Performance of mustard varieties under saline prone areas of Bangladesh

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This study was conducted at farmers’ field with three disperse replicas in three different places viz. Satkhira (AEZ-11), Koyra (AEZ-13), and Bagerhat (AEZ-11) of Khulna division in the Rabi season of 2019-2020 to determine salt tolerant varieties for maximizing mustard yield, as well as farmers’ income. Characterization was done with six varieties namely BARI Sarisha-11, BARI Sarisha-14, BARI Sarisha-16, BARI Sarisha-17, and BARI Sarisha-18 (Canola) and a control variety Tori-7 under saline stress condition in coastal area of Bangladesh. Seed Tori-7, BARI Sarisha-11, BARI Sarisha-16, and BARI Sarisha-18 (Canola) were pingol in color while BARI Sarisha-14 and BARI Sarisha-17 were yellow. The yields range of the varieties was 1.13 to 2.09 t ha⁻¹ and oil was 41.37 to 43.40%. Variety BARI Sarisha-18 (Canola) produced the maximum yield (2.09 t ha⁻¹) followed by BARI Sarisha-16 (1.98 t ha⁻¹) and BARI Sarisha-11 (1.84 t ha⁻¹). Because BARI Sarisha-18 (Canola) and BARI Sarisha-16 are suitable for coastal areas, combining this variety with a coastal area cropping pattern will increase cropping intensity, which will benefit farmers both economically and nutritionally.

Key word: Mustard variety, soil salinity, tolerance, growth, yields performance.

INTRODUCTION

Mustard (Brassica juncea L.), is an important edible oilseed crop in Bangladesh belonging to the family Brassicaceae. It is known to Greeks, Romans, Indians, and Chinese 2000 years ago. Genus Brassica comprises five cultivated species viz., B. juncea (Indian mustard), Brassica campestris (Toria), Brassica nigra (Banarasi rye), Brassica napus (Gobhisarson), and Brassica carinata (Abyesinian mustard) predominantly grown in China, India, Canada, Pakistan, USSR, and Europe. Brassica oilseed species now hold the third position among oilseed crops and is an important source of vegetable oil. The most common Brassica oilseed crops grown for commercial purposes are rape seeds (B. campestris L. and B. napus L.) and mustards (B. juncea L. Czern. and Coss. and B. carinata A.Br.). Mustard is a leading oilseed crop, covering about 80% of the total

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oilseed area and contributed more than 60% of the total oilseed production in Bangladesh. It is a cold loving crop grown during Rabi season (Miah et al., 2015).

Plant growth and productivity optimization are required to meet the world’s projected population of 9.1 billion by 2050 (FAO, 2009). Various environmental risk factors including low or high temperatures, salt stress, heavy metals, and drought have impacted the development (yield) of plants (Sehar et al., 2019). Salt stress is one of the world’s disastrous environmental pressures and is anticipated to escalate drastically as a result of climate change (Munns and Tester, 2008; Silva et al., 2017; Reddy et al., 2017). It has been proven to be elevated in 7% of the world’s soil and almost 20% of the land planted and 33% of the irrigated field of the world suffer from salt stress (Schroeder et al., 2013; Kibria et al., 2017; Machado and Serralheiro, 2017). The increased stress of high salt has an adverse effects on growth and development as Na\(^+\) and Cl\(^-\) ions accumulate in plant bodies cause photosynthetic process and photosynthesis damage, impairing the nutritional and the water balance, inhibiting enzymes, contributing to metabolic dysfunction and hindering other significant biochemical and physiological processes that lead to the death of plants ultimately (Munns and Tester, 2008; Fatma et al., 2013; Khan et al., 2014; Rahman et al., 2017).

*Brassica* is considered salinity resistant (Maas and Hoffman, 1977). The threshold values are greater (that is, 9.0 dS/m), but the yield declining rate over thresholds are significantly larger than other plant species (Mass, 1993). Sodium (Na\(^+\)) ions build up faster than tolerable cultivars with salinity-sensitive genotypes, and this build-up of ions contributes to leaf death and gradual death of the plant (Munns, 2002). Considering the facts, mustard cultivation especially salt tolerant genotypes in saline-sodic soils could be good option for farmers to upsurge their annual production.

