield of Rapeseed (*Brassica campestris* L.) Varieties as Affected by Levels of Irrigation

S. Sultana, A.K.M. Ruhul Amin and Mirza Hasanuzzaman

Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh

Abstract: The study was carried out at the Agronomy Field of Sher-e- Bangla Agricultural University farm, Dhaka, Bangladesh during November 2006 to March 2007 to evaluate the effect of irrigation and variety on growth, yield attributes and yield of rapeseed. The treatment comprised of three levels of irrigation viz. no irrigation, one irrigation at 20 DAS, one irrigation at 35 DAS, two irrigations at 20 and 35 DAS and three irrigations at 20, 35 50 DAS and three varieties viz. SAU Sarisha-1, Kollania and Improved Tori-7. Three irrigations (at 20, 35 and 50 DAS) increased economic yield with higher values of harvest index as the yield attributes like branches plant^{-1}, siliqua plant^{-1}, seeds siliqua^{-1} and 1000 seed weigh were higher. The seed yield with three irrigations was 111.93% and 10.73% higher than no irrigation and two irrigations, respectively. The variety SAU Sarisha-1 showed its superiority by producing 1.4 % and 45.94 % higher yield than Kollania and Improved Tori-7, respectively. This variety (SAU Sarisha-1) also showed higher branches plant^{-1}, seeds siliqua^{-1}, 1000 seed weight, biological yield and harvest index. In most of the cases interaction of three irrigations with SAU Sarisha-1 performed best in respect of grain yield as well as other studied parameters. The highest seed yield (1827.0 kg ha^{-1}) was obtained with the interaction of three irrigation with SAU Sarisha-1. This was achieved due to the maximum number of branches plant^{1}, seeds siliquae^{-1} and 1000 seed weight in this interaction.

Key words: *Brassica*, Soil moisture, Siliquae, Yield

INTRODUCTION

Edible oil plays a vital role in human nutrition. Edible oil is a high-energy component of food and meeting the calorie requirements of human nutrition. In Bangladesh the annual oil seed production is 3,76,000 metric tons of which rapeseed (*Brassica spp.*)covers 62% of the total edible oil [1]. Each gram of oil supplies 9 kcal energy, whereas 4 kcal energy comes from 1-gram carbohydrate or protein [2].

Bangladesh has been facing acute shortage of edible oil for the last several decades. On the basis of RDA, Bangladesh requires 0.29 million tons of oil annually to meet the demand of her people [3]. But one-third of total requirement of oil is meeting by local production of rapeseed and mustard [4]. Rapeseed-mustard is grown more or less all over Bangladesh. Bangladesh Agricultural Research Institute (BARI), Bangladesh Agriculture University, Bangladesh Institute of Nuclear Agriculture (BINA) and Sher-e-Bangla Agricultural University (SAU) has released a number of new high yielding varieties of rapeseed/mustard for farmer's cultivation. The yield of HYV's ranges from 1.4 to 2.1 t ha^{-1} [5]. But the yields in farmer's field are still low compared to their potentialities due to lack of proper management practices. So there is a scope to increase the yield level of HYVs with proper management practices like spacing, irrigation, seed rate, fertilizer application etc.

Irrigation is a vital factor for proper growth and development of these crops in dry season [6]. The crop essentially requires water ranging from 60 to 69 mm through out its life cycle [7,8]. Mondal *et al.* [9] reported that one irrigation at flowering and another at siliquae development stages gave the highest yield (2.56 t ha^{-1}). In recent years some promising varieties have been released which are growing with irrigation facilities in Bangladesh. But the information regarding irrigation on the yield of rapeseed is still unlimited. In view of the limited information on the problems mentioned above a field study on rapeseed containing the different varieties and irrigation time were conducted to study the combined effect of variety and irrigation on the growth and yield of rapeseed.

Corresponding Author: Mirza Hasanuzzaman, Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh

MATERIALS AND METHOD

The research work was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from November 2006 to March 2007. The experimental field is located at 90°22'E longitude and 23°41'N latitude at an altitude of 8.6 meter above sea level. The soil was clay loam in texture. Organic matter content was very low (0.82%) and soil pH varied from 5.47-5.63.

