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Sustainability Study of Indian Mustard in Barind Track by Evaluating Growth and Yield Parameters

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ARTICLE INFO	ABSTRACT
Received date: April 12, 2022 Accepted date: August 25, 2022	Mustard is a very important oilseed crop in Bangladesh. Bangladesh has a huge amount of scarcity in the production of edible oil, for this a big amount of foreign currency is spent every year for importing oil and oilseeds. Therefore, an attempt was made in the present study to introduce HYV Indian mustard [<i>Brassica juncea</i> (L.) Czern & Coss] as a new variety at the Barind tract of Bangladesh. An experiment was conducted at field of EXIM Bank Agricultural University Bangladesh, Chapainawabganj in six plots (Plot-A, B, C, D, E and F) using same treatment to examine the growth and yield parameters. Degrees of relationships were examined within the parameters. Benefit Cost Ratio (BCR) was measured. Plot A showed neutral pH (7.0) while pH level of Plot C was high alkalinity (8.0). The pH level of Plot B, D, E and F were showed also alkalinity but below 8.0. The texture of Plot C was loamy sand. The considerable number of plants/m² (66.00) in Plot C where highest (79.00) and lowest (41.00) number of plants/m² were recorded in Plot D and Plot A, respectively. The highest plant height recorded in Plot D that was 184.33 cm and the lowest one was 151.67 cm in Plot C. The silique number was highest in Plot A (153). Plot C had lowest silique number (86). The highest seed yields per square meter (173.48 g) obtained in the Plot-C, which was significantly different from the other six plots studied. Positive and negative relationships were found within the parameters those all were insignificant. The BCR was measured 1.8 in the present study. The present study will helpful for the further higher studies of mustards.

Keywords: Growth parameter, Indian mustard, Profitability, Sustainability, Yield parameter

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1. INTRODUCTION

Rapeseed-mustard is the third important oilseed crop in the world after soybean (*Glycine max*) and palm oil (*Elaeisguineensis* Jacq.). Among the seven edible oilseeds cultivated in Bangladesh, rapeseed-mustard (*Brassica spp.*) contributes 39.83% the total production of oilseeds (BBS, 2021; Shekhawat et al., 2012). There is a good number of

variety of mustard in Bangladesh. Bangladesh Agricultural Research Institute (BARI) released 9 varieties and Bangladesh Institute of Nuclear Agriculture (BINA) released 6 varieties. In Chapainawabganj, Tori-7 and BARI Sarisha-14 are cultivated widely. Tori-7 plants are small in size, have a short life cycle up to 70-80 days and yield 900-1000 kg/ha.

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BARI Sarisha-14 was released in 2006 which matures 75-80 DAS and yielded 1270-1451 kg/ha (Azad et al., 2020).

According to the National Nutrition Council (NNC) of Bangladesh, the Recommended Dietary Allowance (RDA) is estimated to be 6 gm oil/capita/day for a diet with 2700 Kcal. Brown mustard seeds have a caloric value of 541 Kcal, a little less than that of groundnut (561 Kcal) (Thomas et al., 2012). Oil cake is also a nutritious food item for cattle and fish as well as used as good organic fertilizer. Oil cake is used as cattle feed and manure. Mustards are very important honey crops in the Lompoc valley of California where the mustard is grown commercially. Honeybees forage on mustard plants during the peak flowering season and produce substantial quality of mild-flavored light-colored honey (Thomas et al., 2012).

