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Effect of Sowing Dates on Yield of Wheat Grown in Excess Water and Salt Affected Soils in Southwestern Coastal Bangladesh

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Transplanted *aman* rice (T. *aman*) is the only crop in a year during the monsoon season and no crop is grown during the rest of year in the southwestern (SW) coastal region of Bangladesh. The fallow results from the prolonged post-monsoon (*kharif* 2) soil saturation, soil and water salinity, as well as the low risk-bearing and investment capacity of resource-poor farmers. In response, we investigated the potential of a *rabi* season crop, wheat, by establishing the crop in excessive wet soil within the optimum sowing window during 2016-17 and 2017-18. To cultivate wheat, we planned from the *kharif* 2: cultivation of short duration rice, drainage of land and irrigation with less saline water (electrical conductivity (EC) <3 dS m^{-1}). By early vacating the land, sowing of wheat seed was possible within the optimum sowing window in excess soil water than that of field capacity. As wheat is a new crop in typical SW region, it was necessary to investigate how wheat responds to early and late sowing in this constraint cropping environment. In 2016-17 season, there were eight sowing dates started from early (November) to late (January). Sowing in relatively wet soil wheat was established in both years. By sowing wheat after 15 December, the grain yield was lower than those of before 15 December. In 2017-18 season, the sowing was very late (four sowing dates) started from after 15 December to early January. The grain yield was poor ranging from 2.72 to 1.34 t ha^{-1} which was lower than those of the last four sowings of 2016-17. The cause of poor yield in all sowings in 2017-18 season was mainly delayed sowing as well as some plant and soil factors. With proper crop planning and management of field, wheat could be a potential crop during *rabi* season for increasing cropping intensity and food security of the country.

(***Key words:*** *Cropping intensity, Fallow, Salinity, Sowing dates, Waterlogging, Winter crops*)

The coastal zone of southwestern (SW) Bangladesh is a low lying (2-3 m above mean sea level) poldered area (land below sea level and surrounded by embankment) where cropping during the dry winter or *rabi* season (November to mid-March) is mainly constrained by salinity (water and soil) and waterlogging (Kabir *et al*., 2017). Among the three crop growing seasons in Bangladesh (*rabi, kharif* 1 and *kharif* 2) single crop of T. aman rice (long duration, late transplanted and harvested) is generally the only crop planted in this region. Thus, the cropping intensity is low compared to that of the country average. After the harvest of T. *aman* rice and during the optimum sowing window of *rabi*/winter crops, the soils are often saturated for ~15-45 days, depending on topography. As a result, farmers cannot sow *rabi* crop seed within the optimal sowing window so a vast area remains fallow during the *rabi* season (World Bank, 2010). Therefore, excess soil water is the first constraint to the cultivation of timely/ early sown (sown before 15 December) *rabi* crops (Krupnik *et al*., 2015). In the later part of *rabi* season, surface water salinity increases to levels not suitable for irrigation. Therefore, if *rabi* crops are sown late after 15 December (Krupnik *et al*., 2015), crops often suffer from lack of irrigation because fresh water is scarce even for drinking. Later in the *rabi* season, the salinity of water bodies (river, canal) and in soil increases, and if crops are irrigated with this water, they suffer from salinity effects. In addition, under late sown condition increased temperature forces the crops to complete their life cycle with a reduced duration, and this can decrease growth and yield (Mainuddin *et al*., 2014; Rashid *et al*., 2014). In the *kharif* 1 season, some farmers cultivate sesame and mungbean, but these are very prone to waterlogging so any early monsoon rain during the growth of these crops can cause complete failure (Jahan *et al*., 2008). In these complex situations of crop cultivation after T. *aman* in typical coastal soils, no research intervention

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to our knowledge, has successfully fitted *rabi* crop(s) into the optimum cultivation time. However, some research has been done on well-drained medium high land with relatively fresh irrigation water (Krupnik *et al*., 2017; Saifuzzaman *et al*., 2011a, 2011b). Within these constraints, better planning for crop production might pave the way to fit a second crop in the *rabi* season. The key elements of this are the planting of a short duration high yielding rice variety (HYV) in the *kharif* 2 season followed by rapid drainage of surface water off the field after the harvest of rice.

Wheat is the most popular *rabi* crop in Bangladesh. Wheat seed can also emerge in puddled soil. The presence of aerenchyma (hollow roots that enable the transport of oxygen down the inside of the roots to the root tips) is an important anatomical adaptation that helps plants to withstand waterlogging; typically aerenchyma increases in response to root zone hypoxia (Benjamin and Greenway, 1979). Wheat typically forms aerenchyma to a small extent in roots under upland conditions, but this is more substantial under hypoxic conditions (Yamauchi *et al*., 2018, 2019). We hypothesized that it might be possible to increase cropping intensity with wheat in SW coastal Bangladesh by, (a) sowing the seed into wet soil (without waiting for reduction of excess soil moisture to field capacity water) during the optimum sowing time (November to mid December) so that the crop would use fresh water from the soil profile during early growth, and (b) irrigating the crop with the relatively fresh water available in the early *rabi* season.

