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Yield performance based selection of superior mutant lines from mutant wheat genotypes

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Abstract

Wheat is the most widely grown cereal crop in the world. However, yield performance of wheat in Bangladesh is very low and the amount of cultivating land is decreasing drastically. Wheat cultivation in coastal saline regions can be a new dimension to increase the wheat production. Therefore, the first step of our research project was conducted out to evaluate the genotypic variability among the salt tolerant mutant lines of wheat genotypes to select superior lines based on yield performance on non-saline soil to bring them in the next step of screening process in salt affected areas. The performance of yield and yield contributing characters of 154 wheat genotypes were evaluated through Francis and Kannenberg's method of selection. To evaluate the yield performance of mutant wheat lines, 'Prodip', a high yielding variety, developed by Bangladesh Agriculture Research Institute (BARI), was used as check variety. Thirty-seven wheat mutant lines, which perform better than 'Prodip' were selected based on yield contributing characters i.e. plant height, flag leaf duration, spike length, spikelet per spike, number of tillers, 100-grain weight and yield per plant. During selection of mutant lines, more emphasize given on the character 100-grain weight and yield per plant. The result of this study can be used for further evaluation of selected genotypes on saline soil before going to farmer level evaluation.

Key words: Mutants, wheat, yield contributing characters, saline tolerant, prodip

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Introduction

Wheat is the most widely grown food crop in the world. It ranks first in world crop production and is the national staple food of most of the countries. Bread wheat is belonging to the genus *Triticum,* family Graminae. *Triticum* includes diploid (2n=2x=14), tetraploid (2n=4x=28) and hexaploid (2n=6x=42) species. The genomic constitution of diploid, tetraploid and hexaploid groups is AA, AABB and AABBDD respectively. The genus *Triticum* includes two commercially cultivated species *Triticum aestivum* L. and *Triticum durum* L. The former species includes two types- winter and spring wheat, both are commercially cultivated and known as bread wheat.

Bread wheat is the second most important cereal crop in Bangladesh. However, the average yield is very low. More recently, during 2014/15, 2015/16 and 2016/17 wheat production was about 1347, 1318 and 1311 thousand metric ton (BBS 2017). This decreasing trend of wheat production is due to some constraints such as socioeconomic condition, lack of irrigation facilities, lack of stress tolerant varieties, crop competition with others profitable crops, sterility in the spikes and short duration of winter in Bangladesh.

Saline soil contains an excess accumulation of soluble salt in the root zone leading to detrimental effect on the

growth and development of crop plants. Salt injury depends on crop species, varieties, growth stages, environmental factors and characteristics of the soil which include salt source, nature and content, nutrient status, distribution of salt pH organic matter content, water regime and other soil related toxicities. It is thus difficult to define saline soil precisely. A common view about saline soil is soil that has enough salt in the root zone to give an electrical conductivity (EC) in the saturation extract exceeding 4 dS/m at 25°c, an exchangeable sodium percentage (ESP) less than 15, and usually a pH below 8.5 (US Salinity Laboratory, 1954). Strong saline soils are defined as soils with EC's more than 15 ds/m (FAO-Unesco, 1974).

Salinity is one of the major obstacles of increasing wheat yield on millions of hectares of land in arid and coastal areas in the tropics and sub-tropics. In principle, elevated salinity in soils results mainly from two sources such as natural and man-made (Yuncai 1996). About 52.8 %of cultivable land in 64 upazillas of 13 districts are adversely affected by varying degrees of salinity (Karim et al. 1990)and remains fallow during the dry months. This is the target area for which salt tolerant varieties are needed. The intrusion of sea water during tidal flood and tidal bores along the rivers and estuaries in the coastal belt is the main cause of this salinization. Those soils have highly saline shallow underground water table and subsequent evaporation of water from the soil increases salinity during the dry season. Salinity also moves into inland areas as well as ground water level due to drainage deterioration of the flood plain of the Ganges and greater use of sea water for shrimp culture. In principle, the loss of agricultural land resulting from increasing salinity could be reversed either by soil desalinization or by the use of salt tolerant varieties (Yeo and Flowers, 1986) which can produce high yield both in saline and non-saline land. Therefore, the present study was carried out in wheat to evaluate the genetic variation of some morphological characters of mutant wheat germplasm to select superior mutant lines in non-saline soil. The aim of this study to select the best performing genotypes, considering the yield contributing characters, in non-saline soil, for our next step of screening process in saline soil.