Oilseeds were cultivated in less than 2.20% of total arable land under rice-based cultivation system in Bangladesh, where three fourth of total cultivable land was engaged in rice production in 2015-16 (BBS, 2019). Mustard occupied more than 69.94% of the total cultivated area of oilseeds followed by sesame, groundnut, and soybean (BBS, 2019). In 2020-2021, the cultivation area of mustard was 814288.54 acre and productions were 396594.28 MT. The scenario was far more than the cultivated area 667242 acre and production 311740 MT of mustard in 2018-2019. The second highest cultivated oilseed crop on the basis of cultivable area was soybean, which occupy 142447 acre area but according to yield of production, the second highest oilseed crop was coconut which production was 402852 MT. The lowest cultivated oilseed crop in Bangladesh was sunflower which occupies 3951.88 acre land and production was 2006.20 MT in 2020-2021 (BBS, 2021). Bangladesh is producing about 0.36 million tons of edible oil per year where the total amount of oil requirement is 1.4 million tons (Mallik, 2013). The internal production of edible oil can meet up only less than one-third of the annual requirement of Bangladesh and it has been in short of 65 to 70% of the requirement. As a result, a huge amount of foreign currency is spent every year for importing oil and oilseed from abroad. The values of imported edible oils and oilseeds were USD1574 million and USD354 million in 2014-2015, respectively (Bangladesh Bank, 2016). Mustard plays a significant role in the national economy of Bangladesh. But seed yield/ha is very low compared to other rapeseed growing countries of the world. The low average yield of mustard is due to cultivation of traditional varieties, non-availability of seeds of high yielding varieties and delayed sowing (Alam et al., 2014).

Indian mustard (*Brassica juncea* L. Czern&Coss) is a HYV oilseed crop belonging to family Brassicaceae. Indian mustard was originally introduced from China into northern India from where it has extended to Afghanistan via Punjab (Vaughan& Gordon, 1973). This species originated from the hybridization of *Brassica nigra* with *Brassica campestris* and this probably happened in southwestern Asia and India where the natural distribution of the two species overlaps (Saucer, 1993). Seeds are small and contain 38-42% oil and yielded 2300 - 2400 kg/ha (Shekhawat et al., 2012).

Ghosh & Chatterjee (1988) conducted a research to determine the effect of sowing date on the productivity of Indian mustard in their research area. Woods et al. (1991) conducted a study on *Brassica juncea* (L.) Cossin Western Canada about the potentiality of that variety. In the present study, a feasibility study was attempted to introduce a new variety of mustard (*Brassica juncea* L. Czern&Coss) in Barind region.

2. MATERIALS AND METHODS

The present study was conducted to the experimental plant, Indian mustard (*Brassica juncea* L. Czern&Coss) a tall variety of mustard was used. The present study was conducted at the main campus of EXIM Bank Agricultural University Bangladesh located at Chapainawabganj district under Agroecological Zone (AEZ) of 10 (Active Ganges Floodplain), 11 (High Ganges River Floodplain), 26 (High Barind Tract).

The experiment land (1.8 bigha) was divided into six plots (Plot-A, B, C, D, E and F) that were not uniform in size and in topography. Plot-A & Plot-B were parallel but high land among six plots. Plot-C was medium high land. Plot-D and Plot-E were parallel but lower than Plot-C. Plot-F was the lowest among six plots. Same irrigation, fertilizer and manure doses, pesticides, etc. were applied to every plot.

Soil samples were collected separately in three different places of each six plots using auger. Then the samples were oven dried and crash into powdered form. The pH and finger feel method were used to diagnose pH value and texture of the soil samples, respectively.

The land was prepared by cross ploughing. The fertilizers were applied according to the recommended dose of AEZ 10, 11, and 26. Urea (55 kg/1.8 bigha), TSP (39.6 kg/1.8 bigha), MoP (36 kg/1.8 bigha), Gypsum (21.6 kg/1.8 bigha), ZnSO₄ (2.2 kg/1.8 bigha) and Boric Acid (1.8 kg/1.8 bigha). Seeds were sown (1 kg/bigha) by broadcasting method. After emergence of seeds, weeding and thinning were done once at 25 DAS. Urea was applied two times. First half at the time of land preparation and the rest part were top dressed. Top dressed was done with half amount of urea at 55 DAS and half was used before at the time of ploughing. Two irrigations were applied: first irrigation was given at 7 DAS (days after sowing) and second irrigation was given at flowering stage (75 DAS). Harvesting was done at 117 DAS. Harvest was done early in the morning by threshing. After harvesting the seeds were dried in the sun light in an open place for 2-3 days and then packed in sack.

