EVALUATION OF SOWING DATES ON MUSTARD GROWN IN A COASTAL SALINE SOIL OF BANGLADESH

A Thesis

By

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Student ID: MS-150810

This thesis is submitted to the Agrotechnology Discipline for the partial fulfillment of the requirements for the Degree of Master of Science in Agronomy

Agrotechnology Discipline
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Approved as to style and content

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ABSTRACT

Timely sowing of any crop is important for realizing higher yield in any climatic region and so for in southwestern coastal Bangladesh. The farmers of this region cannot cultivate any rabi crop timely due mainly to excees soil moisture after transplanted (t) aman rice harvest and salinity (water and soil) in the later part of the rabi season. By cultivating early and short duration t. aman rice and making the land vacant during the optimum window of rabi crop sowing, an additional crop may be cultivated. Keeping in mind the constraints of crop growing in rabi season and with probable interventions, an experiment on mustard was conducted in Pankhali under Dacope upazila in Khulna during November, 2016 to March, 2017 to investigate the feasibility of fitting mustard after t. aman rice and to find out the optimum sowing time of mustard. There were 3 sowing dates. (i) 24 November (ii) 1 December (iii) 8 December. The result showed that mustard establishment in excess moisture was possible between last week of November and 1st December with satisfactory seed yield (0.7-0.6 t/ha). The yield reduction in the 3rd sowing was not due to soil and/or irrigation water salinity as the electrical conductivity of water and soil remained below 4 dS/m. The main causes were late sowing and insect infestation at the early stage of growth. During establishment the weather conditon was favourable for insect infestation. Further research should be conducted in large area and by a large farmers community by cultivating short duration T. aman rice and managing the canal water (keeping it's salinity low by disconnecting the canal from the river during the start of rabi season).

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June, 2019 **The Author**

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CHAPTER I

INTRODUCTION

In Bangladesh, coastal area covered more than 30 % of cultivable land area (Karim *et al.*, 1990). Most of the coastal areas are dominated by medium to medium low lands, where flooding depth ranges from 0.3-0.9 meter. The usual cropping pattern in the southwestern (SW) coastal areas is fallow- fallow- T. aman. Keeping the land fallow for long duration is contributed by several reasons: i) farmers cultivate long duration transplanted (t) aman rice that matures late, ii) after harvest of rice, the land remains with excess water, iii) this excess water stays in soil for longer time as the water table is shallow with the clay dominated soil type. When the soil dries to field capacity water, the sowing window of winter crops goes off: considered one of the main cause of not cultivating of winter crop in optimum time. In addition, inadequate drainage and faulty operation of sluice gates restrict potential land use of the low lands within the poldered areas of SW Bangladesh. It thus indicates the waterlogging is the main obstacle to intensification of crop production in the coastal zone including SW part of Bangladesh. Some farmers cultivate late winter crops but they suffer from fresh water scarcity and if irrigated with saline water, the yield reduces. Some farmers cultivate Kharif 1 crops (e.g., sesame, mungbean) but they are too risky to successful harvest in every year. These are the causes of long-time fallowness of vast area in the SW region. Overall, establishment of winter crop during optimum time of sowing is the first constraint of cropping in winter then the salinity (soil and water).

There were many research works conducted in coastal area in the late winter (Kabir *et al.*, 2017) on maize and in Kharif-I season (Jahan *et al.*, 2008) but no successful research, to our

knowledge, is conducted within the optimum sowing time of winter crops. But there is a great potentiality to take this area under cultivation of winter crops by managing the land, cropping sequence, and water sources properly to increase the cropping intensity. Early harvesting of T. aman rice (HYV) and draining the field can make free the land and that may create an opportunity to cultivate winter/dry season crops (e.g., mustard) in this region.

In coastal region salinity is a great problem for cropping after T. aman. High content of salts in the root zone is another obstacle in the coastal region. Salts spread in the cultivable area of coastal region through rivers and channels, especially during the dry season, when the downstream flow of fresh water becomes very low. In the dry season salinity of rivers and canal water increases. Salts enter into the soil by seepage from rivers and channels. Salt content in the surface soil increases due to evaporation and capillary rise. Cultivation of *rabi* (winter) crops and *boro* rice are limited during dry season due to scarcity of fresh irrigation water. Keeping lands fallow leads to high salinity in soil due to evaporation. Water from pond, canal and river is the main source of irrigation. The river fed water the canal as the canals are connected with the river. As salinity of river water increases with progress of dry season, the canal water salinity also increases. Management of field and efficient utilization options of canal water may create opportunities for cropping during winter. The field management might include early cultivation of aman rice (short duration), drainage of standing water after rice harvest can vacant the land by mid-November. During this time (November) the canal remains with plenty of sweet water. If the canals are disconnected from the river, the canal water may remain relatively fresh and might be used for irrigation during rabi season. In this experiment, these interventions were done to make the field ready for mustard cultivation. In addition, mustard is a short duration crop, timely (in November

and early December) sowing may avoid the effect of irrigation water salinity and soil salinity. Moreover, early sowing of rabi crops in this region may utilize the soil profile water efficiently. The hypothesis of the current study was: timely sowing of mustard may give a remunerative yield and farmers of this region might get a second crop after rice. As mustard is not a usual crop in the rabi season of SW region, determination of sowing time and yield response to different sowing time of mustard was thus necessary.

The objectives of the study were:

Objectives

- To determine suitable time of sowing of mustard in a SW coastal soil.
- To evaluate the effect of sowing dates on yield of mustard.

CHAPTER II

REVIEW OF LITERATURE

Rapeseed and mustard are grown in different agro- climatic zones mostly under rain fed and to some extent under irrigated conditions. A brief review of recent published literature and available reports pertaining to sowing dates and moisture conservation practice in *Brassica* oilseed crops in general and rapeseed and mustard in particular in Bangladesh and abroad is given in this chapter.

A field experiment was conducted by Dinesh Chandra (1997) at Central Rice Research Institute, Cuttack who reported that sowing mustard cultivar Pusa Bold on 15th October produced higher yield over sowing on 25th or 30th November.