The huge demand for edible oil makes oilseed crops so important in the economy of Bangladesh. Mustard is the top ranked oilseed crop. It covers about 78% of the total oilseeds acreage and 62% of the total production (BBS, 2020). The oilseed crop occupies 5% of the total cropped area. Out of this, 73% is covered by rapeseed and mustard, 18% by sesame and 9% by groundnut (BBS, 2020). Total production of rapeseed and mustard was 311740 M tons from 667242 acres (BBS, 2020). In Bangladesh, over 30% of cultivated areas are in the coastal belt. Arable land is just 0.88 million ha out of 2.85 million ha, which constitute about 52.8% of the cultivable area. In comparison, the region affected by salt continues to rise continuously. But salinity affects the growth and yield attributes of *Brassica* species (Javaid et al., 2002). In most of the areas, farmers do not have any suitable crop to bring this land under cultivation in several months (middle of November to June). There is a possibility of bringing this vast fallow saline land under cultivation with salt tolerant mustard varieties in Rabi season (November to February). Considering these facts, an experiment was laid out to evaluate the yield performances of six mustard varieties under different salinity levels.

**MATERIALS AND METHODS**

Farmer’s field was chosen to conduct the experiment in three replication in different locations viz. Satkhira, Koyra, and Bagerhat of Khulna division in the *Rabi* season of 2019-2020. The land type was medium highland with salinity level 2.96 to 4.22 dSm\(^{-1}\) at the time of planting and at harvesting period, salinity was 7.04 dSm\(^{-1}\). Six varieties were tested with th experimental material, viz. Tori-7, BARI Sarisha-11, BARI Sarisha-14, BARI Sarisha-16, BARI Sarisha-17 and BARI Sarisha-18. Tori-7 was used as check. These six varieties were collected from Bangladesh Agricultural Research Institute (BARI), Joydepur, Gazipur. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total numbers of plot was 18. The size of the plot was 4 m × 5 m. Cowdung, Urea, Triple Super Phosphate, Muriate of Potash, Gypsum and Boron were applied to the plots at 10000, 300, 170, 100, 150 and 10 kg ha\(^{-1}\), respectively (BARC, BARI). Total amount of Cowdung, Urea, Triple Super Phosphate, Muriate of Potash, Gypsum and Boron were applied as basal dose during the final land preparation. The remaining urea was applied during flower initiation. Seeds were sown on December 05, 2019 by maintaining row to row spacing of 20 cm. Weeding was done manually from 15 DAS up to final harvest. Weeding was done 6 times to keep the plots free from weeds. Aktara (Thiamethoxam) 25 WG at 0.2 g L\(^{-1}\) was sprayed for controlling aphid. First irrigation was done at 25 days after planting and second irrigation was done during fruit initiation stage. Soil salinity of the experimental plots was recorded at 15 days’ interval from planting to harvest. Soil samples were collected before planting and after harvesting of mustard to determine the nutrient status of soil in the experimental plots. Ten mustard plants from each plot were selected randomly for collecting data. The plants of the outer rows and the extreme end of the middle rows were excluded from data collection. Data on the morphological and yield parameters were initial plant population/m\(^{2}\), final plant population/m\(^{2}\), plant height (cm), number of leaves plant\(^{-1}\) at 60 DAS, number of branches plant\(^{-1}\), number of silique plant\(^{-1}\), number of seed silique\(^{-1}\), 1000 seed weight, crop duration (days), yield (t ha\(^{-1}\)) and oil (%) from the selected plants during experimental period. The data were subjected to analysis of variance using the R (4.0.2) software (Tables 1 and 2 and Figure 1).

**RESULTS AND DISCUSSION**

**Plant population/m\(^{2}\)**

There existed varietal difference in respect of plant population/m\(^{2}\). There was a non-significant variation in initial plant population among the varieties but significant variation was final plant population/m\(^{2}\) among the varieties (Table 2 and Figure 2). Initial plant population/m\(^{2}\) for different varieties was Tori-7 (105), BARI Sarisha-11 (102), BARI Sarisha-14 (104), BARI Sarisha-16 (104), BARI Sarisha-17 (101) and BARI Sarisha-18 (106). At the final plant population/m\(^{2}\), the highest was BARI Sarisha-11 (78.26) and the lowest plant population was Tori-7 (51.00). Islam et al. (2015)
Table 1. Monthly average air temperature, total rainfall and total rainy days during the experimental period from November 2019 to March 2020 in Satkhira, Koyra and Bagerhat.