Three rapeseed varieties viz. SAU Sarisha-1 (V_1); Improved Tori-7 (V_2) and Kollania (V_3) were used as experimental materials. There were 5 different irrigation treatments as: no irrigation (I0); irrigation at 20 days after sowing (1_1); irrigation at 35 days after sowing (1_2); irrigation at 20 and 35 days (1_3); and irrigation at 20, 35 & 50 days after sowing (I_4). The experiment was laid out in a two factor Split plot design with three replications. Irrigation was given in main plot and variety was in sub-plots. Each replication was divided into 5 equal main plots randomly. Further each main plot was also divided into 3 sub plots. The experimental plots were fertilized with the recommended dose of 300, 180, 100, 180, 5 and 10 kg ha^{-1} of Urea, Triple Super Phosphate (TSP), Muriate of Potash (MP), Gypsum, Zinc Oxide (ZnO) and Boric acid, respectively. During final land preparation, one half of the urea and total amount of other fertilizers were applied and incorporated into soil. Rest of the urea was top dressed at 28 days after sowing (DAS).

Seeds were sown in lines continuously and line to line distance was maintained 30 cm. Seeds were placed 2 cm depth and then rows were covered with loose soil properly.The seed rate was used as 7.5 kg for SAU Sarisha-1, 8 kg for Improved Tori-7 and kollania. Weeding was done two times manually. Thinning was done in all the unit plots with care maintaining a constant plant population in each row. Finally plants were kept at 5 cm distance in rows. First irrigation was given at 20 DAS the plots according to treatments. The second irrigation was given at 35 DAS and in the plots as required by the treatments and the third irrigation was given at 50 DAS. Irrigation was done by check basin method. Control plots were maintained with no irrigation. The crop was sprayed with Malathion 60 EC to prevent infestation of aphids at siliquae formation stage. Dithane M-45 was also applied immediately after irrigation to prevent soft rot of plants. At maturity when 80% of the siliquae turned straw yellowish in colour, the experimental crop was harvested. Four linear meters were harvested from the centre of each plot at ground level with the help of a sickle. The seeds thus collected were dried in the sun for reducing the moisture in the seed to about 9% level. The stovers were also dried in the sun. Seed and stover yield were recorded and converted into kg ha^{-1}. The biological yield was calculated as the sum of the seed yield and stover yield.

The data collected on different parameters were statistically analyzed to obtain the level of significance using the MSTAT-C [10] computer package program. The mean differences among the treatments were compared by Least Significant Difference Test at 5% level of significance.

RESULTS AND DISCUSSION

Number of Branches Plant^{-1}: From the study it was observed that irrigation exerted significant influence on the number of branches plant^{-1} (Table 1). The maximum number of branches plant^{-1} (6.26) was found from a plant subjected to three irrigations, one at 20 DAS, one at 35 DAS and another at 50 DAS. The lowest numbers of branches plant^{-1} (2.89) was found from control treatment. The maximum increase 116.6% of branches plant^{-1} was observed with three irrigations (at 20, 35 and 50 DAS) compared to unirrigated control treatment. Branch number was also increased with the application of one irrigation at 20 DAS over control but the rate was lower than three irrigations. In case of one irrigation (at 20 DAS) the rate of increase was 52.60% and in case of one irrigation (at 35 DAS) the rate was 95.50%. The same thing was also happend in case of two irrigations (at 20 and 35 DAS). Similar finding was reported by Joarder *et al.* [11] that irrigation increased primary and secondary branches plant^{-1}. Number of branches plant^{-1} differed significantly due to varieties (Table 2). SAU Sarisha-1 produced the highest number of branches plant^{-1} (5.43) which was significantly higher than Kollania (4.80) and Improved Tori-7 (4.40). Numerical value indicated that SAU Sarisha-1 produced 23.36% and 13.10% higher branches plant^{-1} thanImproved Tori-7 and Kollania, respectively. Numbers of branches plant^{-1} was significantly increased by the interaction effect of irrigation and variety (Table 3). The maximum number of branches plant^{-1} (7.12) was found from the interactions between two irrigations (at 20 and 35 DAS) and three irrigations (at 20, 35 and 50 DAS) with SAU Sarisha-1. The lowest number of branches plant^{-1} (2.38) was found from the interaction between without irrigation × Improved Tori-7. It revealed that the plants of SAU Sarisha-1 produced higher number of branches plant^{-1}by possing sufficient moisture.