A field experiment was conducted by Khushu and Jamwal (2001) at Dryland Research Station, Dhiansar (Jammu), showed that seed yield of mustard was higher under 24th October sowing as compared to 8th November sowing.

Afroz *et al.* (2011) observed that the highest seed yield (1.63 t/ha) was produced when BARI Sarisha-9 was sown on 10 November. In case of interaction between variety and seed rate, BARI Sarisha-9 with 10 kg seeds ha^{-1} produced the maximum seed yield. Results further showed that the interaction of 10 November sowing with 8 kg seeds ha^{-1} produced the highest seed yield (1.55 t/ha).

Alam *et al.* (2015) conducted an experiment at Shibganj upazila under Bogra district during October, 2014 to January, 2015 to observe the effect of planting dates on the yield of mustard

seed. He reported that the best planting date of mustard is on 30 October in the northern parts of Bangladesh.

Anil Kumar *et al.* (2004) conducted an experiment at Bawal, Haryana and quoted that crop sown on 21st October recorded higher number of primary and secondary branches per plant as compared to 7th and 14th October sowing. Greater seed yield (2980 kg/ha) was also observed when the crop was sown on 21st October and seed yield increased by 6.5 and 3.5% over that planted on 7th and 14th October.

Bhuiyan *et al.* (2008) noticed that the highest seed yield (1.86 t/ha) of mustard was obtained from the second planting date (October 30) and it was significantly different from other dates of planting. All yield attributes were also found higher in the second planting date at the Bangladesh Agricultural Research Institute, Burirhat, Rangpur.

Chandrakar and Urkurkar (1993) reported that plant height of mustard was higher with 23rd November sowing (158 cm) as compared to 14th December sowing (129 cm).

Choudhary and Thakuria (1994) reported that the mustard cultivar TM2 produced significantly higher seed yield (1262 kg/ha) when sown on 15th November as compared to 5th December sowing (219 kg/ha).

Dhobale *et al.* (1997) conducted a field experiment in Parbhani, Maharashtra and found that the seed yield was higher with 18th October sowing (1074 kg/ha) as compared to 17th November sowing (436 kg/ha).

Gare *et al.* (1996) observed that seed yield of mustard decreased with delayed sowing date from 1st October to 30th November.

In Hissar, Raj Singh *et al.* (2002) suggested that the crop sown on 5th October recorded higher seed yield (2510 kg/ha) as compared to 5th November sowing (1010 kg/ha).

In Patna, Kumar and Singh (2003) conducted a field experiment and reported that there was a significant decrease in the seed yield with the early sowing date. The greater seed yield was observed with 20th to 25th October sown crop (1735 kg/ha).

Jadhav and Singh (1992) conducted a field experiment and observed that seed yield was higher with 18th October sowing (1360 kg/ha) as compared to 17th November sowing (750 kg/ha).

Khan and Jha (2010) revealed that the initial incidence times of aphid varied from 19 November to 3 December, depending upon dates of sowing done during 1 October to 5 November, which fall under recommended dates of sowing. In crops sown during 22 October to 5 November, critical periods of aphid infestation (having greater than 30 aphids plant^{-1}) prevailed between 19 December and 21 January. Number of aphids plant^{-1} was consistently greater in crops grown under irrigated condition than those under rain fed condition.

Khan and Tak (2002) conducted a field experiment on a clay loam soil at Jammu and suggested that the seed yield was higher with 20th October sowing than 5th October and 5th November sowing.

Khichar *et al.* (2000) conducted a field experiment at Hissar and reported that the higher seed yield was recorded from 20th October sowing (2050 kg/ha). Khushu and Singh (2005) conducted a field experiment at University of Agricultural Sciences and Technology, Main Campus, Chatna (Jammu) which revealed that 24th October sown crop recorded higher seed yield than 8th November sown crop.

Kumar and Shaktawat (1992) conducted a field trial in Udaipur on loamy soil and quoted that higher plant height was recorded with 8 September sowing (112.7 cm) compared to 22 September sowing (108.8 cm) but number of primary and secondary branches were higher with 22 September as compared to 8 September sowing.

Kumari *et al.* (2012) found that the yield attributes and seed yield were significantly higher in October 10 sowing compared to delay sowing. The decrease in seed yield due to sowing on October 20 and October 30 over October 10 was to the tune of 8.7 and 29.2 % during first year and 10.1 and 29.3 % during second year, respectively.

Kurmi (2002) reported that the seed yield was higher with 17th November sowing (826 kg/ha) as compared to 14th December sowing (438 kg/ha) in Titabar, Assam.

Kurmi and Kalita (1992) observed taller plant with 17th November sowing (103 cm) as compared to 2nd December sowing (88.4 cm).

Panda *et al.* (2004) conducted a field experiment at Indian Agricultural Research Institute, New Delhi, and reported that plant height was higher on 16th October sowing as compared to 31st October and 15th November sowing and reduced the number of primary and secondary branches per plant due to delayed sowing beyond 16th October. Delayed sowing after 16th October reduced the seed yield. Crop sown on 16th October recorded a higher seed yield (1945 kg/ha) than the crops sown on 31st October (1556 kg/ha) and 15th November (872 kg/ha).

Panwar *et al.* (2000) conducted a field experiment in Hissar, and reported that yield of mustard decreased when sown on 5th November (Mean 1.17 t/ha) as compared to 5th or 20th October (1.70 and 1.77 t/ha), respectively.

Pooran Chand *et al.* (2000) conducted a field experiment in Palem, Andhra Pradesh, and revealed that sowing in the first week of October recorded a significantly higher yield (1106 kg/ha) as compared to sowing on 23rd October or 8th November (860 and 646 kg/ha), respectively.

Raj Singh *et al.* (2001) observed in Jodhpur, that the crop sown on October second week recorded significantly higher plant height and higher number of primary branches per plant as compared to November first week sowing. October third week sowing recorded higher seed yield (1900 kg/ha) as compared to November first week sowing (1430 kg/ha).

Reddy and Avilkumar (1997) conducted a field experiment in the Northern Telangana region of Andhra Pradesh and observed that seed yield recorded higher with 4th October sowing (646 kg/ha) as compared to 5th November sowing (486 kg/ha).