The data on growth and yield parameters were collected. The plant number/m², leaf number/plant, leaf length/plant (cm) and plant height/plant (cm) as growth parameters were collected at 50 DAS. The inflorescence length/plant (cm), silique number/plant, yield/m² (g) and 1000 seed weight (g) as yield parameters were taken after harvesting. A quadrant (1 square meter) was used for taking data in the fields. The quadrant was placed five locations in a plot for collecting data.

The experiment was laid out in a randomized complete block design (RCBD) with six replications (plots). From each plot, data were collected in five locations with quadrant (1m^2). Descriptive statistics were used to analyze and compare the variables. Excel was used to estimate mean value of all growth and yield parameters. The significant difference within the mean value of growth and yield parameters were measured with Tukey's multiple comparisons test in SPSS. The correlations among the variables were done with SPSS also.

Profitability or cost benefit analysis (CBA) was done using detailed financial cost of production and returns in 1.8 bigha land. The total cost was composed of total variable costs (TVC) and total fixed costs (TFC) (Begum et al., 2019). TVC included costs of human labor, mechanical power, seed, manure, fertilizers, and pesticides for this study. TFC included land rent and interest on operating capital. The gross return (GR) was computed as total mustard output multiplied by the market price of mustard. Profits or gross margin (GM) was defined as difference from GR to TVC, whereas the net return (NR) was defined as difference from GR to TC. Finally, the Benefit Cost Ratio (BCR) was computed as divided GR from TC (Begum et al., 2019).

3. RESULTS

3.1. Soil Features of Study Field

Different pH values were observed in six experimented plots at a range between 7.0-8.0. No acidic plot was observed in the studied field. One plot (Plot A) was neutral soil (pH 7.0). In Plot C, the highest pH was observed (8.0) indicating high alkalinity. The pH values of Plot B, D, E and F were showed also alkalinity but bellow 8.0 pH value. The texture of Plot C was loamy sand. Plot A, Plot B, Plot D, Plot E and Plot F have sandy loam, clay, sandy loam, silty loam and clay loam types of soil texture, respectively (Table 1).

Table 1 Soil features of the study field

Plot number	pH	Texture
Plot A	7.00	Sandy loam
Plot B	7.23	Clay
Plot C	8.00	Loamy sand
Plot D	7.56	Sandy loam
Plot E	7.44	Silty loam
Plot F	7.67	Clay loam

3.2. Growth Parameters

Growth parameters of Indian mustard such as, number of plant/ m^2 , plant height, leaf number/plant, leaf length/plant were recorded in six different plots and presented in Table 2. The number of plant/ m^2 had significant variation in different plots after 50 DAS. The highest number of plant was recorded in Plot D (Fig. 1A) and Plot B that was 79.00 and 77.00 plants/ m^2 , respectively and the lowest number was in Plot-A (Fig. 1C, 41.00 plants/ m^2). The considerable



Fig. 1 Germination of Indian mustard in different plots. A) Best germination in Plot-D, B) Medium germination in Plot-C, C) Poor germination in plot-A.

number of plants/m² in Plot C (Fig. 1B), Plot E and Plot F were 66.00, 57.00 and 60.00, respectively. A significant difference in plant height at 50 DAS was shown within plots. The highest plant height recorded in Plot D that was 184.33 cm and the lowest one was 151.67 cm in Plot C (Table 2). The estimated data were observed in Plot A, Plot B, Plot E and Plot F for 155 cm, 168 cm, 165.33 cm, 178.33 cm, respectively. Leaf number has also significant variation in different plots. The highest leaf number observed in Plot-E (30.00) and the poorest was in Plot-C (14.00). Plot-A, Plot-B, Plot-D and Plot-F have 17.00, 15.00, 23.00 and 24.00 leaves, respectively (Table 2). It was noticed that significant variations in average leaf length of plants in different plots were observed. Plot F had the highest length of leaf that was 22.54 cm and Plot C had 13.48 cm that was the lowest leaf length. The leaf length of Plot A, Plot B, Plot D and Plot E were 16.29, 20.29, 14.11 and 18.00 cm, respectively (Table 2).