Materials and Methods

***Experimental site and growing season*:** The experiment was carried out at the Experimental Farm, Plant Breeding Division, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, during rabi season (from 29 November, 2010 to May, 2011). The place is geographically located at about 24°75' North latitude and 90°50' East longitude. The soil of the experimental area is a medium high land belonging to the Old Brahmaputra Floodplain, Agro-ecological Zone-9 (UNDP and FAO, 1988). The texture of the soil is silty loam having pH 6.7, low in organic matter and fertility level.

***Plant materials*:** Four segregating populations L-885, L-61, L-897 and L-880 were collected from NIAB, Pakistan by BINA. 29 lines from L-885, 37 lines from L-61, 40 lines from L-897 and 50 lines from L-880 (not yet published) were selected based on yield performance and the salt tolerance level. A variety 'Prodip' (BARI Gom 24), released in 2005, is a high yielding variety and tolerant to heat and resistant to bipolaris leaf blight and, leaf rust diseases. It showed highest farmers' overall yield preference (3797 kg/ha) (Pandit *et al.* 2011). Selected lines in the present study were used for further yield trial, where 'Prodip' was used as a check variety. All the plant materials were collected from wheat research programme, Plant Breeding Division, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, and 'Prodip' BARI Gom 24' was collected from Bangladesh Agriculture Research Institute (BARI), Gazipur.

***Experimental design and plant growing conditions*:** The experiment was laid out in non-replicated trial. It was setup following five rows in which first four rows were mutant lines and other was 'Prodip'. The plot size was 6m × 2m. The distance regarding block to block was 1m, line to line was 30cm and plant to plant within

rows was 5cm, respectively. The seeds were sown on 29 November 2010 in continuous rows keeping the line-to-line distance of 30cm. Finally, plants in a row were kept at a distance of about 5cm.Thinning was done after 25 days of sowing. Two times weeding was done, one after 25 days of sowing seeds and the other after 1st irrigation. The field was irrigated 2 times, one at the crown root initiation stage and the other at the peak tillering stage. Other intercultural operations were done as and whenever necessary.

***Harvesting and data collection*:** The plants were harvested at full maturity and data were recorded from five randomly selected competitive plant. Among the yield contributing characters, data on flag leaf duration, plant height (cm), spike length (cm), spike number, number of spikelets per spike, hundred grain weight (g) and grain yield per plant (g) were recorded. Flag leaf duration was calculated by the number of days from the date of seeding to yellowing of peduncle of 50% of the plant populations.

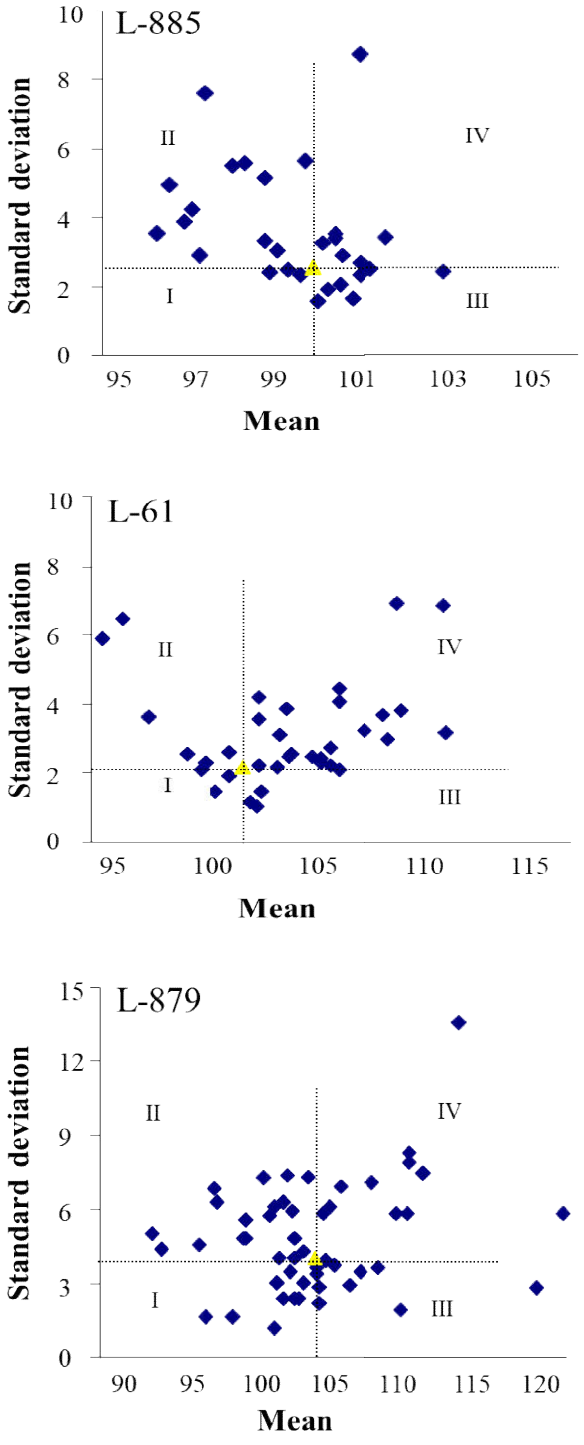
***Data analysis*:** The genotypes were selected based on genotype grouping technique (Mean-SD method) as proposed by (Francis and Kannenberg,1978). It was also employed to determine stable and high potential genotype(s). According to this method the genotypes were classified into 4 categories:

Group-1 High mean value, small SD (%)
Group-II: High mean value, large SD (%)
Group-III: Low mean value, small SD (%)
Group-IV: Low mean value, large SD (%)

The analysis was carried out using SAS Software (SAS Institute 1999).

Results and Discussion

***Plant height*:** In wheat, lower plant height is desirable to the farmers and also to the researchers for getting lodging resistance genotypes. Therefore, in the selection experiment, it had been emphasized to select those genotypes possessed lower mean value in the character plant height following Francis and Kannenberg's (1978) method. According to this method, genotypes were grouped into four classes drawing lines passing through the mean and standard deviation value of the genotype 'Prodip' (Figure 1).



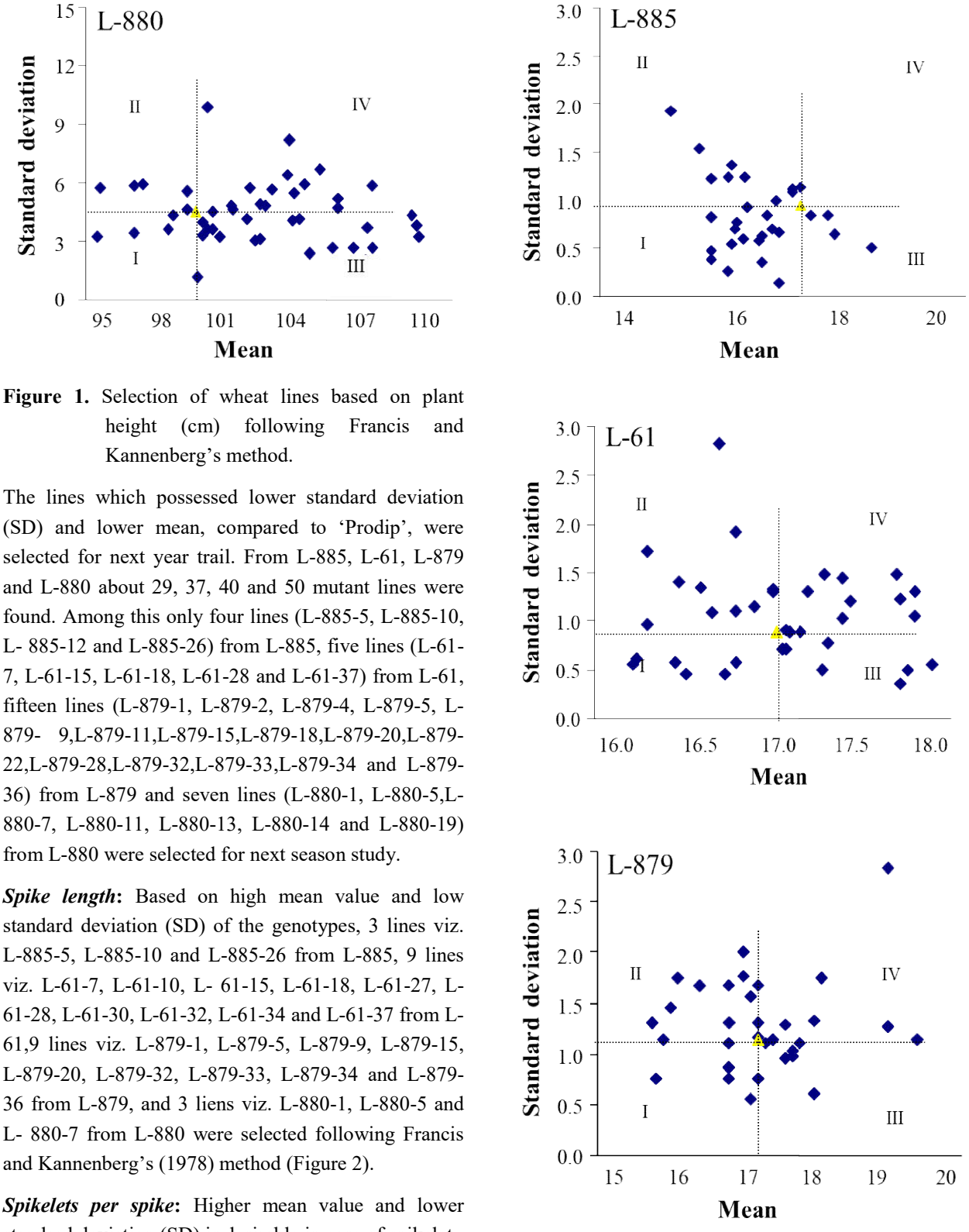


Figure 1. Selection of wheat lines based on plant height (cm) following Francis and Kannenberg's method.

The lines which possessed lower standard deviation (SD) and lower mean, compared to 'Prodip', were selected for next year trail. From L-885, L-61, L-879 and L-880 about 29, 37, 40 and 50 mutant lines were found. Among this only four lines (L-885-5, L-885-10, L- 885-12 