Samad *et al.* (2007) reported that the plants sown on 3 December had the lowest percentage of sawfly infestations. The plant sown on 31 October had the lowest number of aphids per plant and the lowest percentage of aphids infested plants. The incidence of aphids increased with the advancement of time but it was opposite in case of sawfly infestation. The population of the lady bird beetle was related to the population of aphids in the field. The last sowing caused the highest aphid infestations and the highest number of aphids per plant. The aphid population was influenced by the sowing date and weather factors, namely temperature, relative humidity and sunshine hours.

Shahidullah *et al.* (1997) conducted a field experiment in Dhaka, Bangladesh, and reported that plant height was higher with 16th November sowing as compared to 27th October sowing

but number of primary and secondary branches per plant was higher with 27th October as compared to 6th or 16th November sowing.

Sharif *et al.* (2016) reported that the highest grain yield (1.73 t ha-1) was obtained from the first sowing (30 November) with BINA Sharisha-5 and it was significantly different from the yields of all other combination.

Sharma *et al.* (2006) found that the growth characters viz., plant height, number of branches plant^{-1}, leaves plant^{-1}, dry matter accumulation plant^{-1}, and yield attributes viz., siliquae plant^{-1}, test weight, yield plant^{-1}, grain and straw yield of mustard were maximum in the crop sown on 22nd and 29th October compared to early and late sowing of 6th October and 12th November, respectively.

Shivani and Kumar (2002) at Gangtok, Sikkim emphasized that seed yield was higher under 25th September and 5th October sowing as compared to 15th October 25th October and 4th November sowing. They also observed that crop sown on 25th September and 5th October recorded significantly higher number of primary and secondary branches than 15th October, 25th October and 4th November sown crop, respectively.

Sihag *et al.* (2003) conducted a field experiment at College of Agriculture, Bikaner, and reported that higher seed yield (2150 kg/ha) was obtained in 15th October sowing.

Singh and Singh (2002) conducted a field trial at Narendradev University of Agriculture and Technology, Kumarganj, Faizabad (Uttar Pradesh), which revealed that number of primary and secondary branches per plant and seed yield were higher with 14th October sowing as compared to 29th October, 13th November and 28th November sowing.

Som Pal *et al.* (1996) conducted an experiment at Department of Agricultural Meteorology of Hissar, and reported that seed yield was higher with 20th October sowing.

Sonani *et al.* (2002) conducted experiment at Regional Research Station, Arnej (Gujarat) and quoted that seed yield was higher in 20th October sowing (812 kg/ha) compared to 10th November sowing (271 kg/ha).

Surekha and Reddy (1996) conducted a field experiment at college of agriculture, Rajendranagar, Hyderabad, and reported that plant height and higher number of primary and secondary branches was higher with 5th October sowing as compared to 5th and 20th November sowing. Seed yield of mustard was also higher with 5th October as compared to sowing on 5th and 20th November.

Tomar (1997) at Jawaharlal Nehru Krishi Vishwa vidyalaya, Tikamgarh, reported that the seed yield decreased with delay in sowing date beyond 30th October.

Towhida *el al.* (2016) conducted an experiment on the effect of sowing time and weeding on the seed yield and yield components of three varieties of rapeseed and observed that all the yield components were highest in the 18 October sowing.

Turhan *et al.* (2011) noted that the seed yield of rapeseed-mustard significantly decreased as sowing time was delayed in Turkey. The lowest average seed yield (1027.40 kg ha^{-1}) was obtained from the latest sowing time (10 November), whereas the highest average seed yield (2437.50 kg ha^{-1}) was obtained from the earliest sowing time (10 October).

Tuteja *et al.* (1996) conducted an experiment at Indira Gandhi Agricultural University in Raipur, and reported that seed yield from sowing on 12th October (1110 kg/ha) and 2nd

November (1130 kg/ha) were almost similar and it decreased significantly by delay in sowing on 22 November (450 kg/ha).

Vasi *et al.* (1986) reported that 27th September sowing produced taller plants and higher number of branches per plant as compared to 18th October sowing and seed yield with 27th September sowing (1380 kg/ha) was higher as compared to 18th October sowing (990 kg/ha) in New Delhi.

Yadav *et al.* (1994) observed that crop sown on 5th October recorded significantly higher plant height and number of primary and secondary branches per plant as compared to 25th October sown crop of mustard. Seed yield was also higher with 5th October sowing (14.2 q/ha) as compared to 25th October sowing (1.11 t/ha) in Kanpur.

Yadav *et al.* (1997) conducted a field experiment in Morena, Madhya Pradesh and revealed that the mean seed yield of mustard cultivars was (2,1, 2 and 1,8 t/ha) when sown on 17th, 27th October and 6th November, respectively.

Yadav *et al.* (1999) observed that the crop sown on 17th October recorded significantly higher seed yield (2245 kg/ha) as compared to 16th November sowing.

CHAPTER III

MATERIALS AND METHODS

The field experiment was carried out at the farmer's field in Pankhali village of Dacope upazilla under Khulna district. It belongs to the Agro-Ecological Zone of the Ganges Tidal Floodplain of Bangladesh (AEZ 13). The experiment was carried out during the period of 24 November, 2016 to 17 February, 2017 to investigate the performance of mustard grain yield to different dates of sowing.

3.1 Description of the experimental site

3.1.1 Soil

This region occupies an extensive area of tidal floodplain in the southwestern region of the country. The greater part of this region has smooth relief having large areas with waterlogging after T. aman rice harvest and salinity (soil and water) during dry period (usually mid February to May). The soil of experimental field is silty at 0-15 cm depth and clay up to 60 cm depth.

Table 1: Soil texture at different soil depths (0-15, 15-30, 30-45, 45-60) in the experimental field of Pankhali, Dacope, Khulna in 2016-2017

Increment depth (cm) soil profile	Soil texture	Soil particles (%)		
		Clay	Silt	Sand
0-15	Silt	12	60.2	27.8
15-30	Clay	43.2	29.4	27.4
30-45	Clay	52	20.4	27.6
45-60	Clay	64	8	28

3.1.2 Cropping pattern

The most dominant cropping pattern in the experimental area (polder 31) is fallow- fallow-T. aman. Some farmers cultivate sesame and mungbean in Kharif-I season but these crops are risky to harvest due to unwanted rainfall that causes waterlogging in the root zone and restrict crop growth sometimes complete crop failure occur.