Number of Siliquae Plant^{-1}: Irrigation showed significant variation in producing siliquae plant^{-1} (Table 1). In general, application of irrigation at different levels increased the production of siliquae plant^{-1}

Table 1: Effect of irrigation on yield character of rapeseed

Irrigation level	Branches plant^{-1} (no.)	Siliqua plant^{-1} (no.)	Seed siliqua^{-1} (no.)	Weight of 1000 seed (g)
I_0	2.89	45.01	16.48	2.05
I_1	4.41	75.47	16.38	2.30
I_2	5.65	86.96	16.67	2.49
I_3	5.86	107.10	17.52	2.61
I_4	6.26	124.10	19.89	2.91
LSD (0.05)	0.39	4.19	1.56	0.18

I_0= Control, I_1= Irrigation at 20 DAS, I_2= Irrigation at 35 DAS, I_3= Irrigation at 20 and 35 DAS and I_4= Irrigation at 20, 35 and 50 DAS

Table 2: Effect of variety on yield characters of rapeseed

Variety	Branches plant^{-1} (no.)	Siliqua plant^{-1} (no.)	Seed siliqua^{-1} (no.)	Weight of 1000 seed (g)
SAU Sarisha-1	5.43	89.97	18.20	2.58
Improved Tori-7	4.40	78.28	17.06	2.33
Kollania	4.80	94.96	16.91	2.49
LSD (0.05)	0.30	3.24	1.210	0.14

Table 3: Interaction effect of irrigation and variety on yield character of rapeseed

Irrigation × Variety	Branches plant^{-1} (no.)	Siliqua plant^{-1} (no.)	Seed siliqua^{-1} (no.)	Weight of 1000 seed (g)
I_0V_1	3.09	36.13	16.87	2.03
I_0V_2	2.38	41.43	16.02	1.93
I_0V_3	3.20	57.46	16.55	2.18
I_1V_1	5.31	78.13	16.74	2.37
I_1V_2	4.00	62.13	15.91	2.10
I_1V_3	3.92	86.13	16.50	2.42
I_2V_1	6.53	88.53	16.82	2.48
I_2V_2	5.19	76.25	16.31	2.38
I_2V_3	5.22	96.10	16.89	2.62
I_3V_1	7.12	106.90	19.63	2.95
I_3V_2	4.80	102.60	18.23	2.51
I_3V_3	5.66	111.90	14.70	2.36
I_4V_1	7.12	140.20	20.93	3.09
I_4V_2	5.64	109.00	18.85	2.75
I_4V_3	6.02	123.20	19.90	2.88
LSD (0.05)	0.67	7.25	2.70	0.32

I_0= Control, I_1= Irrigation at 20 DAS, I_2= Irrigation at 35 DAS, I_3= Irrigation at 20 and 35 DAS and I_4= Irrigation at 20, 35 and 50 DAS
V_1=.SAU Sarisha-1, V_2= Tori-7 and V_3= Kollania

over control (no irrigation). Three irrigations (at 20, 35 and 50 DAS) produced the highest number of siliquae plant^{-1} (124.10) followed by two irrigations (at 20 and 35 DAS) and one irrigation (at 35 DAS). The lowest number of siliquae plant^{-1} was found in control treatment which was 63.73, 57.97, 48.24 and 40.36% lower than three irrigations, two irrigations, one irrigation at 35 DAS and one irrigation at 20 DAS, respectively. The results were fully supported by Sharma and Kumar [12] in that irrigation increased siliquae plant^{-1}. Siliquae plant^{-1} varied significantly due to varieties (Table 2). The result revealed that Kollania produced the highest number of siliquae plant^{-1} (94.96) which was significantly higher than SAU Sarisha-1 and Improved Tori-7 (89.97 and 78.28, respectively). Similar observation was also reported by Islam *et al.* [13] that siliquae plant^{-1} varied from variety to variety. Significant difference was found due to the interaction of irrigation and variety (Table 3). Three irrigation with SAU Sarisha-1 (I_4V_1) produced the highest number of siliquae plant^{-1} (140.20) which was 288.36% higher than that of no irrigation × SAU Sarisha-1 interaction (I_0V_1). The lowest number of siliqua plant^{-1} (36.13) was found from the treatment I_0V_1.The result agreed with the findings of Andrews [14] who observed the positive effect of irrigation water towards siliquae formation.

Number of Seeds Siliqua^{-1}: Number of seeds siliqua^{-1} was significantly affected by irrigation level. The number of seeds siliqua^{-1} was increased with the increased number of irrigation (Table 1). Significantly the highest number of seeds siliqua^{-1} (19.89) was found with three irrigations (at 20, 35 and 50 DAS) while the lowest number of seeds siliqua^{-1} was found with control and one irrigation (at 20 DAS). Seeds siliqua^{-1} was increased with the increased irrigation level due to the supply of adequate soil moisture which helped to produced the longer siliqua and have more number of seeds. That reported by Prasad and Ashanullah [15], Sarker and Hassan [16], Sharma and Kumar [17] and Dobariya and Mehta [18]. Seeds siliqua^{-1} varied significantly among the varieties (Table 2). SAU Sarisha-1 showed the highest seeds siliqua^{-1} (18.20) followed by Improved Tori-7 (17.06). The lowest seeds siliqua^{-1} (16.91) was found in Kollania. SAU Sarisha-1 showed 7.63 and 6.68% higher seeds siliqua^{-1} over Kollania and Improved Tori-7, respectively. The present study were consistant with the findings of Jahan and Jakaria [18]. Irrigation and variety interact significantly each other in producing seeds siliqua^{-1} (Table 3). The highest number of seeds siliqua^{-1} (20.93) was found when three irrigations were applied with SAU Sarisha-1 followed by I_4V_1 (three irrigation × SAU Sarisha-1) and I_3V_1 (two irrigation × SAU Sarisha-1).