In SW coastal Bangladesh, wheat is a new crop so we investigated the effect of sowing time (from early to extremely late) on the grain yield. Thus, the objectives of this study were: (i) to fit wheat as a second crop in this region after rice using the proposed interventions, and (ii) to investigate the extent of yield loss due to late sowing (late December to early January).

MATERIALS AND METHODS

The wheat variety, BARI *gom* 25, was grown in two years: 2016-17 and 2017-18 in the typical coastal soil of Pankhali village, Dacope, Khulna (22° 37′ 55′′ N and 89° 30′ 10′′ E, elevation ~3 m above mean sea level), Bangladesh.

Field management and crop sowing

Planning was started before the T. *aman* crop was planted to ensure that the timing of the subsequent rabi crop was optimal. A short duration high yield potential T. *aman* rice variety BINA 7 was cultivated and harvested early in both years: 6 October in 2016 and 5 November in 2017. After the rice harvest the land had a cover of 2-3 cm of standing water in both years. Several narrow channels were dug across the surface and a pit was dug at one end of the field. The standing water flowed through the channels into the pit, and the water was bailed out from this pit every day. The soil moisture was reduced to ~40% (v/v) on 20 November 2016. We then spaded the land and opened the soil. On 24 November the soil moisture declined further to ~37% (still in excess of field capacity). On that day we sowed wheat by broadcasting into furrow (1st sowing). After one week the second sowing was done. In this way we continued six more sowings at one week intervals; the total number of sowing dates was eight in the 2016-17 *rabi* season (24 November, 1, 8, 15, 22 and 29 December in 2016, and 5 and 12 January in 2017).

In 2017, the *aman* rice was transplanted and harvested one month later than in 2016 because in previous year the early rice had been infested by rodents. However, late rain occurred on 8-9 December, 2017 when the field was almost ready to sow wheat. The field was therefore drained as previously described. When soil moisture was decreased to ~45% (v/v), the land was again opened by spading and wheat seed was hand broadcasted into rows on 19 December, 2017 (1st sowing). There followed three more sowing dates at 5 day intervals in late December, 2017 and early January 2018. The four sowing dates were: 19, 24 & 29 December in 2017 and 4 January in 2018.

Crop management

There is no fertilizer recommendation for wheat in agro-ecological zone (AEZ) 13. We therefore adopted the recommendation for this crop in the adjacent AEZ 12. In both years the rates were (kg ha^{-1}): N_{120}-P_{30}-K_{60}-S_{15}-Zn_1-B_1 (FRG, 2012). One third of the nitrogen and all the other fertilizers were applied in furrows during sowing. The remaining two thirds of the N were top-dressed during first two irrigations. In both years, light irrigation was given to the plots two days after sowing, except for the first sowing. Between emergence and maturity in 2016-17, six light irrigations (400 L to a 20 m^2 plot) were given to all plots. Irrigation was given in a similar way in 2017-18. The source of irrigation water was a nearby canal connected to a tidal river (there were two high tides and two low tides in a day). The salinity of the canal water was therefore close to that of the river, an $EC_w < 3$ dS m^{-1} in December (Kabir *et al*., 2017). Later the salinity of the river increased, so a bund was made in December to disconnect the canal water from the river to keep the EC_w of canal water low enough to provide irrigation when necessary. No insect attack or disease was visible in either year except for some stem borer during tillering in 2016-17. Nitro 505 emulsifiable concentrate (Cypermethrin + chlorpyrifos) was sprayed twice @ 2 mL L^{-1} water. Weeding was done twice during the crop growing period.

Soil, water and weather condition

Soil moisture was recorded at weekly interval using a MP406 moisture meter (ICT, Australia) from the end of the rice harvest until the last sowing. Soil samples were collected during each sowing from the surface (15 cm). During crop growth, soil samples were also collected to 60 cm at 15 cm depth increments (in one case in 2016-17 to 120 cm) for measuring electrical conductivity and moisture content at each depth. The electrical conductivity (EC) of soil samples was measured in a 1:5 soil:water extract, and the EC_e was calculated by multiplying the $EC_{1:5}$ value by 8.5, the factor identified by Slavich and Petterson (1993) as being appropriate for a clay soil (confirmed for our site by the hydrometer method). The EC_w of river, canal (in both years) and pond (in 2016-17) water was measured twice a week throughout the growing period. The temperature and rainfall data were recorded at a nearby field weather station.