3.1.3 Climate

Dacope, Khulna, is included into the tropical monsoon climate. Where natural calamities like storm, cyclone, tidal surge, drought, river erosion, waterlogging, soil and water salinity and scarcity of fresh water for cultivation during dry period are the main problems. These areas are subject to flooding in the monsoon season and waterlogging in the early dry season. Tidal flooding through a network of tidal creeks and drainage channels connected to the main river system inundates the soil and impregnates them with soluble salts thereby rendering both the top- and subsoil salinity. Even though the coastal area is low lying, there are elevation differences. Most agricultural lands in polder 31 have an elevation of 2-3 m above mean sea level. During dry period, the salinity of the river water increases. The salts enter the soil by flooding with saline river water, canal or by seepage from the rivers, and the salts become concentrated in the surface layers through evaporation. The saline river water may also cause an increase in salinity of the ground water and make it unsuitable for irrigation. The main obstacle to intensification of crop production in the coastal areas is seasonally high content of salts in the root zone and excess water during the sowing time of winter crops after T. aman.

3.2 Treatments, design and layout of the experiment

There were five sowing dates as treatments:

1. 24 November, 2016
2. 1 December, 2016
3. 8 December, 2016
4. 15 December, 2016
5. 22 December, 2016

The experiment was carried out in a randomized complete block design (RCBD) with three replications. BARI sharisha 14 was used in this study. The total numbers of plots were 15 (3×5). The unit plot size was 4m×2.5m and the plot to plot distance was 1 m. Row to row distance was 15 cm.

3.3 Procedure of crop cultivation

3.3.1 Field preparation and sowing seeds

After T. aman harvest, the experimental field was waterlogged so water was removed from the field by manual drainage. The field was prepared by the aid of spade when the moisture of the soil was ~40% (v/v). After sundry when the soil moisture came down to 37% 1st sowing was done on 24 December 2016. (Provide row-row distance). The seed was sown in the row by hand broadcasting. Fertilizer was applied for the crop according to the requirement for the variety (Krishi Projoktir Hath Boi, 2015). The rate of N, P, K was 140, 80, 60 kg ha^{-1} respectively. The dose of S, Zn and B was 27, 1.8 and 1.7 kg ha^{-1} respectively.

Half of N and all other fertilizer were given as basal dose, rest portion of N were given during flowering.

Among five sowing dates (treatments), sowing on 15 and 22 December were severely attacked by flea beetle during emergence. Despite several plant protection measures were taken, but mustard seedlings in those two sowing dates were not possible to save from flea beetle attack. Flea beetle harms the matured plants but seedlings stage was the most sensitive stage that can cause total failure of crop. First attack of flea beetle was noticed at 19 December 2016 in the plots of 2nd sowing Nitro 505 emulsifiable concentrate (nitroguanidine) was sprayed to the plots to control flea beetle and plants responded good against flea beetle. Plants recovered soon with normal health. Second time flea beetle attack was noticed at 10 January, 2017. That attack was severe. During that time the seeds of 4th and 5th sowings were emerging and the different types of control measures like spraying of nitro (Emulsifiable Concentrate, Cypermethrin Chlorpyriphos), karate (Wettable Granule, lamda cyhalothrin), ash, liquid soap and *mehegni* oil were applied in the field but 4th and 5th sowing plots were damaged fully. Finally the first three treatments were survived in this experiment. In the subsequent part of this thesis consists of the first three sowing dates.

3.3.2 Time of irrigation

Irrigations were given three times. Sources of irrigational water was canal water. Salinity level (dS/m) of irrigation water during irrigation was measured with the help of EC meter. Equal amount of water was irrigated in each plot (Table 2) using plastic pipe by keeping the valve of the pipe open for a specific time for each plot.

Table 2: Time of irrigation

Irrigation	Date	Date	Date	Amount of water
1st sowing	12.12.16	07.01.17	17.01.17	40 L/plot (10 m^2)
2nd sowing	19.12.16	07.01.17	17.01.17	200 L/plot (10 m^2)
3rd sowing	22.12.16	07.01.17	17.01.17	200 L/plot (10 m^2)

3.4 Thinning and intercultural operations

Thinning and intercultural operations were done when necessary. Thinning was done after 15 days of seed sowing. Mustard field were protected from domestic animals by net fence. The field was attacked by flea beetle and aphid and the plant protection measures taken were described in the 'Field preparation and sowing seeds'. There was little aphid attack and was controlled by Actara (thiamethoxam) and different insecticides (Nitro, Karate, mahegoni, oil, liquid soap, ash) were used to control flea beetle.

3.5 Harvesting, sampling, threshing and processing

Maturity of crops was determined when almost all the leaves and silique were brownish color. 1st harvesting (crop duration 77 days) was done on 9 February 2017, 2nd harvesting (crop duration 73 days) was done on 11 February 2017 and 3rd harvesting (crop duration 71 days) was done on 17 February 2017.

At maturity, plants from 50 × 50 cm area (3 areas from a plot) were cut. The plants were sundried, the silique and stem were separated. The stem was oven dried and the seeds were sundried to 10% moisture. Three plants from each plot and five siliques from each plant were randomly selected for recording yield attributes. Then number of silique per plant,

length of silique, number of seeds per silique, number of underdeveloped seeds per silique, weight of grain per silique and weight of seeds per plant were recorded. Then rest of the plants of each plot was harvested. Threshing was done after sundry. Straw and grains were separated. Grain and straw yields were recorded as kg plot^{-1} and finally converted into tons per hactare.

3.6 Data collection

3.6.1 Soil moisture

Soil moisture data was collected twice in a week and during sowing. Soil moisture was determined with the help of moisture meter MP406 (volumetric water content) from (0-40) cm at 10 cm increment depths profile.

3.6.2 Temperature and relative humidity (RH)

Temperature and relative humidity were recorded from 1st December to 31st January from the meteorological station, Dacope , Khulna.