and L-885-26) from L-885, five lines (L-61-7, L-61-15, L-61-18, L-61-28 and L-61-37) from L-61, fifteen lines (L-879-1, L-879-2, L-879-4, L-879-5, L-879- 9,L-879-11,L-879-15,L-879-18,L-879-20,L-879-22,L-879-28,L-879-32,L-879-33,L-879-34 and L-879-36) from L-879 and seven lines (L-880-1, L-880-5,L-880-7, L-880-11, L-880-13, L-880-14 and L-880-19) from L-880 were selected for next season study.

***Spike length*:** Based on high mean value and low standard deviation (SD) of the genotypes, 3 lines viz. L-885-5, L-885-10 and L-885-26 from L-885, 9 lines viz. L-61-7, L-61-10, L- 61-15, L-61-18, L-61-27, L-61-28, L-61-30, L-61-32, L-61-34 and L-61-37 from L-61,9 lines viz. L-879-1, L-879-5, L-879-9, L-879-15, L-879-20, L-879-32, L-879-33, L-879-34 and L-879-36 from L-879, and 3 liens viz. L-880-1, L-880-5 and L- 880-7 from L-880 were selected following Francis and Kannenberg's (1978) method (Figure 2).

***Spikelets per spike*:** Higher mean value and lower standard deviation (SD) is desirable in case of spikelet

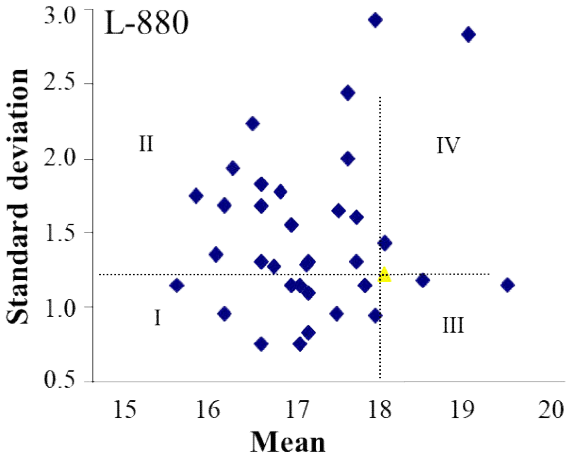
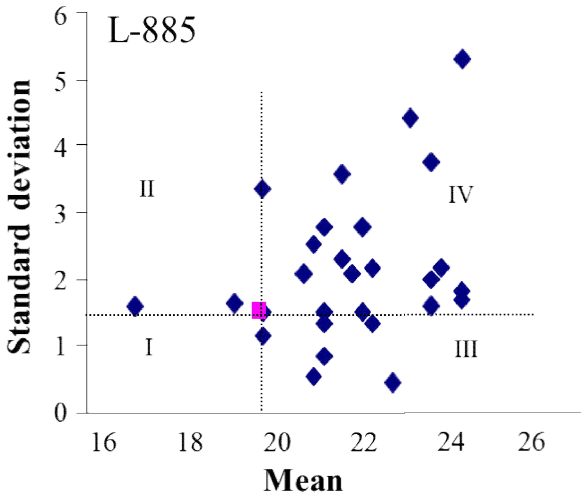
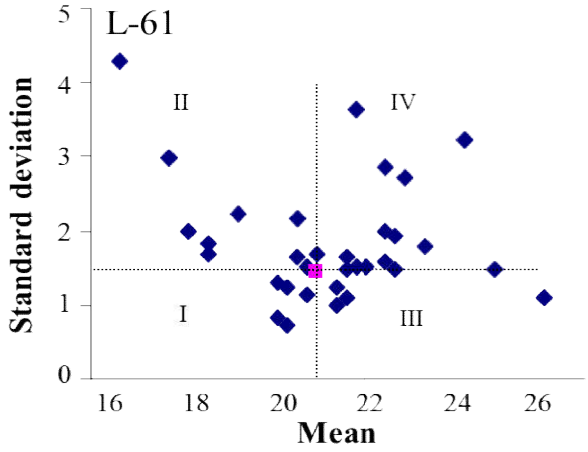
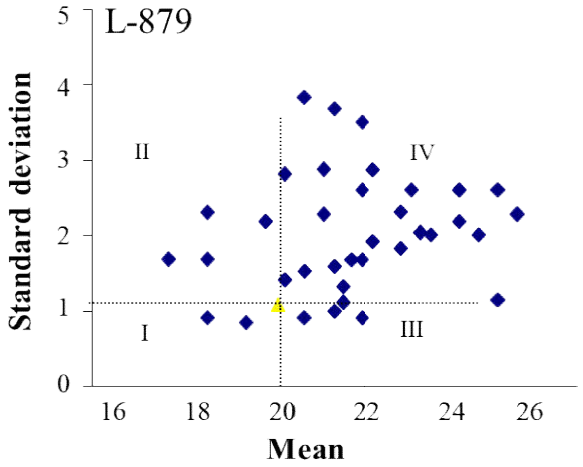


