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Validation of Rapeseed-mustard Varieties/Line in High Land for Development of Rapeseed/ Mustard-Fallow-T. Aman Pattern of Sylhet in Bangladesh

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Authors' contributions

This work was carried out in collaboration between both authors. Author RAF designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author MB managed the analyses of the study and literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: To select high yielding variety(s) of rapeseed-mustard suitable for cultivation in the high land areas under partially irrigated conditions after harvest of T. Aman rice.
Study Design: Split plot.
Place and Duration of Study: Farmer's fields at Sylhet, Bangladesh during November 2014 to March 2015.
Methodology: A split plot design was used in the experiment assigning factor A. Irrigation levels viz. i. One irrigation at 25 DAS & ii. Two irrigation at 25 DAS and 55 DAS in the main plot and factor B. Rapeseed-mustard varieties viz. i. Tori-7, ii. BARI sarisha-13 (*B. napus*), iii. BARI sarisha-14 (*B. campestris*), iv. BARI sarisha-15 (*B. campestris*), v. BARI sarisha-16 (*B. juncea*), vi. Advanced line Nap-205 and vii. BINA sarisha-4 (*B. napus*) in the sub-plot. Fertilizers were applied at the rate of 120-36-90-27-6-3-0.8 kg ha^{-1} of N, P, K, S, Mg, Zn and B, respectively.
Results: Results indicated that yield and yield contributing characters did not differ significantly due

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to irrigation levels because of rainfall at pod filling stage. Yield and yield contributing characters differed significantly among the varieties. The variety BARI sarisha-16 produced the highest seed yield (993 kg ha^{-1}) which was significantly different from the others. BINA sarisha-4 produced the second highest seed yield (898 kg ha^{-1}) while the lowest (645 kg ha^{-1}) was produced by the variety Tori-7. BARI sarisha-16 required the maximum days (89.3) for maturity but Tori-7 and BARI sarisha-14 had the minimum days (76.3 & 77.5 days respectively). There was no significant variation due to combined effect of variety and irrigation level on yield and yield attributes. Seed yield was positively correlated with plant height, siliqua $plant^{-1}$ and 1000-seed weight.

Conclusion: Mustard varieties BARI sarisha-16 and BINA sarisha-4 with high seed yield potential may be well accommodated for developing Rapeseed/Mustard-Fallow-T.Aman rice cropping pattern.

Keywords: Rapeseed-mustard; irrigation; yield attributes; yield.

1. INTRODUCTION

Rapeseed-mustard are the major cold loving oilseed crops in Bangladesh, contributes about 70% to the total oil production of the country. They produce annually a total of 494 thousand tons of seed from an area of 606 thousand hectares in the world [1]. Rapeseed-mustard covers 67% of total oil seed cropped area of Bangladesh and produces about 56% of the total seed requirement [2]. At present, the local production of edible oil cannot meet the demand of the increasing population. Bangladesh imports more or less 1.9 million ton of edible oil and on an average 31,685 MT mustard seed was imported from 2006 to 2010 annually [3]. As a result, a huge amount of foreign exchange involving over 160 million US Dollar is being spent every year for importing edible oils in Bangladesh [4]. In Bangladesh, the average yield of mustard is very low (0.74 t ha^{-1}) compared to advanced countries like UK (3.43 t ha^{-1}), France (2.68 t ha^{-1}), Poland (2.04 t ha^{-1}) and Japan (1.73 t ha^{-1}) [5]. The major reasons for such a poor yield of mustard in Bangladesh are lack of high yielding rapeseed-mustard varieties and poor management practices. The yield of rapeseed-mustard in Bangladesh has been increased obviously with the validation of newly developed rapeseed-mustard varieties and improvement of management practices. Major cropping patterns in Sylhet district are Boro-Fallow-Fallow (60%), Fallow-Fallow-T. Aman (10%), Boro-Fallow-T. Aman (21%) and Fallow-Fallow-B. Aman (5%) [6]. Rainfall prevails from late October to early November usually in each year that offers the opportunity for the production of short duration crop by utilizing the residual moisture [7]. Optimum time and irrigation plays an important role in producing higher yield. Mustard crop essentially require available moisture through its life cycle [8]. Irrigation has been found to increased seed yield [9]. Irrigation has also an effect on mustard to increase nitrogen uptake along with other nutrients [10] resulting in improved yield and yield attributes. Therefore, the scope to validation of rapeseed-mustard varieties with partial irrigation can help to select high yielding variety(s) of rapeseed-mustard suitable for cultivation after harvest of T. Aman rice which encourage the oilseed production in the high land areas and could be able to develop Mustard-Fallow-T. Aman cropping pattern in greater Sylhet region of Bangladesh.