3.3. Yield Parameters

As yield parameters, inflorescence length/plant, siliqua number/plant, yield/m² and 1000 seeds weight were examined. Data were collected after harvesting, were presented in Table 3. Significant variation observed among the inflorescence length/plant of Indian mustard in different plots. The highest inflorescence length was recorded in Plot D 175 cm and the lowest one was 122 cm in Plot A. The inflorescence length in Plot-B, Plot-C, Plot-E and Plot-F were 168.67 cm, 129 cm, 142 cm and 143.67 cm, respectively (Table 3). The siliqua number was highest in Plot A (153).

Plot C had the lowest siliqua number 86 among the length of the siliqua number/plant in the plots. Plot-B, Plot-D, Plot-E and Plot-F had 112, 101, 95 and 118 siliqua, respectively (Table 3). Significant differences were observed in yield per square meter among the plots. The highest yield obtained from Plot-C (173.48 g) and the lowest yield was obtained from Plot-B (92.58 g). Plot A, Plot D, Plot E and Plot F have 93.92 g, 173.48 g, 109.43 g and 135.06 g, respectively (Table 3). Thousand seed weight showed non-significant difference in the plots. Plot B had 3.27 g weight of 1000 seed and Plot E had 2.92 g weight. The 1000 seeds weight of Plot A, Plot C, Plot D and Plot F were 3.09, 3.12, 3.16 and 3.08 g, respectively (Table 3).

3.4. Correlations of Parameters

The degrees of relationship were examined, plant/m², leaf number/plant, leaf length/plant, plant height/plant, inflorescence length/plant and siliqua number/plant with grain yield/m².

The correlation between number of plant/m² and yield/m² was shown in Fig. 2. The correlation coefficient was 0.112. The result revealed that plant/m² and yield/m² have a positive but very weak relationship that was non-significant (Fig. 2). In the graph, the scattered dot from the fit line was also showing the weak relationship. The dependent variable yield/m² can be explained only 1.3% by independent variable plant/m² (Fig. 3A).

The correlation between leaf number/plant and yield/m² was shown in Fig. 2. The correlation coefficient was -0.123.

Table 2 Growth parameters of Indian mustard (*Brassica juncea* L. Czern & Cross) in different plots at 50 DAS

Plot	Number of Plant/m ² ($\bar{x} \pm SD$)	Leaf number/plant ($\bar{x} \pm SD$)	Leaf length/plant (cm) $\bar{x} \pm SD$	Plant height/plant (cm) $\bar{x} \pm SD$
Plot-A	41.00 $\pm$ 2.65d	17.00 $\pm$ 1.53c	16.29 $\pm$ 0.78d	155.00 $\pm$ 1b
Plot-B	77.00 $\pm$ 4.04a	15.00 $\pm$ 0.58c	20.29 $\pm$ 2.57b	168.00 $\pm$ 9.17a
Plot-C	66.00 $\pm$ 4.16b	14.00 $\pm$ 4.36c	13.48 $\pm$ 0.006e	151.67 $\pm$ 10.07b
Plot-D	79.00 $\pm$ 4.58a	23.00 $\pm$ 3.06b	14.11 $\pm$ 1.47e	184.33 $\pm$ 20.82a
Plot-E	57.00 $\pm$ 7.21c	30.00 $\pm$ 3.79a	18.00 $\pm$ 1.8c	165.33 $\pm$ 2.52ab
Plot-F	60.00 $\pm$ 9.07c	24.00 $\pm$ 2.08b	22.54 $\pm$ 1.45a	178.33 $\pm$ 12.50a

$\bar{x}$: Mean value; SD: Standard deviation; in a column, means followed by a similar letter(s) were not significantly different whereas, means followed by dissimilar letter(s) were significantly different.