Figure 2. Selection of wheat lines based on spike length following Francis and Kannenberg's method.

per spike. According to Francis and Kannenberg's (1978) method, genotypes were grouped into four classes drawing lines passing through the mean and standard deviation value (SD) of 'Prodip' (Figure 3). Eleven lines viz. L-885-2, L-885-5, L-885-10, L-885-12, L-885-13, L-885-17, L-885-20, L-885- 21, L-885-23, L-885-25 and L-885-26 from L-885, 13 lines viz. L-61-2, L-61-6,L-61-7, L-61-10, L-61-14, L-61-15, L-61-18, L-61-27, L-61-28, L-61-30, L-61-32,L-61-34 and L-61-37 from L-61, 5 lines viz. L-879-1, L-879-5, L-879-15, L-879-32 and L-879-34 from L-879







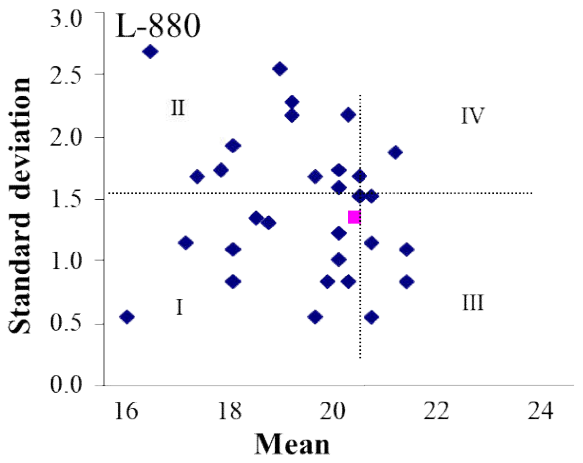
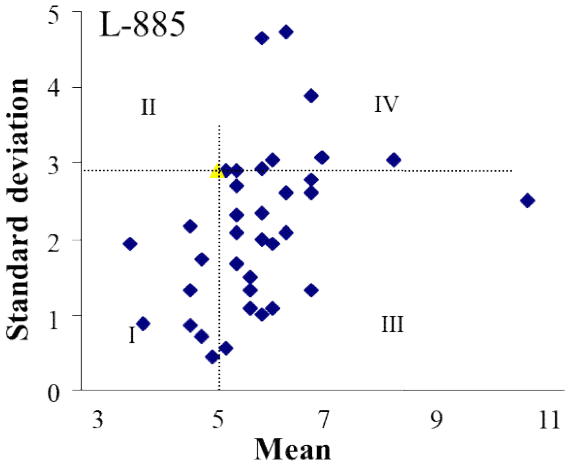
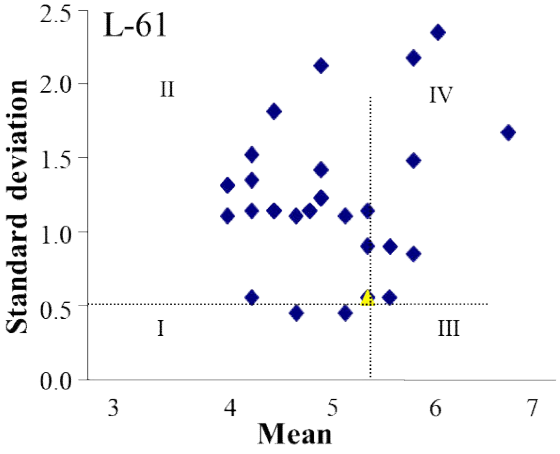