2. MATERIALS AND METHODS

The experiment was made at the farmer's fields at Kamalbazar, South Surma, Sylhet districts during November 2014 to March 2015 to select high yielding variety(s) of rapeseed-mustard suitable for cultivation in high land areas after harvest of T. Aman rice. The treatments included in the experiment were A. Irrigation levels: i. One irrigation at 25 DAS and ii. Two irrigation at 25 DAS and 55 DAS and B. Rapeseed-mustard varieties: i. Tori-7, ii. BARI sarisha-13 (*B. napus*), iii. BARI sarisha-14 (*B. campestris*), iv. BARI sarisha-15 (*B. campestris*), v. BARI sarisha-16 (*B. juncea*), vi. Advanced line Nap-205 and vii. BINA sarisha-4 (*B. napus*). Design of the experiment was split plot assigning irrigation levels in the main plot and varieties in the sub-plot with 3 (three) replications. Unit plot size was 3 m x 4 m. Seed was sown on 24 November at the rate of 7-8 kg ha^{-1} following broadcast method. The experimental plots were fertilized at the rate of 120-36-90-27-6-3-0.8 kg ha^{-1} of N, P, K, S, Mg, Zn and B, respectively [11]. During final land preparation half of urea and total amount of all other fertilizers were applied as basal and incorporated into soil by spading and laddering. Rest of the urea was top dressed at the time of

flower initiation (at 25 DAS) after irrigation. Weeding and thinning were done twice. Observations were made on plant height (cm), number of branches plant^{-1}, number of siliqua plant^{-1}, siliqua length (cm), number of seeds siliqua^{-1}, 1000-seed weight (g), seed yield (kg ha^{-1}), straw yield (kg ha^{-1}), biological yield (t ha^{-1}) and harvest index (%), days to maturity. Biological yield and harvest index were calculated as follows.

Biological yield (t ha^{-1}): he biological yield was calculated by the formula: Biological yield = Seed yield + straw yield.

Harvest index (HI) (%): Harvest index was calculated on the basis of grain and straw yield using the following formula [12].

$$\text{Harvest index}(\%)=\frac{\text{Grain yield}}{\text{Biological yield}}\text{x}100$$

Ten plants were collected to record data on yield attributes and yield data was undertaken on individual plot-wise after threshing, drying and cleaning of seeds. Collected data were analyzed statistically and mean separation were done using Least Significant Difference (LSD) test at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Effect of Irrigation

Yield contributing characters did not differ significantly due to irrigation levels (Tables 2,3). There was 16.1 mm rainfall occurred in the months of January and 40.2 mm in the month of February (Table 1). The rainfall might have the favourable and similar effect on the crops under both one and two irrigation. Hence, the growth and yield of mustard were not found significantly influenced by irrigation levels.

Table 1. Monthly average rainfall, minimum and maximum temperatures during the study period (October 2014-March 2015) in Sylhet district

Months/Year	Average Temp. (°C)		Total rainfall (mm)
	Maximum	Minimum	
October 2014	33.1	23.1	33.4
November 2014	31.2	18.9	Nil
December 2014	27.8	15.2	Nil
January 2015	27.2	14.8	16.1
February 2015	28.7	15.1	40.2
March 2015	33.1	18.7	28.6

Source: Regional Weather Station, Sylhet.

Table 2. Yield attributes of rapeseed-mustard varieties/line as influenced by irrigation

Irrigation level	Plant height (cm)	No. of branch plant^{-1}	Length of siliqua (cm)	No. of siliqua plant^{-1}	No. of seed siliqua^{-1}	1000-seed weight (g)
I_1	78.2	4.5	5.6	88.3	19.1	2.91
I_2	78.3	4.0	5.6	93.4	20.1	2.95
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS
CV(%)	7.48	36.94	13.99	12.09	15.01	9.96

Note: NS = Not significant, I_1= Irrigation at 25 days after sowing; I_2= Irrigation at 25 DAS & 55 DAS

Table 3. Yield, harvest index and days to maturity of rapeseed-mustard varieties/line as influenced by irrigation

Irrigation level	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)	Days to maturity
I_1	824.52	2064.24	2.89	28.75	82
I_2	856.19	2106.29	2.95	28.84	83
$LSD_{0.05}$	NS	NS	NS	NS	NS
CV(%)	5.45	3.52	3.06	2.25	5.62