The solute potential of the soil solution was calculated using the formula: $\Psi s = -22580 \times EC_{1:5}/W$; where, Ψs is the solute potential (kPa), $EC_{1:5}$ is the electrical conductivity (dS m^{-1}) of the 1:5 soil: water extract and W is the soil water content (% w/w).

Plant parameters

In both years, measurements were made of plant population, plant height, number of tillers, and dates of occurrence of critical phenological phases (booting, heading, flowering, and duration of crop). Yield attributes were measured on 10 randomly selected plants per plot at harvest in both years. Grain yield (average of 3 x 1 m^2 areas per plot in 2016-17 and average of 3 x 0.25 m^2 in 2017-18) was measured for each sowing date.

Statistical analysis

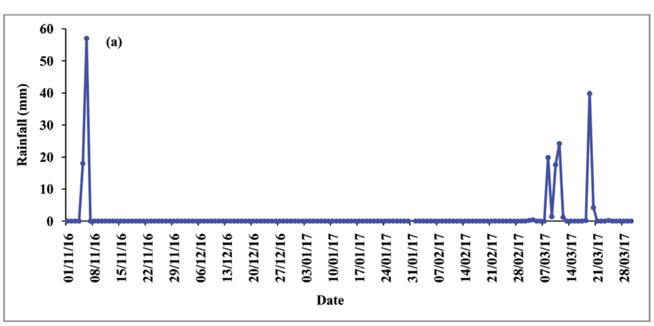
The data from each experiment were analyzed by one-way analysis of variance using the Statistix 10 package. The differences between treatment means were compared with least significance difference (LSD) at the 5% level of significance.

RESULTS AND DISCUSSION

Weather condition during crop growing period

In 2016-17, there was 173 mm of rainfall between December and April, concentrated mostly in March (Fig. 1a). At that time the wheat was nearly at maturity stage in first four sowings, and in the remaining four sowings crops were at grain filling stage. By contrast, 2017-18 was a tough year, because ~50 mm rainfall occurred in early December (Fig. 1b) which delayed sowing to late December, and the number of sowing dates was reduced to four with an interval of 5 days. No rainfall occurred during the growing season.

Temperature in both years was almost similar with lowest between December and February. The condition was a little warmer during grain filling period *i.e.*, in



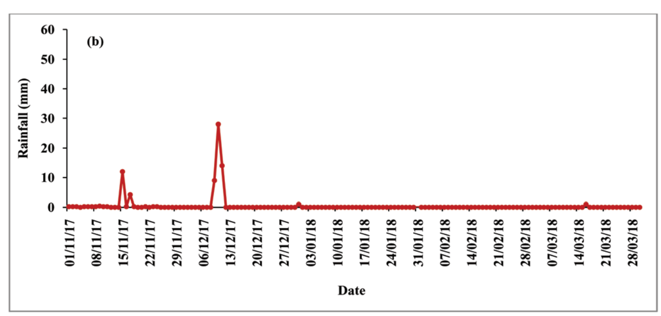


Fig. 1. *Rainfall during wheat growing season in 2016-17 (a) and 2017-18 (b) in the experimental field of Pankhali, Dacope, Khulna, Bangladesh*

the 1st half of March in 2018 (Fig. 2a) than in 2017 (Fig. 2b). Temperature continued to increase in the rest half of March and April in both years which is usual in Bangladesh.

At sowing and during the growing season, irrigation was given when topsoil moisture went below 20% (v/v). The source of irrigation water was the nearby canal. The EC of the canal water remained below 3 dS m^{-1} throughout the growing season in both years (Fig. 3a,c) and the soil EC_e up to 60 cm (15 cm depth increments) was below 4 dS m^{-1} in both the years at all depths (Fig. 3b,d) except at 45-60 cm in 2016-17 when the soil EC_e fluctuated between 4 and 6 dS m^{-1} between late January to early March (Fig. 3b). The EC of the river water in both years was very high and was unsuitable for irrigation (Fig. 3a, c).

In 2016-17, the topsoil moisture in the 1st sowing was 37% (v/v). Soil moisture decreased at later sowing dates to ~12% as recorded from uncultivated land. In the wheat plots, the moisture of the topsoil in the subsequent sowings was maintained at ~30-35% (v/v) by applying light irrigation to improve emergence. In the subsoil (depths below 30 cm) there was substantial moisture even in the end of March in both the years (Fig. 4a, c).