3.6.3 Soil samples collection and measurement of $EC_{1:5}$ (dS m^{-1})

Soil sample was taken randomly from each plot at 15 days interval during the growing season. The samples were taken (up to 60 cm) by means of an auger from different location of each plot covering the field. All soil samples were oven-dried and the soil was ground using a morter and pestle to break up aggregates to ~2 mm size. Electrical conductivity (EC) was measured in a 1:5 soil:water from the extract according to Rayment and Higginson (1992). Finally, $EC_{1:5}$ were converted into ECe following Slavich and Peterson (1993).

Estimating electrical conductivity:

The conversion factor (f) relating ECe to $EC_{1:5}$

i.e. $ECe = f EC_{1:5}$

f = Conversion factor

Conversion factor to estimate ECe from $EC_{1:5}$ (i.e. $ECe = f EC_{1:5}$) and saturated paste water content (θ_{SP}) for soil of different texture grade classed by clay percentage.

Table 3: Conversion factor for different texture grades soil relating to ECe to $EC_{1:5}$

Texture grades	Clay%	Conversion factor (f)
Silt loam	20-30	9.5
Clay	20-30	8.6
Clay	30-45	8.6
Clay	45-55	8.6

3.7 Growth, yield and yield contributing parameters

3.7.1 Emergence number

The number of emergence was counted in 1 m^2 areas from each plot.

3.7.2 Plant height (cm)

Plant height was taken at 15 days interval started after 30 DAS. From each of the mustard plots, 5 plants were measured and average height was taken.

3.7.3 Number of silique per plant

Number of silique per plant was counted from 3 plant samples and its average values were taken.

3.7.4 Length of silique (cm)

Five silique from each of the three plant samples were taken and length was measured.

3.7.5 Number of seeds per silique

Five silique from each of the three plants were taken and number of seeds in each silique were counted and average values were taken.

3.7.6 Weight of grain per silique (g)

The seeds of five siliques from each of the sample plants were weighed and average values were taken.

3.7.7 Weight of seeds per plant (g)

Three plant samples were taken and its grain was threshed by hand. Grain weight of each plant was measured separately from three plant samples, then average grain weight of three plants were taken by an electric balance.

3.7.8 Grain yield (t/ha)

Grains obtained from each plot were threshed, cleaned, dried and then weighed. The yield of grain was in kilogram per plot and then it was converted into ton per hectare.

3.7.9 Straw yield (t/ha)

Straw obtained from each plot were dried and weighed and then it was converted into ton per hectare.

3.7.10 Biological yield (t/ha)

The grain yield and straw yield obtained from each plot were added which was biological yield. The yield was converted into ton per hectare.

3.7.11 Harvest index (HI)%

It is the ratio between grain yield and biological yield. Harvest index of each plot were determined by the equation-

$$\text{HI } \% = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

3.8 Statistical analysis

The collected data were analyzed by using Statistical Tool for Agricultural Research (STAR) following one-way ANOVA based on randomized complete block design. Treatment means were separated by Duncan's New Multiple Range Test (DMRT) at 5% level of significance.

CHAPTER IV

RESULTS

4.1 Soil Moisture

The field was saturated up to the mid November, although the stagnant water of the field drained out manually in the first week of November. The field was sundried up to a level (37% during the field preparation) then the field was ready for tillage. During growth, the soil moisture of the field up to 60 cm increased gradually from the surface. On 20 December 2016, the moisture was 26%, 29%, 33% and 36%, respectively at four different depths (Table 4). Moisture percentage at 0-15 cm, 15-30 cm, 30-45 cm, 45-60 cm depth on 4th January, 2017 was 24%, 27%, 32%, 35% respectively. Moisture percentage of the field decreased with the passes of time but it was not less than 20% throughout the growing season. When moisture percentage decreased to ~20% (v/v), irrigation was done.

Table 4: Moisture percentage at different depth (0-15, 15-30, 30-45, 45-60 cm) of soil on mustard field of Pankhali, Dacope, Khulna in 2016-2017.

Date	Depth of soil (cm)	Moisture (%)
20.12.16	0-15	26
	15-30	29
	30-45	33.2
	45-60	35.3
04.01.17	0-15	24
	15-30	27
	30-45	32
	45-60	35
19.01.17	0-15	28
	15-30	31
	30-45	34
	45-60	37
03.02.17	0-15	26
	15-30	30
	30-45	32
	45-60	35

4.2 Salinity of water and soil

Water salinity: Figure 1 shows that the EC (Electrical Conductivity) of canal water which was not more than 3 dS/m throughout the growing season which was used for irrigation. The EC of river water started to increase: at early January it was ~5 dS/m and at the end of the season in March it was ~25 dS/m. The river water was not used in irrigation. Pond water salinity did not increase significantly throughout the growing period.

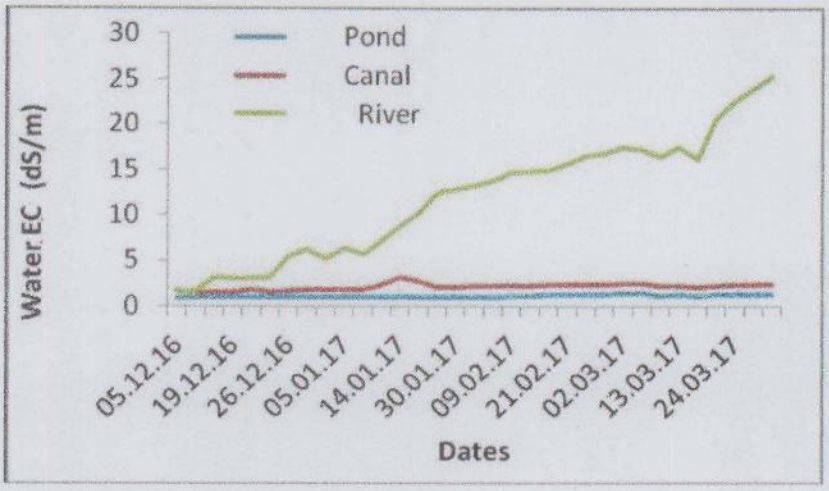

Figure 1: Water salinity of pond, canal and river in the experimental area (2016-2017) in Pankhali, Dacope, Khulna.