Note: NS = Not significant, I_1= Irrigation at 25 days after sowing; I_2= Irrigation at 25 DAS & 55 DAS

3.2 Effect of Variety

Significant differences were observed among the varieties in respect of plant height (cm), number of branches plant^{-1}, number of siliqua plant^{-1}, siliqua length (cm), number of seeds siliqua^{-1}, 1000-seed weight (g), seed yield (kg ha^{-1}), straw yield (kg ha^{-1}), biological yield (t ha^{-1}), harvest index (%) and days to maturity (Tables 4,5). Among the varieties, BARI sarisha-16 produced the tallest plant (127.7 cm) compared with the other varieties whereas BARI sharisa-14 produced the shortest plant (60.1 cm) which was statistically similar to Tori-7 (60.5 cm) (Table 4). Alam [13], Ali et al. [14] and Bhuiyan [15] found similar results. They observed significant variations in terms of plant height in different varieties of rapeseed-mustard. The maximum number of branch plant^{-1} (5.9) was produced by BARI sarisha-15 which was followed by BARI sarisha-14 (5.4/plant^{-1}) and lowest number of branches plant^{-1} (3.1) by BARI sarisha-13 (Table 4). Khaleque [16] found different number of branches of 3.9 and 3.1 plant^{-1} in TS-72 and Sonali sarisha, respectively. Length of siliqua, number of siliqua plant^{-1}, number of seeds siliqua^{-1}, 1000-seed weight and seed yields significantly differed among the varieties and advanced line (Table 4). The variety BARI sarisha-16 produced the highest number of siliqua plant^{-1} (190.2) which was significantly superior than those of the others. The lowest number of siliqua plant^{-1} (53.1) was produced by the variety BARI sarisha-14 which was followed by the numbers 58.6 and 66.5 of the varieties BARI sarisha-13 and BARI sarisha-15, respectively. These results were partially similar with Pooran et al. [17], Hossain et al. [18], Jahan and Zakaria [19] and Mondal et al. [20]. They found that the highest number of siliqua plant^{-1} (187.3) in BLN-900 and the lowest (150.4) in Semu 249/84. They also noted the lowest number of siliqua plant^{-1} (45.9) in the variety SS-75. The variety BARI sarisha-16 produced the highest seed yield (993 kg ha^{-1}) which was significantly different from the others. BINA sarisha-4 produced the second highest seed yield (898 kg ha^{-1}) while the lowest (645 kg ha^{-1}) was produced by the variety Tori-7(Table 5). Possibly higher number of siliqua plant^{-1} was mainly attributed to higher seed yield. Similar results were explained by Pooran et al. [17]. They studied six cultivars of mustard and found that among the mustard cultivars, GM-1 gave the highest seed yield (1050 kg ha^{-1}), followed by Kranti and Pusa Bold (790 and 760 kg ha^{-1}, respectively) and Varuna and Sita produced comparably lower yields (680 and 610 kg ha^{-1}, respectively). Bilgili et al. [21] stated a significant response between all yield contributing characters and seed yield in *Brassica rapa* L. averaging 1151 kg ha^{-1}.There was a significant variation in straw yield of different varieties in this experiment. The highest straw yield (2789 kg ha^{-1}) was produced by the variety BARI sarisha-16 while Tori-7 produced the lowest (1511 kg ha^{-1}) (Table 5). These results are partially similar with the findings of Reddy and Avilkumar [22]. BARI sarisha-16 produced the highest (3.79 t ha^{-1}) biological yield over all the varieties. The lowest biological yield (2.16 t ha^{-1}) was obtained from the variety of Tori-7 (Table 5). Significant variation was found in respect of harvest index among the varieties. Maximum harvest index (30.51%) found in the variety BARI sarisha-14 and it was identical with Tori-7 (29.92%) and BARI sarisha-13 (29.87%) and the minimum (26.30%) harvest index was in the line BARI sarisha-16 (Table 5). These findings are in