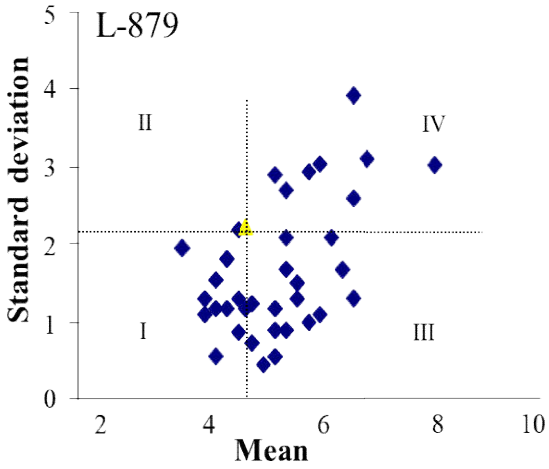
Figure 3. Selection of wheat lines based on number of spikelets per spike following Francis and Kannenberg's method.

and 6 liens viz. L-880-1, L-880-5, L-880-10, L-880-17, L-880-27 and L-880-38 from L-880 were selected.

***Number of tillers*:** Wheat lines were also selected depending on high mean value in case of number tiller following Francis and Kannenberg's (1978) method (Figure 4). About 21 lines viz. L-885-1, L-885-2, L-885-3, L-885-4, L-885-5, L-885-7, L-885-8, L-885-9, L-885-11, L-885-12, L-885-13, L-885-15, L-885-16, L-885-18, L-885-19, L-885-20, L-885-21, L-885-22, L-885-23, L-885-24, L-885-25, L-885-26 and L-885-29 from L-885, 1 line L-61-18 from L-61, 18 lines viz. L-879-1, L-879-2, L-879-4, L-879-5, L-879-9, L-879-10, L-879-11, L-879-15, L-879-22, L-879-24, L-879-25, L-879-27, L-879-31, L-879-32, L-879-33, L-879-34, L-879-38







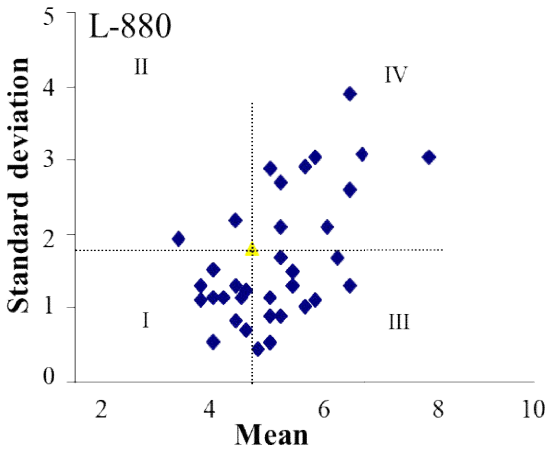
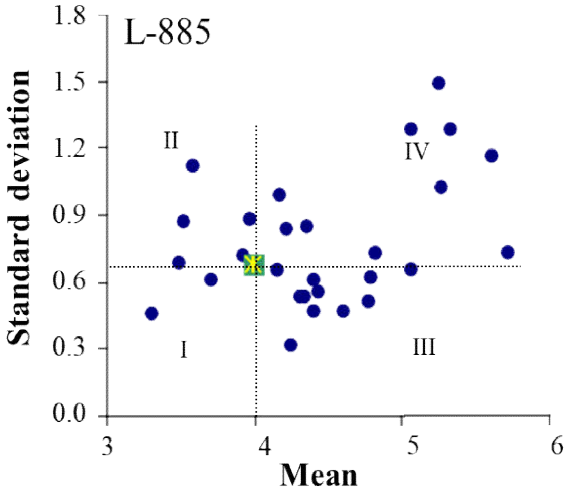
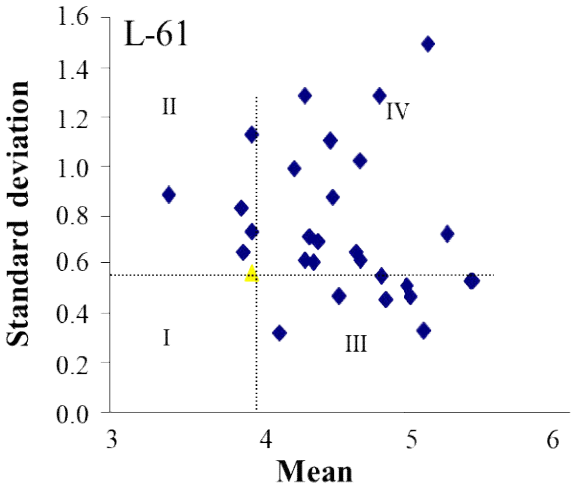