Soil salinity: Soil salinity (up to 60 cm depth) was measured throughout the growing season at a certain interval of time. Figure 2 shows the results of soil ECe 0 cm to 60 cm depth. Soil ECe did not exceed 4 dS/m up to 45 cm depth, after this depth the ECe fluctuated between 3 to 6 dS/m.

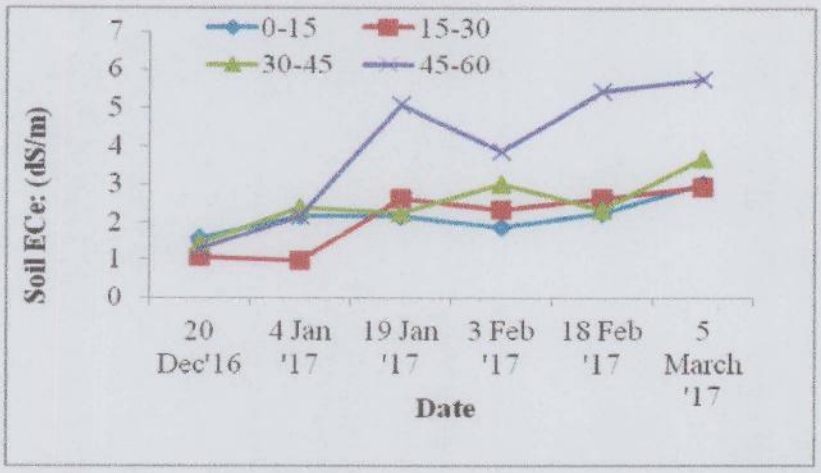

Figure 2: Soil salinity at depth 0 to 60 cm (0-15, 15-30, 30-45, 45-60 cm) of the mustard field of Pankhali, Dacope, Khulna,2016-2017

4.3 Temperature

The minimum and maximum temperature were recorded from 1st December, 2016 to 31st January, 2017. The maximum temperature ranged from 22° to 30 °C while the minimum temperature was between ~10° to 20 °C.

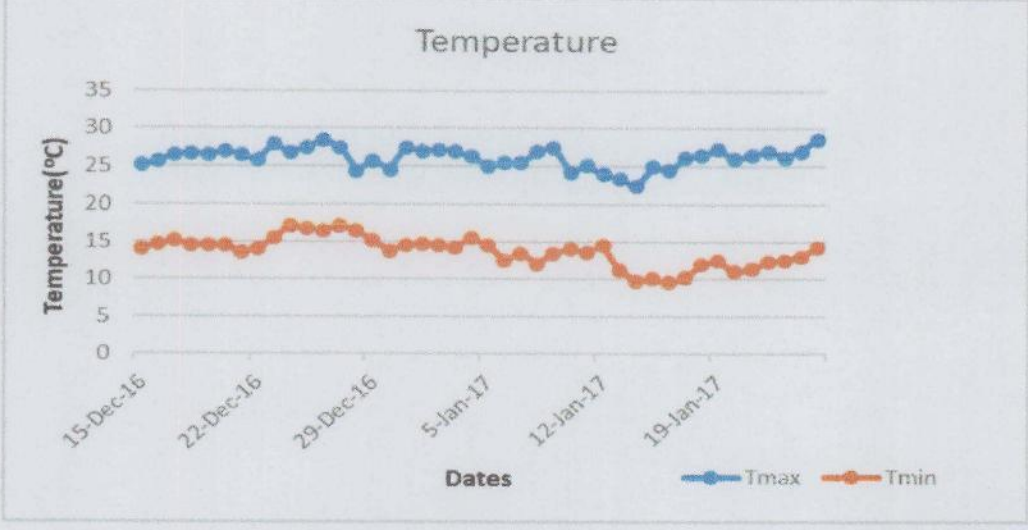

Figure 3: Temperature of Pankhali, Dacope, Khulna from 1st December, 2016 to 31st January, 2017

4.4 Relative humidity (RH)

The data of relative humidity were collected from the weather station of Pankhali from 1st December, 2016 to 1st January, 2017. Data were collected two times in a day at morning (6 AM) and at evening (6 PM).

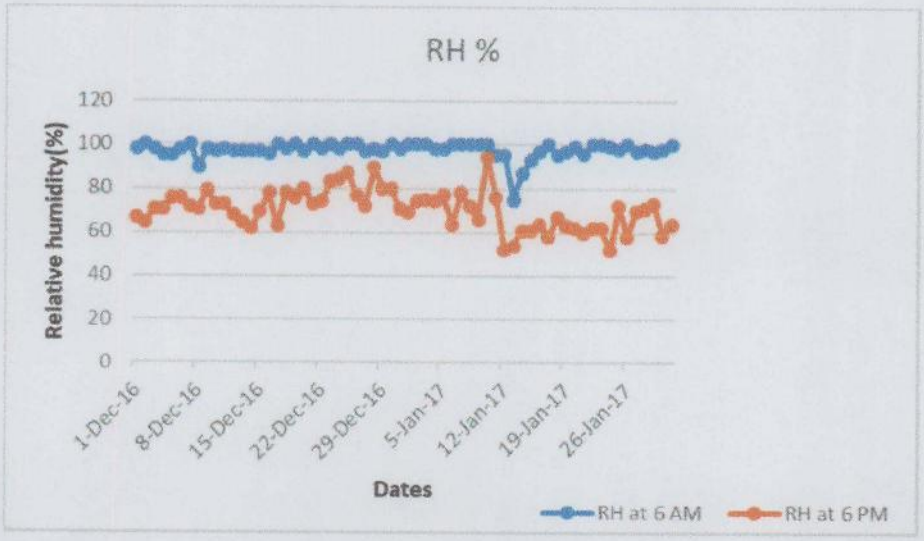

Figure 4: Relative humidity of Pankhali, Dacope, Khulna from 1st December, 2016 to 31st January, 2017

4.5 Emergence and plant height

With the delay of sowing date, the emergence was decreased in late sowing but there was no significant difference in plant emergence of mustard among the first three sowing dates. The number of plants in the first sowing was 178 (in 1 sq m). In the second sowing the number was 188 and in the third sowing the number of plant was 160.