In both the years, the soil water (% w/w) during mid-February was ~20-25 % (Fig. 4a, c). In 2016-17 there were rain on 8, 9, 18 and 19 March thus the soil water content increased. From the 3rd week of March the soil moisture decreased again at all depths. In 2017-18, there was no rain during the crop growing period and the soil water decreased gradually (Fig. 4c).

The solute potential (SP) of soil up to 60 cm depth in 2016-17 season remained between -400 kPa to -475 kPa (Fig. 4b). Due to rain in March, the solute potential also increased. In 2017-18 season, the lowest SP (reported in early April) was -540 kPa (Fig. 4d). By the end of April, the soil was therefore well on the way to being limited for water.

Plant phenological response to different sowing dates

Seedling emergence was greater at the early sowing dates and decreased in the subsequent sowing dates in both years. In 2016-17, the highest emergence occurred with the 1st sowing (24 December), there was 9% reduction with the 2nd sowing, about 30% reduction with the 3rd, 4th and 5th sowings, about 40% reduction with the 6th sowing, and about 50% reduction with the 7th and 8th sowings (Table 1) despite the soil moisture being maintained around 30-37% (by irrigation) on sowing dates.

In 2017-18, the emergence was much lower than in the previous year, ranging from 111 to 86 plants m^{-2} (Table 1). The emergence (from 1st to 4th sowings in 2017-18) was lower than those corresponding to the last four sowings in 2016-17. The plant height was more in

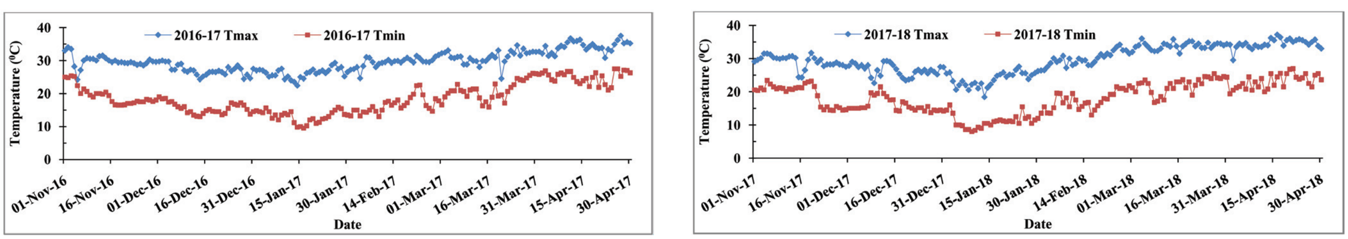
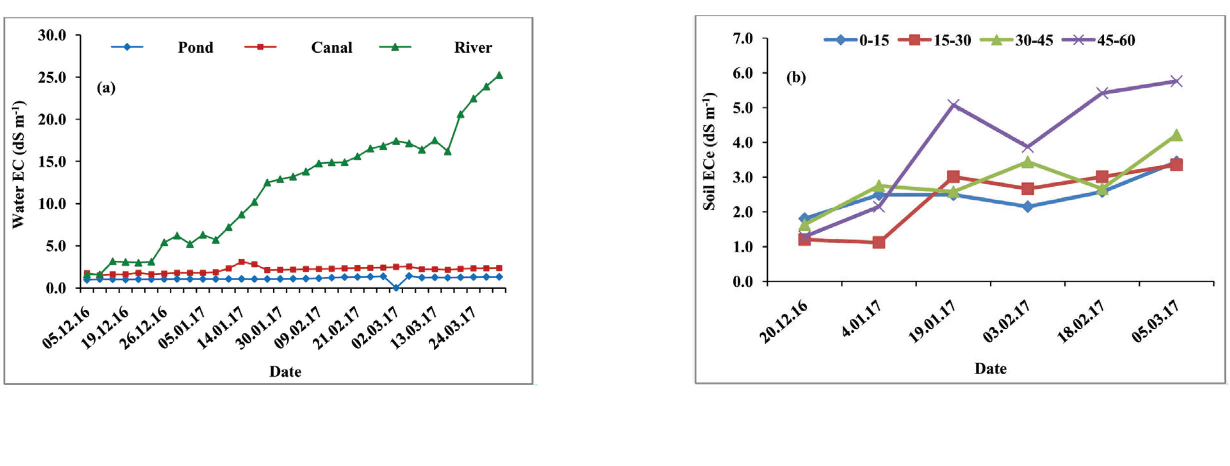


Fig. 2. *Daily minimum and maximum temperature in 2016-17 (a) and 2017-18 (b) of wheat growing seasons in the experimental field of Pankhali, Dacope, Khulna, Bangladesh.*