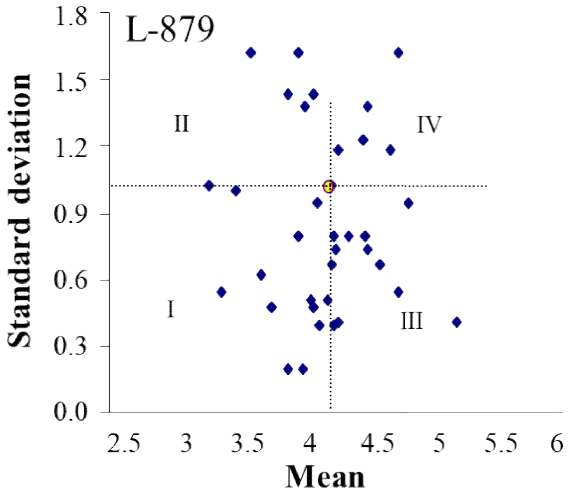
Figure 4. Selection of wheat lines based on number of tillers following Francis and Kannenberg's method.

and L-879-42 from L-879 and 13 liens viz. L-880-1, L-880-5, L-880-07, L-880-10, L-880-11, L-880-13, L-880-14, L-880-15, L-880-17, L-880-18, L-880-34, L-880-36, L-880-38 and L-880-43 from L-880 were selected.

***100 grain weight*:** In wheat, higher 100-grain weight is desirable to farmers as well as to the researchers for getting higher yield per plant. Therefore, it was emphasized to select those genotypes that possessed higher mean in the character 100-grain weight following Francis and Kannenberg's (1978) method (Figure 5).







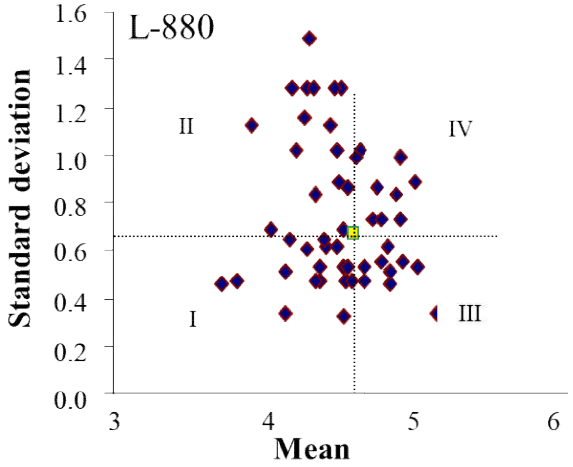
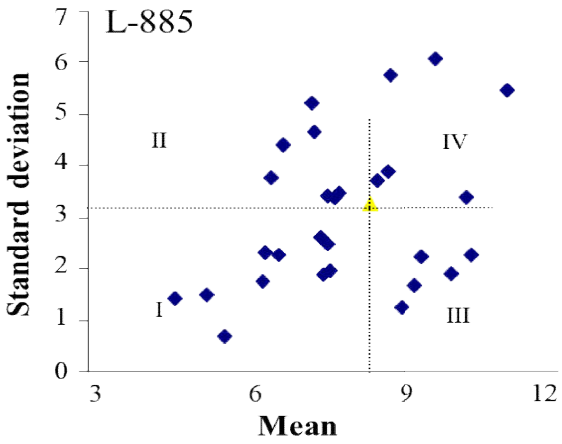


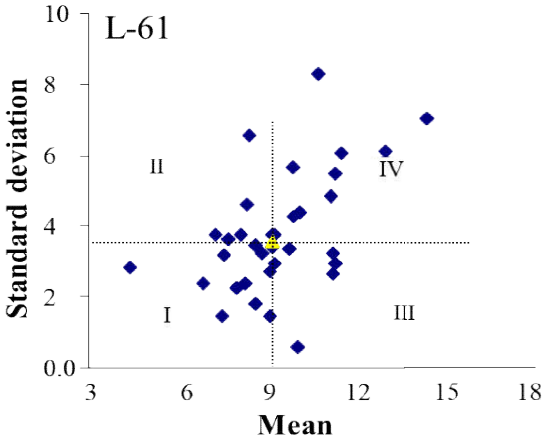
Figure 5. Selection of wheat lines based on 100-grain weight (g) weight following Francis and Kannenberg's method.