Table 3 Yield parameters of Indian mustard (*Brassica juncea* L. Czern & Cross) in different plots

Plot	Inflorescence length/plant (cm) ($\bar{x} \pm SD$)	Siliqua number/plant ($\bar{x} \pm SD$)	Yield/m ² (g) ($\bar{x} \pm SD$)	1000 seeds weight (g) ($\bar{x} \pm SD$)
Plot A	122.00 $\pm$ 4.58b	153.00 $\pm$ 24.25a	93.92 $\pm$ 4.89d	3.09 $\pm$ 0.11a
Plot B	168.67 $\pm$ 20.82a	112.00 $\pm$ 4.51b	92.58 $\pm$ 1.80d	3.27 $\pm$ 0.31a
Plot C	129.00 $\pm$ 11.14b	86.00 $\pm$ 6.11d	173.48 $\pm$ 5.74a	3.12 $\pm$ 0.04a
Plot D	175.00 $\pm$ 15.62a	101.00 $\pm$ 10.97bc	105.03 $\pm$ 7.05c	3.16 $\pm$ 0.34a
Plot E	142.00 $\pm$ 29.05b	95.00 $\pm$ 15.04c	109.43 $\pm$ 9.64c	2.92 $\pm$ 0.08a
Plot F	143.67 $\pm$ 7.64b	118.00 $\pm$ 10.69b	135.06 $\pm$ 5.74b	3.08 $\pm$ 0.22a

$\bar{x}$: Mean value; SD: Standard deviation; in a column, means followed by a similar letter(s) were not significantly different whereas, means followed by dissimilar letter(s) were significantly different.

The result revealed that leaf number/plant and yield/m² have a negative and very weak relationship that is non-significant. In the graph, the scattered dot from the fit line

also showing the weak relationship. The dependent variable yield/m² can be explained only 1.5% by independent variable leaf number/plant (Fig 3B).