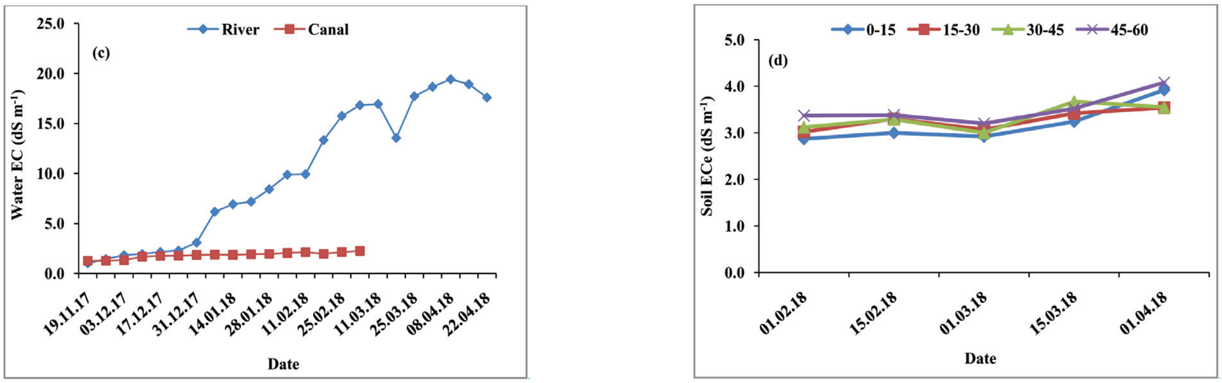


Fig. 3. *Electrical conductivity (EC) of canal and river water of nearby field of wheat in Pankhali (a) and (c) in 2016-17 and 2017-18, respectively and soil ECe of wheat field at different depth increments (b) and (d) in 2016-17 and 2017-18, respectively. Pond water salinity was taken only in 2016-17 (a)*

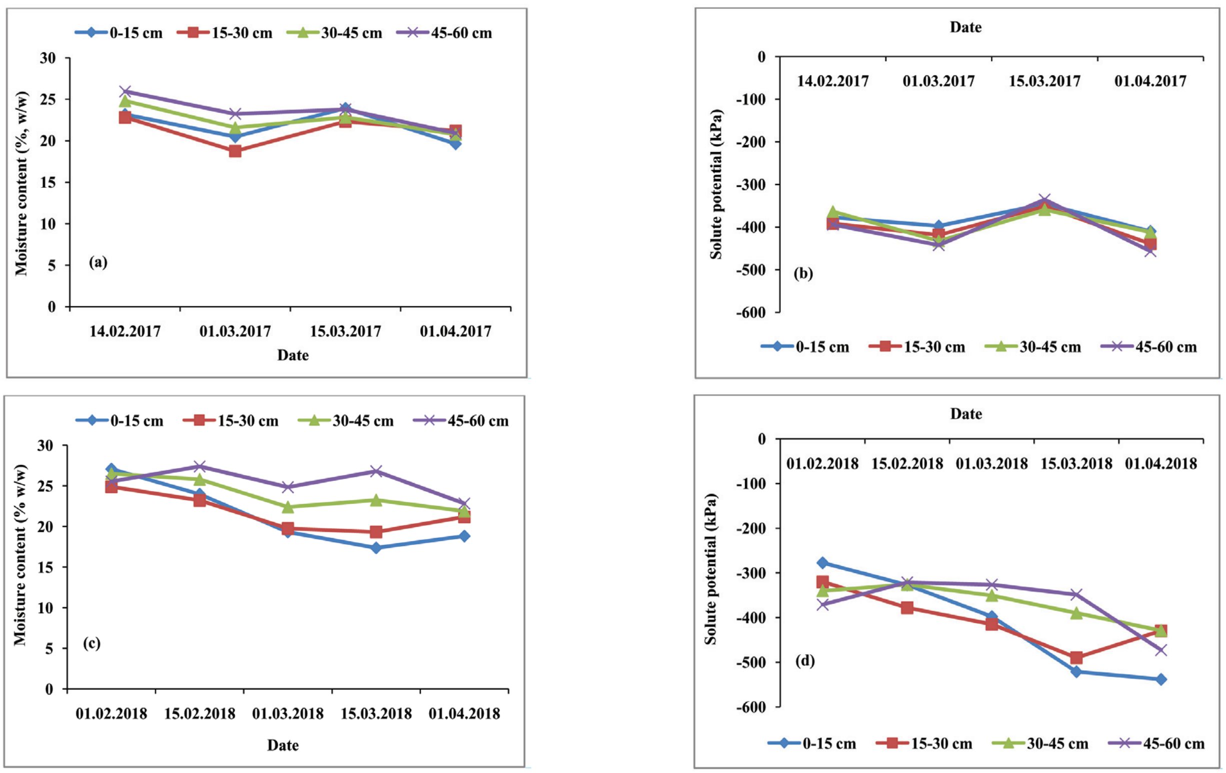


Fig. 4. *Moisture content (% w/w, dry basis): (a) and (c) in 2016-17 and 2017-18, respectively, and solute potential: (b) and (d) in 2016-17 and 2017-18, respectively, of soil up to 60 cm depth (15 cm increment) of wheat in 2017-18. At each date the number of soil samples from each depth was 12, i.e., n = 12 in all depths and dates for soil moisture and solute potential*

earlier sown wheat in both years than that of late sown condition (Table 1).