| District | Month/2019-2020 | Monthly average air temperature (°C) | Average humidity (%) | Total rainfall (mm) |
|----------|-----------------|-------------------------------------|----------------------|---------------------|
|          |                 | Maximum average | Minimum average |                  |                     |
| Satkhira | November        | 29.76          | 20.05         | 80                    | 171.9               |
|          | December        | 25             | 14.75         | 87                    | 11.4                |
|          | January         | 24.36          | 13.39         | 87                    | 34.4                |
|          | February        | 27.00          | 14.76         | 89                    | 2.5                 |
|          | March           | 31.95          | 20.14         | 91                    | 84.8                |
| Koyra    | November        | 31.5           | 17.2          | 81                    | 0.00                |
|          | December        | 27.5           | 11.6          | 84                    | 0.00                |
|          | January         | 29             | 11.3          | 78                    | 0.00                |
|          | February        | 30.5           | 10.8          | 74                    | 2.5                 |
|          | March           | 34.5           | 19.5          | 71                    | 10.00               |
| Bagerhat | November        | 32.5           | 17.4          | 76                    | 0                   |
|          | December        | 28.80          | 9.6           | 77                    | 2.4                 |
|          | January         | 30.80          | 10.90         | 71                    | 0                   |
|          | February        | 33.40          | 12.00         | 67                    | 10                  |
|          | March           | 35.50          | 14.70         | 64                    | 41.6                |

Source: Satkhira, Khulna and Bagerhat Meteorological Station.

Table 2. Effects of varieties on morphological characters of mustard.

| Variety    | Initial plant population/m² | Final plant population/m² | Plant height (cm) | Number of leaves plant⁻¹ at 60 DAS | Number of branches Plant⁻¹ |
|------------|-----------------------------|---------------------------|-------------------|-------------------------------------|----------------------------|
| Tori-7     | 105                         | 51.00d                    | 65.33e            | 17.66c                              | 2.56b                      |
| BARI Sarisha-11 | 102                  | 78.26a                    | 125.04b          | 26.12b                              | 4.67a                      |
| BARI Sarisha-14 | 104                  | 69.35bc                   | 103.26d          | 24.01b                              | 2.67b                      |
| BARI Sarisha-16 | 104                  | 66.76c                    | 143.77a          | 30.67a                              | 5.33a                      |
| BARI Sarisha-17 | 101                  | 73.13ab                   | 109.67c          | 26.00b                              | 4.12ab                     |
| BARI Sarisha-18 | 106                  | 75.88ab                   | 115.00c          | 32.75a                              | 5.00a                      |
| CV (%)     | 2.13                       | 5.22                      | 3.56             | 7.44                                | 22.048                     |
| Level of significance | NS |                             |                |                                     |                           |

Mean(s) within a column bearing similar letter(s) are statistically similar. Level of significance: ‘***’ 0.001, ‘**’ 0.01, ‘*’ 0.05, ‘NS’ Non-significant.

Table 2: Data were collected from the experimental field from three locations Satkhira, Koyra and Bagerhat and analyzed by software R.

found out non-significant variation where the lowest plant population/m² was found in BARI Sarisha-13 (55) and highest in BARI Sarisha-15 (60). Kapila et al. (2012) reported that initial plant population was 90 to 110 and final plant population was 71 to 90.

Plant height (cm)

Wide variation was observed among the varieties in plant height (Table 2). The tallest (143.77 cm) height was observed in the variety BARI Sarisha-16 and the shortest was Tori-7 (55.27 cm) including BARI Sarisha-11 (125.04 cm), BARI Sarisha-14 (103.26 cm), BARI Sarisha-17 (109.67 cm) and BARI Sarisha-18 (115.00 cm). Except Tori-7 and BARI Sarisha-14 all other varieties’ plant height was found to be taller. Ahmed and Kashem (2017) registered significant variation among five varieties and those more or less similar in comparison with this finding, whereas the tallest variety was BARI Sarisha-11 (126.33 cm) and smallest was BARI Sarisha-14 (8384 cm). Alom et al. (2014) observed significant variation among 30 genotypes where the shortest and tallest plant height was similar with same varieties used in the present study in which the shortest result was found in Tori-7 (85 cm) and tallest plant height was BARI Sarisha-16 (141 cm).
Salinity hampers the normal metabolism of the plants and retards the cell division as well as cell expansion which causes plant height and fresh weight reduction of the plants Rahman et al. (2016).

**Number of leaves plant$^{-1}$ at 60 DAS**

There was a significant variation in the number of leaves plant$^{-1}$ among the varieties (Table 2). At 60 DAS, the
highest number of leaves plant\(^{-1}\) was obtained from BARI Sarisha-18 (32.75) which is statistically similar with BARI Sarisha-16 (30.67). The lowest number of leaves plant\(^{-1}\) (17.66) was recorded from Tori-7 variety. BARI Sarisha-11, BARI Sarisha-14 and BARI Sarisha-17 had 26.12, 24.01 and 26.00 leaves plant\(^{-1}\), respectively to be statistically similar. Laila (2014) found out significant result among the varieties at 60 DAS where the highest leaves' number was SAU SR-03 (32.27) which was similar with variety BARI Sarisha-18 (32.75) and the lowest was BARI Sarisha-13 (18.37) which was similar with variety Tori-7 (17.66). Under saline condition, plants tried to modify its physical and physiological structure to withstand the physiological stress. More leaves transpire more water and as physiological drought prevails under salinity, so plants reduce its leaf numbers to tolerate saline stress (Acosta-Motos et al., 2017). Number of leaves and biomass accumulation is reduced under salinity and leaf primordia disruption is the plausible cause of lower leaves number under saline condition (Khanam et al., 2018).