Table 4: Effect of irrigation on yield and harvest index of rapeseed

Irrigation level	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
I_0	715.8	1469.0	32.80
I_1	1016.0	1997.0	33.72
I_2	1151.0	2138.0	35.03
I_3	1370.0	2181.0	38.68
I_4	1517.0	2208.0	40.44
LSD (0.05)	63.48	208.0	2.024

I_0= Control, I_1= Irrigation at 20 DAS, I_2= Irrigation at 35 DAS, I_3= Irrigation at 20 and 35 DAS and I_4= Irrigation at 20, 35 and 50 DAS

Table 5: Effect of variety on yield and harvest index of rapeseed

Variety	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
SAU Sarisha-1	1296.0	2156.0	37.10
Improved Tori-7	888.7	1681.0	34.37
Kollania	1278.0	2159.0	36.92
LSD (0.05)	49.18	161.10	1.568

Weight of 1000 Seeds: Irrigation levels had significant effect on 1000 seed weight (Table 1). Three irrigations (at 20, 35 and 50 DAS) produced the highest 1000 seed weight (2.90 g) which was significantly superior to one irrigation applied at 20 DAS (2.299) and one irrigation at 35 DAS (2.49), respectively. The lowest 1000 seed weight (2.04g) was produced by without irrigation (control). The result was supported by Sarker and Hassan [16], Sharma and Kumar [19], Rahman [20] and Sarker *et al.* [21]. Weight of 1000 seed differed significantly among the varieties (Table 2). The result revealed that SAU Sarisha-1 had the highest 1000 seeds weight (2.58g) which was statistically higher from that of Kollania (2.49g) and Improved Tori-7(2.33g). However, 1000 seed weight was statistically at par with SAU Sarisha-1 and Kollania. Similar findings were reported by Mondal and Wahhab [22] that weight of 1000 seeds vary from variety to variety. Interaction effect of irrigation and variety was found significant in producing 1000 seed weight (Table 3). The highest weight of 1000 seed (3.09g) was found from the combination of three irrigations (at 20, 35 and 50 DAS) with SAU Sarisha-1. The lightest seed (1.93g) was found from the treatment combination of no irrigation and Improved Tori-7 (I_0V_2). However, the combination of the all varieties with no irrigation treatment were found statistically similar in respect of seed weight.

Seed Yield: Seed yield varied significantly due to irrigation level (Table 4). In general irrigation application increased seed yield over control (no irrigation). Maximum seed yield (1517.0kg ha^{-1}) was

Table 6: Effect of irrigation and variety on yield and harvest index of rapeseed

Irrigation × Variety	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
I_0V_1	746.10	1546.00	32.70
I_0V_2	563.20	1179.00	32.34
I_0V_3	838.00	1682.00	33.35
I_1V_1	1086.00	2131.00	33.81
I_1V_2	797.20	1664.00	32.51
I_1V_3	1164.00	2195.00	34.83
I_2V_1	1247.00	2344.00	34.89
I_2V_2	899.60	1770.00	33.87
I_2V_3	1308.00	2300.00	36.32
I_3V_1	1573.00	2347.00	40.92
I_3V_2	1068.00	1898.00	36.10
I_3V_3	1469.00	2299.00	39.01
I_4V_1	1827.00	2911.00	43.16
I_4V_2	1115.00	1897.00	37.05
I_4V_3	1609.00	2317.00	41.11
LSD (0.05)	110.00	360.30	3.51