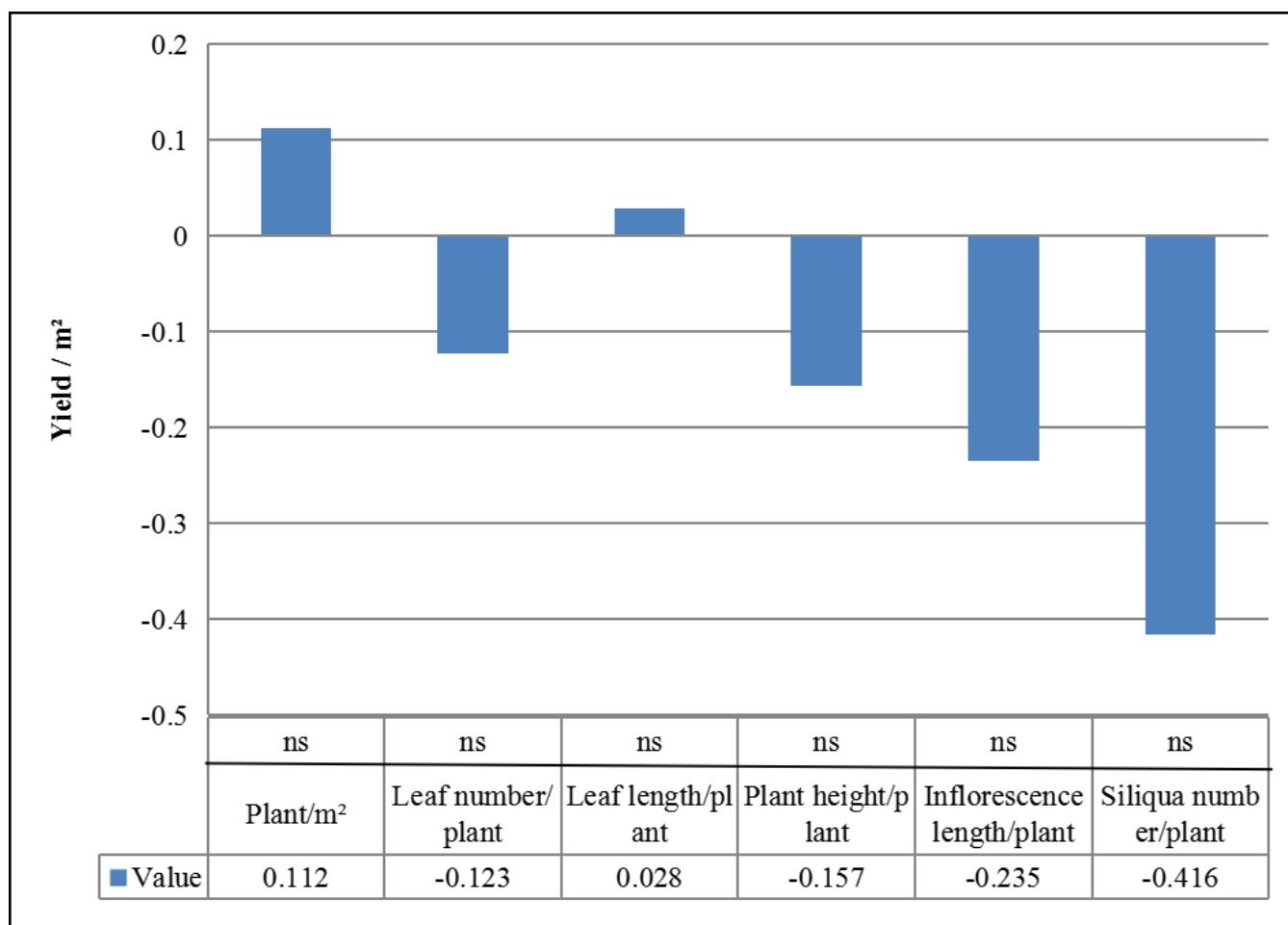


Fig. 2 Correlation of six parameters with yield/m² of Indian mustard.

Table 4 Cost of Indian mustard cultivation in the study area (1.8 bigha)

Particular	Tk/1.8 bigha	%
A. Total Variable Cost (Tk)	17760.8	76.68
Land preparation	1080	4.66
Labor	8000	34.54
Seed	1200	5.18
Threshing	1000	4.32
Fertilizers	1180.8	5.11
Pesticides	2100	9.07
Irrigation	2200	9.48
Miscellaneous	1000	4.32
B. Total Fixed Cost (Tk)		
Land Use	5400	23.32
C. Total Cost (A+B)	23160.8	100

Source: Cost Benefit Analysis (CBA) Method (Begum et al., 2019).

The correlation between leaf length/plant and yield/m² was shown in Fig. 2. The result revealed that leaf length/plant and yield/m² have a positive (correlation coefficient 0.028) but very weak relationship that is non-significant. The dots are placed scattered from the fit line

indicating weak relationship between leaf length/plant and yield/m². The dependent variable yield/m² can be explained only 3.3% by independent variable leaf length/plant (Fig. 3C).

Table 5 Profitability of Indian mustard cultivation (Tk/1.8 bigha)

Particular	Indian Mustard
1. Seed yield (kg/1.8 bigha)	417
2. Price (Tk/kg)	100
3. Gross return main product only (Tk/1.8 bigha)	41700
4. Total variable cost (Tk/1.8 bigha)	17760.8
5. Total cost (Tk/1.8 bigha)	23160.8
6. Gross margin (Tk/1.8 bigha) (3-4)	23939.2
7. Net return (Tk/1.8 bigha) (3-5)	18539.2
Over variable cost (3/4)	2.35
BCR (Over total cost) (3/5)	1.8

Source: Cost Benefit Analysis (CBA) Method (Begum et al., 2019)

The correlation between plant height/plant and yield/m² was shown in Fig. 2. The result revealed that height/plant and yield/m² have a negative (correlation coefficient -0.157)

and very weak relationship that is non-significant. The dots are placed scattered from the fit line indicating weak relationship of height/plant and yield/m². The dependent

variable yield/m² can be explained only 2.5% by independent variable height /plant (Fig. 3D).