**Number of siliqua plant\(^{-1}\)**

The number of siliqua plant\(^{-1}\) showed significant variation among the varieties (Table 3). The highest number of siliqua plant\(^{-1}\) (118.39) was obtained from BARI Sarisha-16, which was statistically similar with BARI Sarisha-11 (103.67) and BARI Sarisha-18 (102.53) and the lowest number of siliqua plant\(^{-1}\) (56.12) was obtained from Tori-7. Laila (2014) found significant result among the varieties where the highest number of branch plant\(^{-1}\) was found in SAU SR-03 (5.20) and lowest was BARI Sarisha-13 (2.92). Ahmed and Kashem (2017) found out non-significant variation where the highest branches plant\(^{-1}\) was BARI Sarisha-11 (5.00) and lowest was BADC-1 (4.73). Roy (2007) and Akhter (2005)'s results were also in conformity with the findings of the present study. Plants uptake more Na than K and Ca in saline condition and maximum number of Na ion was accumulated in the branch of the plant.

**Number of branches plant\(^{-1}\)**

The number of branches plant\(^{-1}\) was significantly influenced by different varieties of mustard (Table 2). The highest number of branches plant\(^{-1}\) (5.33) was obtained from BARI Sarisha-16, which was statistically similar with BARI Sarisha-18 (5.00) followed by BARI Sarisha-11 (4.67). The lowest number of branches plant\(^{-1}\) (2.56) was recorded from Tori-7, which was statistically similar to BARI Sarisha-14 (2.67). The minimum number of primary branches plant\(^{-1}\) of 2.90 was found in Jatarai which was identical to BARI Sarisha-8. Similar report was also found by Hossain et al. (1996). The findings were not in conformity with the result of the present study. But it is partially in conformity such that the variety affects significantly on the number of branches plant\(^{-1}\). Laila (2014) found significant result among the varieties where

### Table 3. Effects of varieties on yield and yield contributing characteristics of mustard.

| Variety         | Number of siliqua plant\(^{-1}\) | Number of seed siliqua\(^{-1}\) | 1000 seed weight (g) | Crop duration (Days) | Yield (tha\(^{-1}\)) | Oil (%) |
|-----------------|----------------------------------|---------------------------------|----------------------|----------------------|----------------------|---------|
| Tori-7          | 56.12\(^{ab}\)                  | 10.00\(^{a}\)                  | 2.36\(^{c}\)         | 75\(^{d}\)           | 1.13\(^{ab}\)       | 41.37\(^{d}\) |
| BARI Sarisha-11 | 103.67\(^{ab}\)                | 22.52\(^{c}\)                  | 3.16\(^{bc}\)        | 109\(^{b}\)          | 1.84\(^{bc}\)       | 41.43\(^{e}\) |
| BARI Sarisha-14 | 81.26\(^{b}\)                   | 18.80\(^{d}\)                  | 3.24\(^{b}\)         | 79\(^{a}\)           | 1.48\(^{d}\)        | 43.00\(^{b}\) |
| BARI Sarisha-16 | 118.39\(^{a}\)                 | 17.77\(^{d}\)                  | 3.13\(^{b}\)         | 115\(^{a}\)          | 1.98\(^{ab}\)       | 42.30\(^{c}\) |
| BARI Sarisha-17 | 87.06\(^{bc}\)                 | 25.20\(^{b}\)                  | 3.73\(^{a}\)         | 84\(^{d}\)           | 1.67\(^{bc}\)       | 41.73\(^{d}\) |
| BARI Sarisha-18 | 102.53\(^{ab}\)                | 29.20\(^{a}\)                  | 3.63\(^{a}\)         | 99\(^{c}\)           | 2.09\(^{a}\)        | 43.40\(^{a}\) |
| CV (%)          | 12.61                            | 5.80                            | 5.97                 | 2.32                 | 6.02                 | 0.177   |

Mean(s) within a column bearing similar letter(s) are statistically similar. Level of significance: '***' 0.001, '**' 0.01, '*' 0.05. 'NS' Non-significant. Source: Authors
variety J-5004; which was identical with the variety Tori-7. The lowest number of siliquae plant\(^{-1}\) (45.9) was found in the variety SS-75. Similar result was also found by Hossain et al. (1996) (Plate 1). Nutrient uptake as well as water uptake is severely hampered due to osmotic imbalance of the saline soil solution. Nutrients and water are essential to develop morphological and yield character of the plants. Uptake of low input reduces the photosynthesis process and ultimately prevents the proper translocation of carbohydrate to form the yield contributing characters (Zaman et al., 2015; Cruz et al., 2018).