In 2016-17, early sown wheat took more days to reach different phenological stages. First sowing took 8 to 12 days more than that of eighth sowing for booting, heading, flowering and physiological maturity (Table 2). Thus the crop duration was more in 1st few sowings than in the later sowings. The trend in phenology of wheat in 2017-18 was almost similar to that of 2016-17 (data not given). According to the varietal characters of BARI *gom* 25, the crop duration of this wheat variety should be 102 to 110 days. Compared to 102 days, the crop duration was reduced by 4 days at the 1st sowing and 15 days at the last sowing in 2016-17 (Table 2). The duration of the 5th sowing of 2016-17 was similar to that of 1st sowing of 2017-18; in the 6th, 7th and 8th sowings of 2016-17, the reported phonological

Table 1. *Emergence in 2016-17 and 2017-18 and plant height of field grown wheat in 2016-17*

Sowing dates	Emergence (1 m^2) 2016-17	Emergence (1 m^2) 2017-18	Plant ht (cm) at maturity (2016-17)	Plant ht (cm) at maturity (2017-18)
1st Sowing	171.7a	110.7a	93.5a	81.9a
2nd Sowing	156.3a	98.3b	94.7a	80.4ab
3rd Sowing	118.3b	92.7bc	94.1a	76.4bc
4th Sowing	120.0b	86.3c	87.3b	74.8c
5th Sowing	121.0b		83.7b	
6th Sowing	103.0b		80.7c	
7th Sowing	96.7b		80.2c	
8th Sowing	91.3b		78.3c	
CV (%)	9.30	4.98	2.45	3.30

Values followed by different letters in a column indicate they are significantly different

Table 2. *Phenological dates (days) of wheat sown in eight different dates in 2016-17 in the Pankhali village, Dacope, Khulna, Bangladesh. The dates are recorded when ~50% plants in a plot attained at a certain stage.*

Sowing date	Booting	Heading	Flowering	Physiological maturity	Crop duration in 2016-17 (days)
1st Sowing	49	56	63	94	98a
2nd Sowing	49	56	63	93	98a
3rd Sowing	49	57	64	93	98a
4th Sowing	49	57	64	91	97a
5th Sowing	48	55	62	90	93b
6th Sowing	47	53	60	88	92b
7th Sowing	45	51	58	85	89bc
8th Sowing	41	46	53	82	87c
CV (%)	1.7	1.9	1.5	0.7	0.9

Values followed by different letters in a column indicate they are significantly different

stages took almost similar duration corresponding to the 2^{nd}, 3^{rd} and 4^{th} sowings in 2017-18.

Yield attributes in different sowing dates

In 2016-17, there was no specific trend of increase or decrease in length of spike though the spike lengths were differed significantly among the treatments (Table 3). The number of effective tillers per plant and 1000-grain weight were higher in the early sowings. These might have contributed to higher yields in the early two sowing treatments (Fig. 5). The number of spikelets per spike and grains per spike were not significantly different due to date of sowing. In the four sowings of 2017-18, the effective tillers per plant and 1000-grain weight were higher than those of the last four sowings (5^{th} to 8^{th}) in 2016-17. The other yield attributes were also lower in 2017-18 than the previous year or the parameters were approximately similar in both years.

Grain yield in 2016-17 and 2017-18

In 2016-17, the grain yield was the highest in 1^{st} and 2^{nd} sowing dates (4.4 and 4.1 t ha^{-1}, respectively) (Fig. 5a). After the 2^{nd} sowing, the yield started to decline. From the 3^{rd} to 5^{th} sowing, the grain yield was statistically at par (3.7 to 3.9 t ha^{-1}). With the delay of sowing, the grain yield further declined and the lowest yield (2.4 t ha^{-1}) was found with the 8^{th} sowing (date: 09.01.17, 45 days later the 1^{st} sowing). From 1^{st} sowing to 8^{th} sowing, the grain yield declined ~50%.