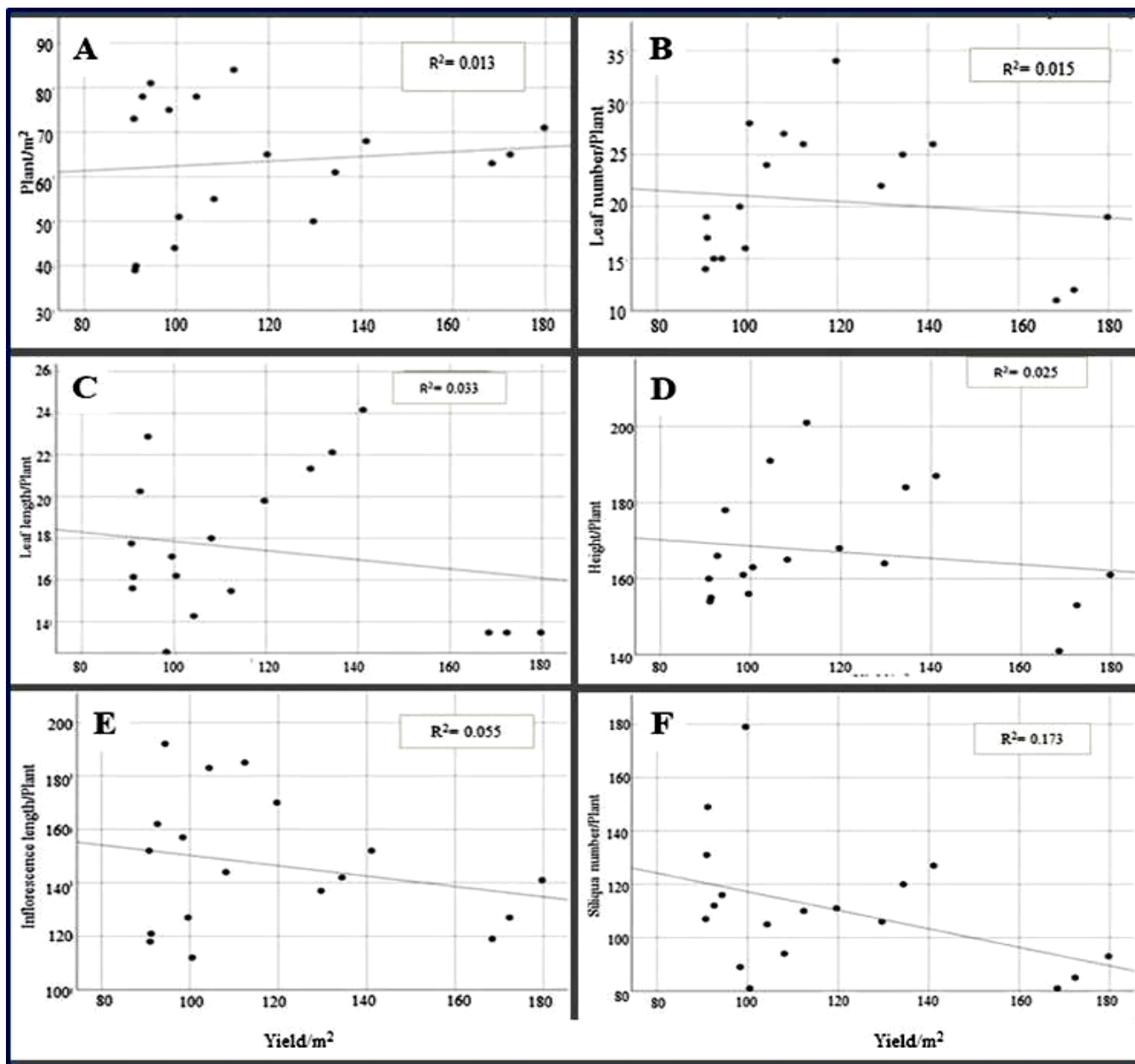


Fig. 3 Scattered diagrams of six parameters with yield/m². Relationship of yield/m² with A) Plant/m², B) Leaf number/plant, C) Leaf length/plant, D) Plant height/plant, E) Inflorescence length/plant, F) Silique number/plant.

The correlation between inflorescence length/plant and yield/m² was shown in Fig. 2. The result revealed that inflorescence length/plant and yield/m² have a negative (correlation coefficient -0.235) and very weak relationship that is non-significant. The dots are placed scattered from the fit line indicating weak relationship of inflorescence length/plant and yield/m². The dependent variable yield/m² can be explained only 5.5% by independent variable inflorescence length/plant (Fig. 3E).