**Number of seed siliqua\(^{-1}\)**

The varieties showed significant difference in the number of seed siliqua\(^{-1}\) (Table 3). The highest number of seeds siliqua\(^{-1}\) (29.20) was produced and the lowest number of seeds siliqua\(^{-1}\) (10.00) was observed in the variety Tori-7. The number of seed siliquae\(^{-1}\) BARI Sarisha-14 and BARI Sarisha-16 was statistically similar 18.80 and 17.77, respectively. Alam et al. (2014) observed significant variation among 30 genotypes where the highest number of seed siliquae\(^{-1}\) was Nap-0538 (25.01) and the lowest was BJDH-11 (10.1); this result agree with the present result. Islam et al. (2015) found significant result where 31 seed siliquae\(^{-1}\) was found BARI sarisha-14 (31) and the lowest was BARI Sarisha-11 (12); this result is similar with the present result. Ahmed and Kashem (2017) observed significant variation where the highest seed siliquae\(^{-1}\) was BARI Sarisha-14 (22.93) and lowest was BADC-1 (9.71).

Variation number of seeds siliqua\(^{-1}\) among the varieties was in conformity with Mamun et al. (2014), who found the highest seeds siliqua\(^{-1}\) in BARI Sarisha-13 and the lowest seeds siliqua\(^{-1}\) in BARI Sarisha-16 and this result supports the findings of Jahan and Zakaria (1997) and Gurjar and Chauhan (1997). Variation in seeds siliqua\(^{-1}\) among the varieties was also in conformity with Islam et al. (1994) who found a significant variation in the number of seeds siliqua\(^{-1}\) among different varieties of mustard and rapeseed. But the result was contradictory to Roy (2007) who found the highest seeds siliqua\(^{-1}\) in Tori-7 and lowest number of seeds siliqua\(^{-1}\) in SAU Sarisha\(^{-1}\). Seeds are the sink of the plants and its development fully
depends on the supply capacity of the source. Salinity disrupts the photosystem-II and hampers the photosynthesis process by reducing CO2 uptake, rubisco enzyme activity and normal metabolism of the plants (Seemann and Critchley, 1985; Jahan et al., 2020). Photosynthesis is the only process to produce food and translocate to sink for proper development. Reduction and disruption of sink (seeds, growing primordia and root) are the output of the hampered photosynthesis (Kumari et al., 2010; Shanker et al., 2011).

1000 seed weight (g)

The weight of the seed is related with the magnitude of seed development as an important yield determinant and plays a decisive role on expression of yield potential of a variety (Sana et al., 2003). The weight of the seed expresses the magnitude of seed development which is an important yield determinant and plays a decisive role in showing off the yield potential of a crop (Mamun et al., 2014). Variety is significantly affected by the 1000-seed weight (Table 3). BARI Sarisha-17 produced the highest 1000-seed weight (3.63 g) which was statistically similar with BARI Sarisha-18 (3.63 g) and the lowest 1000-seed weight was produced by Tori-7 (2.63 g). Alam et al. (2014) found significant variation among the variety where the highest 1000 seed weight was BJDH-20 (3.41 g) and lowest was Tori-7 (2.23); this result is similar with the present result. Ahmed and Kashem (2017) reported that significant variation occurred among their varieties where the highest 1000 seed weight was BARI Sarisha-11 (3.00) and lowest was BADC-1 (2.16 g).

The result of this finding was in conformity with Mamun et al. (2014). They also observed that BARI Sarisha-13 had the highest 1000 seed weight (4.00 g) whereas the lowest (2.82 g) was found in SAU Sarisha-3. The 1000-seed weight is the stable part of yield and it varies from variety to variety which was supported by Mondal and Wahab (2001). Roy (2007) and Karim et al. (2000) suggested that the weight of 1000 seeds varies from variety to variety and from species to species. Moreover, inadequate supply of photo assimilates to the seed due to the fact that salinity is one of the major causes of seed weight reduction under saline condition (Flowers et al., 1991; Zaman et al., 2015).

Crop duration (days)

Significant variation was found in crop duration among the varieties (Table 3). Tori-7 was found to be the shortest in crop duration (75 days). The maximum duration was found in BARI Sarisha-11 (115 days). The duration of BARI Sarisha-11, BARI Sarisha-14, BARI Sarisha-17 and BARI Sarisha-18 were 109, 79, 84 and 99 days, respectively (Table 3). Ahmed and Kashem (2017) observed significant variation among 5 varieties. They also observed that BARI Sarisha-11 was the highest crop duration (115 days) and shortest was BARI Sarisha-14 (82 days) (Plate 1).