In 2017-18, the 1^{st} sowing gave the highest yield (2.72 t ha^{-1}) which was statistically similar to that of 2^{nd} sowing (2.50 t ha^{-1}) while the 4^{th} sowing gave lowest yield (1.34 t ha^{-1}) (Fig. 5b). There was about 50% reduction of grain yield due to delay in sowing. The overall grain yield was much higher in 2016-17 in all sowing dates as compared to that of 2017-18. The grain yield in 5^{th} sowing (3.7 t ha^{-1}) of 2016-17 was 1.4 times higher than the 1^{st} sowing of 2017-18 although the sowing dates were same in both years (19 December).

The timely sowing of winter crops in the southwestern region, wheat in this study, is highly dependent on status of soil moisture after harvest of rice. Early sowing was

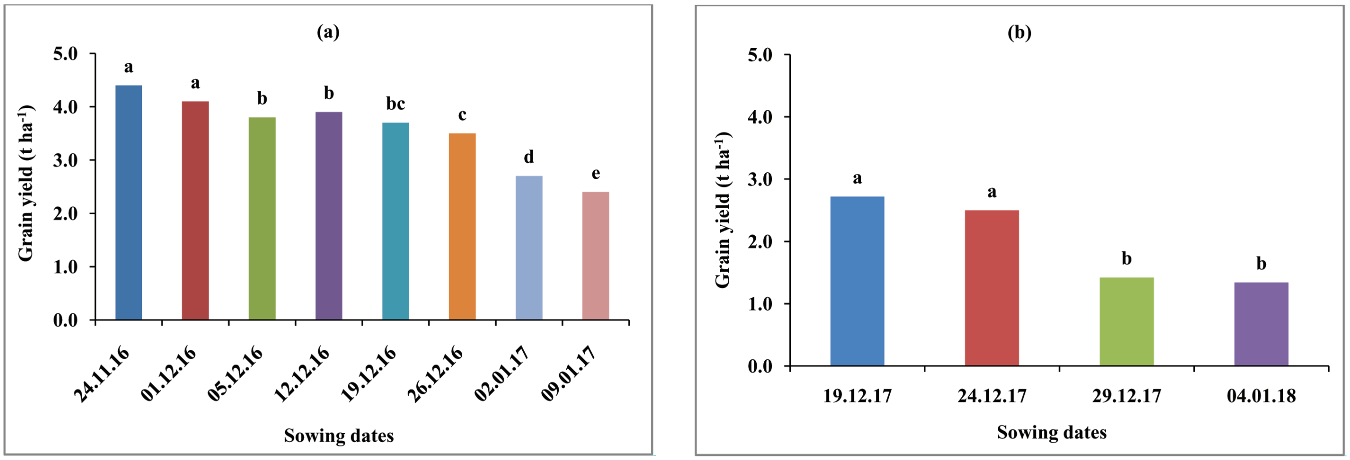


Fig. 5. *Grain yield of field grown wheat in two succesive years: (a) 2016-17 and (b) 2017-18 in the southwestern coastal area of Bangladesh*

closely related to the harvest of short duration T. *aman* rice, the draining of the remaining standing water and rapid reduction of excess soil moisture to a level at which seed can germinate. The optimum sowing time of the *rabi* crop was not only delayed by the excess soil moisture that remained in the field after the previous rice, but also by late rainfall which further delayed the sowing. In addition, the soil texture in the southwestern region is mostly dominated by clay and the water table is close to the surface. Thus once the soil is saturated, more time is required for drainage as compared to the lighter textured soil of traditional wheat growing areas of the country.

With the progress of *rabi* season the topsoil started drying (with cracking) although moisture was retained in the subsoil. The drying of topsoil might reduce the emergence in the late sowing dates although topsoil moisture was kept ~30-35% (v/v) during all sowing dates. However, the water table usually goes down that reduce rate of capillary rise to fill up the pore spaces with water (Prokash, 2017). The residual moisture in the soil profile influenced the germination and emergence of seedling by regulating the seed-soil contact. This was more effective than application of light irrigation after sowing.