Table 4. Yield attributes of different rapeseed-mustard varieties/line

Variety	Plant height (cm)	No. of branch plant^{-1}	Length of siliqua (cm)	No. of siliqua plant^{-1}	No. of seed siliqua^{-1}	1000-seed weight (g)
V_1	60.5d	4.5bc	4.8c	83.9b	15.6d	2.63cd
V_2	72.6bc	3.1e	6.7b	58.6c	20.8c	2.57d
V_3	60.1d	5.4ab	4.2c	53.1c	21.9bc	2.72cd
V_4	69.9cd	5.9a	4.6c	66.5c	18.9c	2.84bcd
V_5	127.7a	4.3cd	4.4c	190.2a	11.1e	2.96bc
V_6	81.7b	3.3de	7.6a	97.9b	24.3ab	3.64a
V_7	75.6bc	3.3de	6.9b	85.6b	25.1a	3.14b
$LSD_{0.05}$	10.30	1.005	0.617	16.19	2.934	0.382
CV(%)	11.04	19.77	9.25	14.96	12.51	10.98

Note: V_1= Tori-7, V_2= BARI sarisha-13, V_3= BARI sarisha-14, V_4= BARI sarisha-15, V_5=BARI sarisha-16, V_6=Nap-205, V_7= BINA sarisha-4

Table 5. Yield, harvest index (%) and days to maturity of different rapeseed-mustard varieties/line

Variety	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)	Days to maturity
V_1	645	1511c	2.16c	29.92a	76.3
V_2	856	2011b	2.87b	29.87a	84.3
V_3	854	1948b	2.80b	30.51a	77.5
V_4	861	2099b	2.96b	29.10b	80.1
V_5	993	2789a	3.79a	26.30d	89.3
V_6	775	2028b	2.81b	27.67c	84.5
V_7	898	2212b	3.08b	28.19c	85.0
$LSD_{0.05}$	84.83	275.5	0.3673	0.7574	2.72
CV(%)	8.47	11.09	10.53	2.21	2.77

Note: V_1= Tori-7, V_2= BARI sarisha-13, V_3= BARI sarisha-14, V_4= BARI sarisha-15, V_5=BARI sarisha-16, V_6=Nap-205, V_7= BINA sarisha-4

Table 6. Yield and yield attributes of rapeseed-mustard varieties/line as influenced by the combined effect of variety and irrigation level

Varieties	Plant height (cm)	No. of branch plant^{-1}	Length of siliqua (cm)	No. of siliqua plant^{-1}	No. of seed siliqua^{-1}	1000-seed weight (g)
I_1V_1	59.7	4.5	4.8	84.3	14.9	2.65
I_1V_2	73.4	3.3	6.7	62.6	21.9	2.37
I_1V_3	63.8	6.3	4.3	52.7	20.5	2.75
I_1V_4	68.9	6.3	4.6	68.2	19.0	2.76
I_1V_5	134.8	4.4	4.1	195.7	11.0	2.99
I_1V_6	79.5	3.2	7.6	106.3	23.5	3.65
I_1V_7	67.7	3.5	7.2	83.8	23.3	3.19
I_2V_1	61.4	4.5	4.9	83.5	16.3	2.61
I_2V_2	71.7	2.9	6.6	54.7	19.6	2.77
I_2V_3	56.4	4.5	4.2	53.5	23.3	2.69
I_2V_4	70.9	5.5	4.6	64.9	18.9	2.91
I_2V_5	120.5	4.1	4.6	164.8	11.2	2.92
I_2V_6	83.9	3.3	7.6	89.6	25.0	3.63
I_2V_7	83.5	3.0	6.6	87.4	26.9	3.09
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS
CV(%)	11.04	19.77	9.25	14.96	12.51	10.98

Note: NS = Not significant, I_1= Irrigation at 25 days after sowing (DAS); I_2= Irrigation at 25 DAS & 55 DAS; V_1= Tori-7, V_2= BARI sarisha-13, V_3= BARI sarisha-14, V_4= BARI sarisha-15, V_5=BARI sarisha-16, V_6=Nap-205, V_7= BINA sarisha-4

partially conformity with Mehrotra et al. [23]. They found considerable variation in harvest index values in early (25-35%), medium (25-32%) and late (26-40%) maturing varieties of *B. juncea*. The variety BARI sarisha-16 required the maximum days (89.3) for maturity but Tori-7 and BARI sarisha-14 had the minimum days (76.3-77.5) (Table 5).

3.3 Combined Effect of Variety and Irrigation Level

There was no significant variation due to combined effect of variety and irrigation level on yield and yield attributes (Tables 6,7). This meant that all varieties produced similar seed yield with one and two irrigation levels.