Crop duration is influenced by environmental and genetic characteristics of the plants. Stress hampers the normal physiological process of the plants and influences its duration (Poonam et al., 2017). Moreover, to tackle the stress like salinity, plants produce different secondary metabolite for osmotic adjustment instead of normal growth and metabolism (Ramakrishna and Ravishankar, 2011). This is another cause of variability of the crop duration under saline condition.

Yield (t ha⁻¹)

The performance of the varieties significantly affected the seed yield (Table 3). BARI Sarisha-18 produced the highest seed yield (2.09 t ha⁻¹) while the lowest seed yield was produced by Tori-7 (1.13 t ha⁻¹). Yield of BARI Sarisha-11, BARI Sarisha-14, BARI Sarisha-16 and BARI Sarisha-17 was 1.84, 1.48, 1.98 and 1.67 t ha⁻¹. The result agreed with Ahmed and Kashem (2017), Islam et al. (2015), Alam et al. (2014), Rahman (2002), BARI (2019) and Mondal (1995) who reported that seed yield of rapeseed and mustard varied with the varieties. Yeasmin (2013) also found significant effects on seed yield of the varieties. This finding was in conformity with the findings of Zaman et al. (1991) and Chakraborthy et al. (1991) who reported that yields were different among the varieties. The performance of yield contributing characteristics was severely affected by salinity stress. Reduction of siliquae per plant, seeds per siliqua, and 1000 seed weight was the main cause of reduction in saline condition (Shanker et al., 2011). Reduction of photosynthesis, nutrient uptake and translocation efficiency significantly lowers the crops total yield (Akhtar et al., 2015; Acosta-Motos et al., 2017; Zörb et al., 2019).

Oil content (%)

Oil was significantly influenced by the varieties (Table 3). The highest oil content in seed (43.40%) was recorded from BARI Sarisha-18 and the lowest (41.37%) was recorded from Tori-7. The result agreed with Ahmed et al. (2014), whereas the highest oil content was found in BARI Sarisha-14 (44.00%) and the lowest in BJDH-12 (38.6%). Ali et al. (2013) reported that the oil of five varieties varied from 31.35 to 41.03. Nutritional imbalance and inadequate uptake of essential nutrients under saline condition retard the oil production of mustards (Ali et al., 2013; Mahmood et al., 2007). Moreover, insufficient supply of photo assimilates, synthesis of secondary metabolites for osmotic adjustment and early maturity of the plants are responsible for lower oil production in
mustards (Cucci et al., 2007; Toorchi et al., 2011).

Conclusion
Better production could be obtained from saline-sodic soils by cultivation of suitable genotypes tolerant to salinity and sodicity. The utilization of saline-sodic soils is itself an advantage in 1999. Salt tolerance potential in different Brassica spp. is in addition to crop yields. Among all genotypes under study, BARI Sarisha-18 (Canola) and BARI Sarisha-16 produced more comparable seed yield and high oil content. These results lead to the conclusion that BARI Sarisha-18 (Canola) and BARI Sarisha-16 may be superior and could successfully be cultivated on saline-sodic soils having an Ece=7.04 dSm⁻¹ without the application of any amendment.

CONFLICT OF INTERESTS
The authors have not declared any conflict of interests.

REFERENCES

Acosta-Motos JR, Ortuño MF, Bernal-Vicente A, Díaz-Vivancos P, Sanchez-Blanco MJ, Hernandez JA (2017). Plant responses to salt stress: Adaptive mechanisms. Agronomy 7(1):18.

Ahmed Z, Kashem MA (2017). Performance of mustard varieties in hour area of Bangladesh. Bangladesh Agronomy Journal 20(1):1-5.

Akhtar SS, Anderson MN, Liu F (2015). Biochar mitigates salinity stress induced from saline soils. Journal of Agricultural Sciences 37(1):157-158.

Ali A, Mahmood IA, Salim M (2013). Growth and yield of different brassica genotypes under saline sodic condition. Pakistan Journal of Agricultural Research 26(1):9-15.

BARI (2019). Annual Report of 2018-2019. Oilseed Research Centre. Bangladesh Agricultural Research Institute. Joydebpur, Gazipur, Bangladesh.

BBS (2020). Bangladesh Bureau of Statistics. Year book of Agricultural statistics of Bangladesh. Government of the People's Republic of Bangladesh P. 122.