There were significant differences in plant height in different sowing dates (Table 5). The plant height decreased gradually with the delay of sowing time. The plant height of 1st

sowing (24 November) was 33.6 cm, the plant height of 2nd sowing (1 December) was 18.1 cm and the plant height of 3rd sowing (8 December) plants was 13.5 cm at 30 DAS. After 45 and 60 days of sowing, the plant height increased than that of 30 DAS; the plant height in 1st and 2nd sowing was statistically higher than that of 3rd sowing. Between 1st and 2nd sowing the difference was insignificant. During harvest, plant height was highest at 1st sowing than those of 2nd and 3rd sowing.

Table 5: Emergence at 12 DAS and plant height (cm) at 30, 45, 60 and 75 DAS of mustard grown in the experimental field of Pankhali, Dacope, Khulna,2016-2017.

Sowing date	Emergence 1 m^2 (12 DAS)	Plant height (cm)			
		30 DAS	45 DAS	60 DAS	75 DAS
(24.11.16)	178.3a	33.6 a	57.5 a	72.6 a	85.3 a
(01.12.16)	188.0a	18.1 b	53.5 a	64.7 a	69.5 b
(08.12.16)	60.0b	13.5 b	40.3 b	59.6 b	62.7 b
CV%	12.2	16.3	5.2	3.6	6.5
LS	**	**	**	**	**

** indicates significant at 1% level; 'NS' denotes non-significant, LS denotes level of significance

4.6 Phenological parameters

Mustard plant is a short duration crop. It took 5 days for germination in the first sowing and 6 days in both 2nd and 3rd sowings (Table 6). Mustard is an indeterminate plant so its vegetative growth overlaps the reproductive growth. First flowering occurred in the first sowing at 35 DAS (days after sowing). In both 2nd and 3rd sowing, flowering occurred at 34 DAS. In each sowing date, 50 % flowering occurred 3-4 days after first flowering.

Table 6: Phenological parameters of mustard in the coastal region of Bangladesh

Sowing date	Growth stage	Duration (day)
24.11.16	Germination	5
	First flowering	30 (35 DAS)
01.12.16	Germination	6
	First flowering	28 (34 DAS)
08.12.16	Germination	6
	First flowering	28 (34 DAS)

4.7 Yield and yield attributes of mustard

Among the recorded yield attributes, the number of silique/plant in first sowing was significantly higher than that of 3rd sowing while this parameter was similar in both 2nd and 3rd sowings (Table 5). On the other hand, the length of silique and number of seed/silique had no difference among the sowing dates. Seed yield followed the similar trend as the number of silique/plant, the highest seed yield was at 1st sowing (0.7 t/ha) and significantly lower seed yield was at 3rd sowing (0.2 t/ha) whereas seed yield of 1st and 2nd sowing was similar. The biological yield was the highest at 1st sowing (2.3 t/ha) then reduced significantly in 2nd (1.9 t/ha) and 3rd sowing (0.7 t/ha). The straw yield followed the similar trend as showed in biological yield. The harvest index among the sowing dates was non-significant.

Table 7: Yield and yield attributes of mustard in the southwestern coastal region, 2016-2017

Sowing date	No. silique /plant	Length of silique (cm)	No. of seed/silique	Seed yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index
(24.11.16)	36.3a	4.7	29.0	0.7 a	1.5 a	2.3 a	0.3
(01.12.16)	35.0a	4.7	30.0	0.6 a	1.3 b	1.9 b	0.3
(08.12.16)	28.0b	4.6	27.7	0.2 b	0.4 c	0.7 c	0.4
LS	*	NS	NS	*	*	*	NS

NS denotes for non-significant; * denotes the significant differences at 5% level; LS denotes level of significance

CHAPTER V

DISCUSSION

Generally, farmers of the southwestern region cannot cultivate rabi crops like mustard. Actually they can't catch the actual growing time of rabi crops for cultivation of late transplanting aman rice. If they can grow mustard timely by cultivating early harvesting or short duration variety of T. aman rice, it is possible to get considerable yield. In the current study, considerable yield was obtained by cultivating mustard in the last of November which was within the optimum sowing window of this crop in other parts of the country.

Yield reduction in mustard was mainly caused by delayed sowing and pest attack. In the other parts (except southwestern region) of the country the optimum sowing window of mustard including BARI sharisha14 is October to November (BARI, Krishi Projuktir Handbook). Delay sowing after this sowing window reduces yield. The 1st and 2nd sowing in the current experiment was within this sowing time. This might be one of the cause of higher yield in first two sowings than that of 3rd sowing. Pest attack increased with the delay of sowing. The seed germinated in 4th and 5th sowing plot but could not emerged due to severe flea beetles attack. Flea beetle did attack mustard field twice. 1st time it was found at 19 December and 2nd time it was found at 10 January. The threshold temperature and degree-days required for egg hatch were determined after exposing the eggs to various constant temperatures (12, 17, 22, 27 and 32 ^{0}C) in separate growth chambers. Optimum temperature for egg hatching was between 17 and 25 ^{0}C (Simeline,2007). Beetles emerge when temperatures warm up to 57 ^{0}F (14 ^{0}C) in early spring (Knodel and Olson, 2002). Figure 3

shows that temperature of the experimental area when flea beetle did attack was optimum for flea beetle's egg hatching.

Flea beetle's egg usually hatch at relative humidity between 85 % and 95 % (Simeline,2007). Figure 4 in this study shows that relative humidity was optimum for growth of flea beetle during the growing period of mustard.

In other research on mustard, crops sown during 22 October to 5 November, critical periods of aphid infestation (having greater than 30 aphids plant^{-1}) prevailed between 19 December and 21 January (Khan and Jha, 2010). The plants sown on 3 December had the lowest percentage of sawfly infestations. The crop sown on 31 October had the lowest number of aphids per plant and the lowest percentage of aphids infested plants. The incidence of aphids increased with the advancement of time but it was opposite in case of sawfly infestation (samad *et al*., 2007).