The duration of crop was reduced due to delayed sowing in both the years (Table 2), and the total biomass and grain yield was therefore less. Generally, long winter season is required for higher production of wheat as found in northern Bangladesh. The wheat variety, BARI *gom* 25 is claimed to be a heat tolerant variety (BARI, 2017) but to what extent it can tolerate hig temperature has not been reported. In 2017-18, the temperature during grain filling (early March to mid March) was higher (34.0°C) than in 2016-17 (30.0°C; Fig. 1). From February when temperature starts to rise, the winter crops like wheat are forced to complete their life cycle within short period (Mainuddin *et al*., 2014). However, in 2016-17, when sowing was not done within optimum time, 2.4 t ha^{-1} grain yield (8th sowing, sown on 9 January) was a substantial yield. On the other hand, 1.6 times less grain yield in the first sowing of 2017-18 compared to the 1st sowing in 2016-17 indicates that not only sowing within the window (November to 15 December) of wheat is important (Krupnik *et al*., 2017) but also the edaphic and environmental factors, solute potential, soil water, etc., which may determine the crop growth and yield in rabi season. Among the yield attributes, the number of effective tillers and plant population were lower in most sowings of 2017-18 than those of 5th to 8th sowings of 2017-18 (Tables 3 and 4). Despite the salinity of soil and the EC of irrigation water was between 3-4 dS m^{-1} in both years, the yield reduction occurred in 2017-18. Because only EC cannot explain the negetive effect of salt on plant as EC cannot identify the ions responsible for the salinity. Thus, the solute potential can better explain the effect of salinity on plant. The solute potential during grain filling in 2017-18 was over -500 kPa, much below the wilting point, -1500 kPa, but is equal to ~110 mM or ~11 dS m^{-1} according to NyPa scale (based on NaCl). This seems to be high level of salinity which might hamper the grain filling and thus reduced the grain yield in 2017-18. Barrett-Lennard *et al*., (1999) showed that 120 mM NaCl salinity can cause huge effect (80-90% damage) on wheat at early

Table 3. *Yield attributes of wheat in 2016-17 in the Pankhali village, Dacope, Khulna, Bangladesh*

Sowing date	Effective tillers per plant	Length of spike (cm) per plant	Spikelet no. per spike	Grain no. per spike	1000-grain wt (g)
1st, 24.11.16	2.7a	14.4d	18.5	33.7	80a
2nd, 1.12.16	2.3b	16.2a	18.5	33.5	77.9ab
3rd, 05.12.16	2.3b	15.9b	19.0	33.0	77.0b
4th, 12.11.16	2.2c	15.3c	18.5	33.0	78.2b
5th, 19.12.16	2.2bc	14.5d	18.5	33	78.0b
6th, 26.12.16	2.1c	14.2de	18.2	32.5	77.0b
7th, 02.01.17	2.1c	14.0e	18.0	32.0	76.6b
8th, 09.01.17	2.0c	13.5f	17.1	32.1	76b
CV (%)	5.6	1.8	NS	NS	2.3

Values followed by different letters in a column indicate they are significantly different

Table 4. *Yield attributes of wheat (2017-18) in the Pankhali village, Dacope, Khulna, Bangladesh*

Sowing date	Effective tillers per plant	Spike length (cm) per plant	Spikelet no. per spike	Grain no. per spike	1000-grain wt. (g)
19.12.17	1.9	14.87a	20.37a	35.47a	72.2
24.12.17	1.9	13.97a	19.67a	34.8a	71.8
29.12.17	1.9	10.73b	15.93c	29.6b	71.4
4.01.18	1.87	11.73b	16.37b	28.27b	70.6
CV (%)	3.62	3.67	3.03	3.51	3.62

Values followed by different letters in a column indicate they are significantly different

stage in solution culture. The current wheat variety claims that it can tolerate 6-9 dS m^{-1} salinity (BARI, 2017) which is much lower than the salinity obtained during grain filling stage in 2017-18 season. Soil water (w/w) in whole growing season of 2016-17 was 20-25% in all depths (Fig. 4a) while in 2017-18, soil water was <20% during grain filling (Fig. 4c). These factors combinedly reduced the grain yield in 2017-18. However, we do not have any control over weather elements but land management vacate the land early by draining out of excess water and by keeping the irrigation water in the canal less saline. Undue rain may not occur every year. It is important to analyse the long time rainfall data for getting a trend of how frequently this unwanted rain occurs. Successful cultivation of wheat and other winter crops in southwestern coastal Bangladesh depends on the management of large area by the farmers' community. When a single farmer cultivates winter crops early, he/she needs to transplant rice early. When the rice attains maturity, the other surrounding rice fields remains at flowering or at grain filling stages. Those fields require water whereas the early sown rice at maturity phase needs to get rid of the excess water. Moreover, the livestock graze freely during the fallow winter season and damage the winter crop in a isolated areas. Thus community intervention in selection of short duration T. *aman* rice, making the land ready for winter crop sowing, canal management, etc. will resolve the management problems and the vast fallow land can be cultivated with winter wheat.

Soil salinity was not the responsible factor for keeping the land fallow during winter season but the excess soil water at the harvest of T. *aman* rice determines the timely sowing of winter crops especially, wheat. Wheat can be cultivated in the typical southwestern coastal soil by early harvesting of HYV rice and irrigating with confined water of canal. Cultivation of winter crop by single farmer might not be feasible but by a community in a large area might be effective.

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