3.4 Correlation between Seed Yield and Yield Contributing Characters of Different Rapeseed-mustard Varieties/ Line

It is found that correlation between seed yield and plant height and number of siliqua plant^{-1} was positive and significant (Table 8). It suggests that seed yield would be increased with the increase of these two characters. Thousand seed BARI sarisha-16 (Table 5). These findings are in

Table 7. Yield, harvest index and days to maturity of rapeseed-mustard varieties/line as influenced by the combined effect of variety and irrigation level

Varieties	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)	Days to maturity
I_1V_1	582.00	1363.00	1.94	29.96	77.0
I_1V_2	855.67	2026.00	2.88	29.71	83.6
I_1V_3	855.67	1968.00	2.82	30.35	77.3
I_1V_4	864.00	2114.33	2.98	29.02	80.6
I_1V_5	980.67	2752.00	3.74	26.34	88.0
I_1V_6	786.67	2038.67	2.83	27.86	83.7
I_1V_7	847.00	2187.67	3.03	28.02	84.3
I_2V_1	708.00	1658.00	2.37	29.88	75.7
I_2V_2	855.67	1995.00	2.85	30.04	85.0
I_2V_3	852.67	1927.33	2.78	30.68	77.7
I_2V_4	858.33	2083.33	2.94	29.18	79.7
I_2V_5	1005.67	2826.33	3.83	26.25	90.7
I_2V_6	764.00	2017.67	2.78	27.47	85.3
I_2V_7	949.00	2236.33	3.12	28.37	85.7
$LSD_{0.05}$	NS	NS	NS	NS	NS
CV(%)	8.47	11.09	10.53	2.21	2.77

Note: NS = Not significant, I_1= Irrigation at 25 days after sowing (DAS); I_2= Irrigation at 25 DAS & 55 DAS ;V_1= Tori-7, V_2= BARI sarisha-13, V_3= BARI sarisha-14, V_4= BARI sarisha-15, V_5=BARI sarisha-16, V_6=Nap-205, V_7= BINA sarisha-4

Table 8. Correlation between seed yield and yield contributing characters of different rapeseed-mustard varieties/line

Characters	Branch plant^{-1}	Siliqua plant^{-1}	Length of siliqua	Seed siliqua^{-1}	1000-seed weight	Seed yield
Plant height	-0.125 ^{NS}	0.882**	-0.065 ^{NS}	-0.457**	0.157 ^{NS}	0.544**
Branch plant^{-1}		-0.113^{NS}	-0.635**	-0.296 ^{NS}	-0.194 ^{NS}	-0.035 ^{NS}
Siliqua plant^{-1}			-0.171 ^{NS}	-0.577**	0.193 ^{NS}	0.364*
Length of siliqua				0.645**	0.474**	-0.079 ^{NS}
Seed siliqua^{-1}					0.366*	-0.059 ^{NS}
1000-seed weight						0.137 ^{NS}

*** = Significant at 1% level of probability;* = Significant at 5% level of probability; NS = Not significant.*

weight had positive but non-significant correlation with seed yield. Number of branch plant^{-1}, length of siliqua, seed siliqua^{-1} had non-significant negative correlation with seed yield. Thousand seed weight was found significantly and positively correlated with length of siliqua and seeds siliqua^{-1}. Plant height and siliqua plant^{-1} had non-significant and positive correlation with 1000-seed weight. Thousand seed weight had also negative non-significant correlation with branch plant^{-1}. Plant height and siliqua plant^{-1} had negative, and length of siliqua had positive significant correlation with seeds siliqua^{-1}. Result revealed that correlation between branch plant^{-1} and seed siliqua^{-1} was found negative but non-significant. Length of siliqua and branch plant^{-1} had significant negative correlation. Plant height had positive significant and branch plant^{-1} had negative non-significant correlation with siliqua plant^{-1}. Non-significant negative correlation found between plant height with branch plant^{-1} (Table 8).

4. CONCLUSION

Usually the land remains fallow after harvest of T. Aman rice in the experimental location. The results indicated that long duration HYV's of BARI sarisha-16 and BINA sarisha-4, and short duration HYV's of BARI sarisha-14 and BARI sarisha-15 which had good yield potentiality could be cultivated after harvest of T. Aman rice in the high land area into the Fallow-Fallow-T. Aman rice cropping pattern for development of Rapeseed/Mustard-Fallow-T.Aman cropping pattern. Usually there might have some differences in terms of yield between one and two irrigation but yield did not differ significantly

in this experiment. This result might be due to occurrence of rainfall in the pod filling stage. Otherwise it may suppose to be achieved higher yield with irrigation.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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