In addition to initial waterlogging of the soil, delay sowing of mustard, another factor might be the soil type (mostly clay in this region) that relates higher water holding capacity than the lighter soils (loam to sand). Thus the initial stage of crop establishment, soil moisture has tremendous effect on subsequent growth and yield. In the southwestern coastal region, there were two types of effect of moisture on mustard. One is excess moisture during field preparation which delayed the sowing time. The other is excess water from late rainfall. During the experimental period rain occurred in early November 2016 that delayed the sowing although the field was vacant on 6 October 2016. In Bangladesh rain during this time is variable, in some year's monsoon rainfall stops before start of November. However, if the field had well drainage system, it would be possible to cultivate mustard earlier than the 1st

sowing date (24.11.16). So a well drainage system in the field should be prepared so that excess water may be drained out from the field if necessary. Another problem was lack of irrigation facilities. The main sources of irrigation water in the coastal area were water from river and canal. When EC of river water became low then water was retained in the canal. In the current study, salinity of canal water and soil was not severe to reduce grain yield. Electrical Conductivity of canal water was not more than 3 dS/m (figure 1). So it is clear that water salinity is not a considerable problem for yield reduction here. Soil salinity might not create problem here because figure 2 shows that salinity was not more than 4 dS/m although sometimes the curve exceeded 4 dS/m but it was at 45-60 cm depth (figure 2). Mustard is a shallow rooted crop. So mild salinity might not harm the crop.

Plant emergence had no significant effect on sowing date but plant height had significant effect on sowing date. The higher plant height in the 1st sowing (Table 3) may be due to early sowing (within November) compared to other sowings. Kurmi and Kalita (1992) observed greater plant height with 17th November sowing (103 cm) as compared to 2nd December sowing (88.4 cm). Panda *et al.* (2004) reported that plant height was higher on 16th October sowing as compared to 31st October and 15th November sowing. Raj Singh *et al.* (2001) observed in Jodhpur, India, that the crop sown on second week of October had significantly higher plant height and higher number of primary branches per plant as compared to November first week sowing. Sowing in the third week of October recorded higher seed yield (1900 kg/ha) as compared to November first week sowing (1430 kg/ha). Shahidullah *et al.* (1997) reported that plant height was higher with 16th November sowing as compared to 27th October sowing but number of primary and secondary branches per plant was higher with 27th October as compared to 6th or 16th November sowing. Yadav *et al.*

(1994) observed that crop sown on 5th October recorded significantly higher plant height and number of primary and secondary branches per plant as compared to 25th October sown crop of mustard. Seed yield was also higher with 5th October sowing (1.4 t/ha) as compared to 25th October sowing (1.1 t/ha) in Kanpur.

Flowering did not significantly vary due to sowing time but number of siliquae varied significantly (Table 5). Seed yield, straw yield and biological yield were high in the first sowing (24 November). The highest seed yield (1.63 t ha^{-1}) was produced when BARI Sarisha-9 was sown on 10 November (Afroz *et al.*, 2011). Pronay *et al.* (2011) showed that primary branches, weight of seeds, biological yield, harvest index and seed yield were the highest from the second sowing (November, 8) and it was significantly different from of all other dates of sowing.

Yield attributes (length of silique, number of seed per silique and number of silique per plant) had no response to sowing time. Sharif *et al.* (2016) observed that length of silique, number of seed per silique, weight of seed, grain yield, harvest index were highest from the first sowing (30 November). Kamrozzaman *et al.* (2016) found that grain yield, straw yield, number of silique per plant, weight of grain per silique, were highest on 25 November shown crop.

From the above discussion it may be concluded that the cause of yield reduction was not for water salinity and soil salinity but delay in sowing time. If the crop can be shown in last week of November, higher yield (0.7 t/ha) can be achieved from the experimental area. By crop planning (sequence, date of sowing/ planting, short duration variety) and field management (e.g., drainage), mustard and other winter crops can be cultivated. Thus further

research on crop establishment in excessively wet soil and irrigation with mild saline water from the canal should be conducted.

CHAPTER VI

SUMMARY AND CONCLUSION

Sowing date is an important factor reducing crop yield in southwestern costal region in Bangladesh. The experiment was carried out at the farmer's field of Dacope upazilla under Khulna district. There were 5 treatment of sowing time. The experiment was laid out in a randomized complete block design with three replications. First sowing date was 24 November, second sowing date was 1 December and third sowing date was 8 December. The crop of three dates was harvested at maturity stage (74 days after sowing) when almost all leaves shaded from plant and silique became grayish color. The most dominant cropping pattern in the southwestern coastal areas is fallow- fallow- T. aman. Farmers do not cultivate rabi crops because of late harvesting of T. aman rice and waterlogging condition at the time of planting rabi crops. Now short duration as well as saline tolerate varieties of T. aman rice are available in Bangladesh. So, if farmers of the southwestern coastal areas cultivate early harvesting T. aman rice variety they will be able to grow rabi crops in due time although water logging condition may prevail in the field. But actual management of sluicegate and well drainage facilities build up in the field may create an opportunity for people of the southwestern coastal areas to use an important cropping season which has huge economic returns not only for the farmers of these areas but also in Gross Domestic Product (GDP) of Bangladesh. The objective of this study was to investigate the best time to get maximum yield of mustard without harming rice yield. The results showed that best time of sowing of mustard seed is on 24 November after that the yield and yield attributes decreased with the delay of sowing. Possibility of pest attack also increased with the delay of sowing time. If mustard can be cultivated within November seed yield (0.7 t/ha), straw yield (1.5 t/ ha),

biological yield (2.3 t/ha), no. of silique (36/plant) will be the highest which all are yield and parameters.

Farmers of this area should cultivate early or short duration T. aman rice variety so that the field can be prepared to cultivate mustard in November last to get maximum yield of mustard as well as normal rice yield. Farmers should practice it in a large area. A single farmer faces many problems like cultivation of rabi crops and drain out of water from the field after harvesting rice because all the fields in its adjacent area contain plenty of water as they can't harvest rice early. Insect, pest can attack crop severely due to single plot. He has to face problem in case of different intercultural operations like tillage, land leveling, irrigation etc. A community of farmers can avoid this problem.

CHATEPR VII

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