Chakraborty PK, Majumder A, Chatterjee BN (1991). Physiological process in Indian mustard (Brassica juncea) and Yellow sarson (Brassica napus var. glauca) and their agronomic appraisal in mild and short winter prevailing in Garo Plains of Eastern India. Indian Journal of Agricultural Sciences 61(11):851-861.

Cruz JL, Coelho EF, Filho MAC, dos Santos AA (2018). Salinity reduces nutrients absorption and efficiency of their utilization in cassava plants. Ciencia Rural 48(11):e20180351.

Cucci G, Rotunno T, De Caro A, Lacolla G, Di Caterina R, Tarantini E (2007). Effects of Saline and Sodic Stress on Yield and Fatty Acid Profile in Sunflower Seeds. Italian Journal of Agronomy 1:13-21.

Food and Agricultural Organization. (FAO) (2009). Land and Plant Nutrition Management Service.

Fatima M, Khan MIR, Masood A, Khan NA (2013). Coordinate changes in assimilatory sulfate reduction are correlated to salt tolerance: involvement of phytohormones. Annual Review and Research in Biology 3(3):267-295.

Flowers TJ, Hajibagherp MA, Yeo AR (1991). Ion accumulation in the cell walls of rice plants growing under saline conditions: evidence for the Oertli hypothesis. Plant, Cell Environ 14(3):319-325.

Gurjar BS, Chauhan DVS (1997). Yield attributes and seed yield of Indian mustard (Brassica juncea) as influenced by varieties, fertility levels and spacing in Harsi Command area. Indian Journal of Agronomy 42(1):142-144.

Hossain MF, Zakaria AKM, Jahan MH (1996). Technical Report on variety Screening Adaptive Research Oilseeds. Rural Development Academy, Bogra, Bangladesh pp. 6-34.

Islam MN, RAhman MS, Atomi MS, Akheruzzaman M (2015). Performance of different crops productivity enhancement through adaptation of crop varieties at Charland in Bangladesh. Bangladesh Journal of Agricultural Research 40(4):629-640.

Islam N, Choudhury M, Karim MR (1994). Effects on sowing date on growth and development of mustard and rapes. Progressive Agriculturists 9:23-29.

Jahan B, AlAJmi MF, Rehman MT, Khan NA (2020). Treatment of nitric oxide supplemented with nitrogen and sulfur regulates photosynthetic performance and stomatal behavior in mustard under salt stress. Physiologia Plantarum 168(2):490-510.

Jahan MH, Zakaria AKM (1997). Growth and yield performance of different varieties of rapeseed, mustard and canola IN Level Barind Tract. Progressive Agriculturists 8(1-2):144-152.

Javad A, Tanveer UH, Muhammad S, Khalid M (2002). Effects of salinity on yield, growth and oil contents of four Brassica species. Pakistan Journal of Agricultural Sciences 39(2):76-79.

Kapila S, Rathore SS, Premi OP, Kandpal BK, Chauhan JS (2012). Advances in Agronomic Management of Indian Mustard (Brassica juncea L.). International Journal of Agronomy 12:14.

Karim MR, Ahmed F, Islam R (2000). Performance of some Brassica juncea varieties/lines under on farm condition at Pabna. Bangladesh Journal of Agricultural Research 27(1):157-158.

Khan MIR, Asgher M, Khan NA (2014). Alleviation of salt-induced photosynthesis and growth inhibition by salicylic acid involves glycinebetaine and ethylene in mungbean (Vigna radiata L.). Plant Physiology and Biochemistry 80:67-74.

Khanam T, Akhtar N, Halim M, Hossain F (2018). Effect of irrigation salinity on the growth and yield of two Aus rice cultivars of Bangladesh. Jahangirnagar University Journal of Biological Sciences 7(2):1-12.

Kibria MG, Hossain M, Murata Y, Hoque MA (2017). Antioxidant defense mechanisms of salinity tolerance in rice genotypes. Rice Science 24(3):155-162.

Kumari V, Sood BC, Kalia R, Dev J (2010). Phenotypic stability for seed yield and component characters in Ethiopian mustard (Brassica carinata A. Brand). Crop Research 39(1/2/3):103-106.

Lalla JF (2014). Performance of rapeseed and mustard varieties with different planting techniques. Ms thesis. Department of agronomy Sher-e-bangla Agricultural University Dhaka-1207.

Mass EV (1993). Salinity and citriculture. Tree Physiology 12(2):195-216.

Maas EV, Hofman GJ (1977). Crop salt tolerance: Current assessment. Journal of the Irrigation and Drainage Division 103(2):115-134.

Machado RMA, Serralheiro RP (2017). Soil salinity: effect on vegetable crop growth. Management practices to prevent and mitigate salt salinization. Horticulture 3(2):30.