I_0= Control, I_1= Irrigation at 20 DAS, I_2= Irrigation at 35 DAS, I_3= Irrigation at 20 and 35 DAS and I_4= Irrigation at 20, 35 and 50 DAS
V_1=.SAU Sarisha-1, V_2= Tori-7 and V_3= Kollania

found from three irrigations (at 20, 35 and 50 DAS) which was statistically higher than the yield obtained from the controll as well as other irrigation treatments. The lowest seed yield (715.8 kg ha^{-1}) was found in unirrigated control condition. In control condition, high mortality of seedlings reasulting from shortage of soil moisture might have drastically reduced the yield. Samui *et al.* [23] and Malavia *et al.* [24] reported similar reasults in rapeseed in respect of seed yield. Under no irrigation treatment internal moisture deficit led to lower plant height, failed to increase in growth parameters and reduced the net assimilation rate, which adversely affected yield components and thus yield was reduced. Three irrigations (at 20, 35 and at 50 DAS) significantly increased the seed yield due to favorable growth condition with maximum production of dry matter due to adequate moisture. The present result was in agreement with those obtained by Sarma and Kumar [17] and Joarder *et al.* [11] who reported that irrigation increased seed yield of rapeseed. Grain yield of rapeseed among the varieties was significantly different from one another (Table 5). The variety SAU Sarisha-1 produced seed yield of 1296 kg ha^{-1}, which was significantly highest than those of Kollania (1278.0 kg ha^{-1}) and Improved Tori-7 (888.7 kg ha^{-1}). Again the yield of Kollania differed significantly from that of Improved Tori-7. The result was in conformity with the findings of

Islam *et al.* [13] who indicated the yield variation due to varietal differences. Interaction effect of irrigation and variety exerted significant variation in respect of grain yield (Table 6). Among the interaction treatments I_4V_1 (three irrigation × SAU Sarisha-1) produced the highest seed yield (1827.0 kg ha^{-1}) which was 224% higher than the lowest yield (563.2 kg ha^{-1}) by I_0V_2 (no irrigation × Improved Tori-7). The lower yield of I_0V_2 compared to other studied varieties might be due to the limitation of varietal genetical makeup.

Stover Yield: Application of irrigation at different levels increased stover yield (ranged from 1997.0 to 2208.0 kg ha^{-1}) over control. Significant variation was found in stover yield at different irrigation levels (Table 4). Three irrigations (at 20, 35 and at 50 DAS) produced the highest stover yield (2208.0 kg ha^{-1}) followed by 2 and 1 irrigations. It is interesting that irrigation applied treatment helped to produce tallest plant, more number of branches $plant^{-1}$ and number of siliquae $plant^{-1}$ which ultimately increased stover yield. The treatment no irrigation produced the lowest stover yield (1469.0 kg ha^{-1}). Patel *et al.* [25], Sarker *et al.* [21] and Sarker *et al.* [26] reported similar views in respect of stover yield that irrigation increased stover yield. Stover yield for different varieties of rapeseed under study differed significantly from one another (Table 5). Kollania produced the higher stover yield (2159.0 kg ha^{-1}) which was statistically at par with SAU Sarisha-1 (2156.0 kg ha^{-1}) and higher than Improved Tori-7 (1681.0 kg ha^{-1}). Kollania and SAU Sarisha-1 out yielded (in respect of stover yield) 478 and 475 kg ha^{-1} over Improved Tori-7. The result was confirmatory with the findings of Chakraborty *et al.* [27] and Saran and Giri [28] that the dry matter production in crops was importantly determined by varietal characteristics. Interaction of irrigation and varietiy showed significant variation in producing stover yield (Table 6). The table showed that the interaction treatment I_4V_1 (three irrigation × SAU Sarisha-1) produced significantly highest stover yield (2911.0 kg ha^{-1}) where as the interaction treatment I_0V_2 (no irrigation × improved Tori-7) produced the lowest stover yield (1179.0 kg ha^{-1}). The result also showed that interactions of SAU Sarisha-1 and Kollania with all irrigation level showed higher and similar amount of stover yield than Tori-7.

Harvest Index: Irrigation level had significant effect on harvest index (Table 4). Among the five irrigation levels three irrigations (at 20, 35 and 50 DAS) gave the highest harvest index (40.44%) Which was statistically at par with two irrigations at 20 and 35 DAS (38.68%). The lowest value of harvest index (32.80%) was obtained from the treatment I_0 (control). The result corroborates with the findings of Sarker [29] who observed irrigation application gave higher harvest index over control. SAU Sarisha-1 exhibited the highest value (37.10 %) of harvest index (37.10 %) and Improved Tori-7 showed the lowest value (34.37 %). SAU Sarisha-1 and Kollania showed statistically similar values of harvest index (Table 5). The results in respect of harvest index was in agreement with the findings of Islam *et al.* [30] who observed the harvest index varied markedly among varieties. Significant interaction effect between irrigation and variety was observed in respect of harvest index (Table 6). Interaction of I_4V_1 (three irrigation × SAU Sarisha-1) produced the highest harvest index (43.16%) followed by I_4V_3 (three irrigation × Kollania). The treatment I_0V_2 (no irrigation × Improved Tori-7) produced the lowest harvest index (32.34%).

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