The correlation between silique number/plant and yield/m² was shown in Fig. 2. The result revealed that silique number /plant and yield/m² have a negative (correlation coefficient -0.416) and very weak relationship that is non-significant. The dots are placed scattered from the fit line indicating the relationship of silique number /plant and yield/m². The dependent variable yield/m² can be explained 17.3% by independent variable silique number /plant (Fig. 3F).

3.5 Profitability Study

The average cost of cultivation of Indian mustard was estimated to be Tk. 23160.8 for 1.8 bigha. Around 23.32% cost was spent for fixed inputs for Indian mustard, which includes land use. The share of total cost was found to be the highest for labor (34.54%) followed by land use (23.32%), irrigation (9.48%) and pesticides (9.07%) among the cost items (Table 4). The average yield of Indian mustard was 417 kg in 1.8 bigha (Table 4). The average net return of Indian mustard was Tk. 18539.2. The Benefit Cost Ratio (BCR) over total cost was 1.8 (Table 5). The result showed that cultivating Indian mustard was profitable.

4. DISCUSSION

Indian mustard cultivated in six plots and the plots showing variation in growth and yield parameters of plants. Plot-C showed low vegetative growth but represented the highest yield per square meter. There has some reason for this, those were to be: Plot-C had optimum number for plant per square meter than the other plots that facilitates good aeration, low competition for water, light, fertilizer, pesticides etc. Lima et al. (2016) also showed in jatropha grain yield (seed production) is significantly influenced by plant density and the highest values were obtained with a density of narrowest spacing that was contrast to the present study.

Plot-C was lower than the Plot A and B therefore organic matter that applied in the high landed plots were deposited during irrigation that will be a cause of high yield. Sangakkara et al. (2006) also stated organic matter increased seed yield in mungbean. On the other hand, irrigation must be perfectly distributed; not below to standard and not over flow. Hossain et al. (2013) proved that irrigation had significant influence on the seed yield of mustard.

The correlations showing plants per meter square and leaf length with yield per meter square have positive and very weak relationship. According to Reddy et al. (2012), the economically important parts of the crop may react to the pressure of crop population density in respect of competition by the biotic and abiotic factors causing a decrease of fruit number and size and/or seed production. The decrease in the number of seeds per plant observed at the high planting densities evaluated can also be attributed to the reduction in photosynthetic capacity as a response to shading, which reduces fruit filling and development (Morais et al., 2008).

Leaf number, pod number, inflorescence length and plant height had negative relation with yield per meter square. The contrast results to other findings such as Rabbani et al. (1999) showed that highly positive correlations were also found between bolting and flowering time and leaf size and plant height of mustard genotypes. Marzan et al. (2019) showed that effective tiller per plant have positive relation with yield.

The agricultural practices can be affected in the production of Indian mustard. In the present study, recommended doses of fertilizer for AEZ 10, 11, 26 were applied in the production of Indian mustard. Sampa et al. (2020) showed that fertilizer had a positive and

significant correlation with mustard yield. Irrigation was applied two times in the cultivation of Indian mustard. Hossain et al. (2013) proved that the highest seed yield was produced at two irrigations. Pesticides were applied at the right time for controlling aphids and mustard caterpillar that reduce the chances of yield loss. Malik et al. (1998) found that insecticides influenced the various growth parameters and yield attributing character leading to the maximum length of silique per plant as compared to control.

The BCR of the Indian mustard production was 1.8. It means Indian mustard cultivation was profitable. It can be benefitted 80% profit in Barind tract. Sanzidur and Haque (2016) reported that mustard production is profitable at the farm level (Benefit Cost Ratio 1.34) with no adverse influence of farm size on yield and profitability. Chanda et al. (2020) a study was conducted in four upazilas, namely Ullapara, Shahzadpur, Tarash and Belkuchi of Sirajganj district to analyze the cost and return of mustard and sesame cultivation. The estimated BCR was 1.11 for cultivation of mustard.

5. CONCLUSION

Indian mustard has a very poor growth and yield performance in Barind tract. In different plots, it shows different growth and yield though same treatments were applied in all the plots. Plot-C had the highest yield per meter square. Indian mustard showed different types of defense mechanism to reduce the chance of disease severity. It yielded also well. This research will be a pioneer for further work on Indian mustard as well as other mustards.

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