Mahmood IA, Ali A, Shahzad A, Salim M, Jamil M, Akhtar J (2007). Yield and quality of Brassica cultivars as affected by soil salinity. Pakistan Journal of Scientific and Industrial Research 50(2):133-137.

Mamun F, Ali MH, Chowdhury IF, Hasanuzzaman M, Matin MA (2014). Performance of rapeseed and mustard varieties grown under different planting density. Scientia Agriculturae 49(2):74-79.

Mehdi MAM, Afroz S, Rashid MA, Shiblee SAM (2015). Factors affecting the adoption of improved varieties of mustard cultivation in some selected sites of Bangladesh. Bangladesh Journal of Agricultural Research 40(3):363-379.

Mondal MRI (1995). Production Technologies for Oilseeds Crops: Recommendations and Future Plan. Proceedings of Workshop on Transfer of Technology of CDP Crops under Research-Extension Linkage Programme. BARI, Gazipur, Bangladesh pp. 5-19.

Mondal MRI, Islam MA, Khaleque MA (1992). Effect of variety and
planting date on the yield performance of mustard/Rape seed. Bangladesh Journal of Agricultural Sciences 19(2):181-188.
Mondal MRI, Wahab MA (2001). Production Technology of Oilseeds. Oilseed Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. pp. 6-24.
Munns R (2002). Comparative physiology of salt and water stress. Plant Cell Environmental 25(2):239-250.
Munns R, Tester M (2008). Mechanisms of salinity tolerance. Annual Review of Plant Biology 59:651-618.
Poonam, Ahmad S, Kumar N, Chakraborty P, Kothari R (2017). Plant Growth Under Stress Conditions: Boon or Bane, in: Plant Adaptation Strategies in Changing Environment. Springer Singapore, Singapore. pp. 291-313.
Rahman A, Nahar K, Mahmud JA, Hasanuzzaman M, Hossain MS, Fujita M (2017). Salt stress tolerance in rice: Emerging role of exogenous phytoprotectants. Advances in International Rice Research pp. 139-174.
Rahman MM (2002). Status of oil seeds and future prospects in Bangladesh. In Review Workshop on the Impact of Technology Transfer on Oil Crops, held at BARI, Gazipur, Bangladesh P 29.
Rahman MM, Anamul-Haque M, Arafat-Islam-Nihad S, Mahmudul-Hasan-Akand M, Ruhul-Amin-Howlader M (2016). Morpho-physiological response of Acacia auriculiformis as influenced by seawater induced salinity stress. Forest Systems 25(3):e071.
Ramakrishna A, Ravishankar GA (2011). Influence of abiotic stress signals on secondary metabolites in plants. Plant Signaling and Behavior 6(11):1720-1731.
Reddy INBL, Kim BK, Yoon IN, Kim KH, Kwon TR (2017). Salt tolerance in rice: focus on mechanisms and approaches. Rice Science 24(3):123-144.
Roy LR (2007). Influence of weeding on growth and yield of rapeseed varieties. M.S. Thesis, SAU, Dhaka, Bangladesh.
Sana M, Ali A, Malik MA, Saleem MF, Rafiq M (2003). Comparative Yield Potential and Oil Contents of Different Canola Cultivars (Brassica napus L.). Journal of Agronomy 2:1-7.
Schroeder JI, Delhaize E, Frommer WB, Gueriot ML, Harrison MJ, Herrera-Estrella L, Tsay YF (2013). Using membrane transporters to improve crops for sustainable food production. Nature 497(7447):60-66.
Seemann JR, Critchley C (1985). Effects of salt stress on the growth, ion content, stomatal behaviour and photosynthetic capacity of a salt-sensitive species (Phaseolus vulgaris L.). Planta 164(2):151-162.
Sehar Z, Masood A, Khan NA (2019). Nitric oxide reverses glucose-mediated photosynthetic repression in wheat (Triticum aestivum L.) under salt stress. Environmental and Experimental Botany 161:277-289.
Shamsuddin AM, Islam MA, Asaduzzaman SM (1987). Effect of nitrogen on yield and yield contributing characters of mustard at different levels. Bangladesh Journal of Agricultural Research 14(2):165-167
Shanker K, Parihar, SKS, Dubey KK, Kumar A (2011). Relative salt tolerance of Indian mustard (Brassica juncea) genotypes in relation to germination, growth and seed yield, Journal of Oilseed Brassica 2(2):76-82.
Silva DCJ, Fontes EPB, Modol LV (2017). Salinity-induced accumulation of endogenous H2S and NO is associated with modulation of the antioxidant and redox defense system in Nicotiana tabacum. Plant Science 256:148-158.