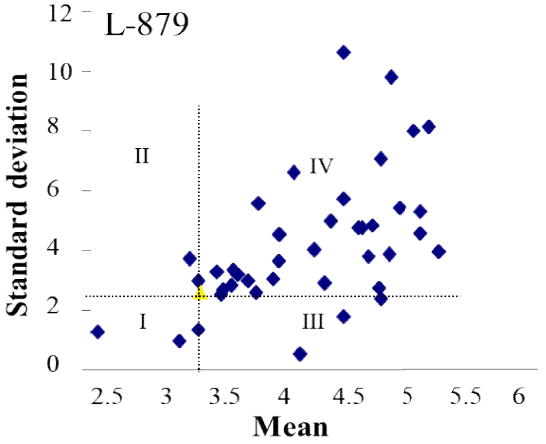
About 12 lines (L-885-1, L-885-7, L-885-10, L-885-12, L-885-15, L-885-17, L- 885-18, L-885-21, L-885-23, L-885-25, L-885-27 and L-885-28) from L-885, 8 lines (L-61-2, L-61-7, L-61-12, L-61-15, L-61-18, L-61-28, L-61-34 and L-61-35) from L-61, 13 line (L-879-1, L-879-2, L-879-4, L-879-5, L-879-11, L-879-22, L- 879-25, L-879-27, L-879-30, L-879-34, L-879-35 and L-879-42) from L-879, 11 lines (L-880-1, L-880-5, L-880-07, L-880-10, L-880-14, L-880-15, L-880-17, L-880-18, L-880-34, L-880-36 and L-880-38) from L-880 were selected.

***Yield per plant*:** Higher yield is desirable in every step of variety development and researcher as well as farmers demand for higher production. Therefore, in selection experiment, it was emphasized to select genotypes possessing higher mean value (Figure 6) for the character yield per plant following Francis and Kannenberg's (1978) method. According to Francis and Kannenberg's (1978) method genotypes were grouped into 4 classes those were better than 'Prodip'. Five lines viz. L-885-10, L-885-21, L-885-23, L-885-27 and L-885-28 from L-885, 9 lines viz. L- 61-2, L-61-7, L-61-12, L-61-15, L-61-18, L-61-28, L-61-33, L-61-34 and L-61-35 from L-61, 5 lines L-879-1, L-879-2, L-879-4, L-879-5 and L-879-34 from L-879, 13 lines

L-880-1, L-880-5, L-880-07, L-880-10, L-880-14, L-880-15, L-880-17,L-880-18, L-880-19, L-880-26, L-880-34, L-880-36 and L-880-38 fromL-880 were selected, respectively.







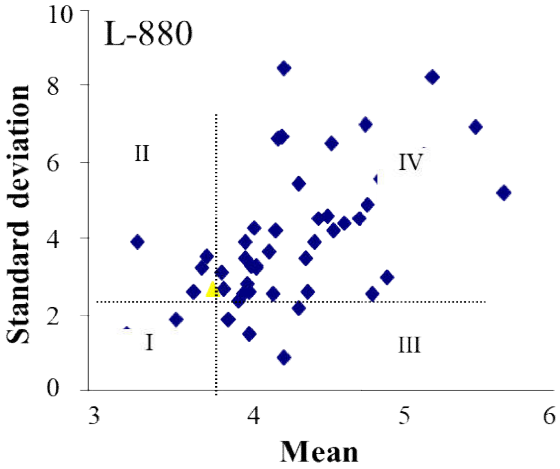


Figure 6. Selection of wheat lines based on plant yield (g/plant) following Francis and Kannenberg's method.

Table 1. Summary table of parent to offspring selection based on different traits following Francis and Kannenberg's (1978) method considering mean and standard deviation (SD) as selection criteria.

	Number of genotypes selected					
Lines	Plant height	Spike length	No of spikelets per spike	No. of tillers	100-grain weight	Yield per plant
L-885	4	3	11	21	12	5
L-61	5	9	13	1	8	9
L-879	15	9	5	18	13	5
L-880	7	3	6	13	11	13

Considering all lines of the genotypes L-885, L-61, L-879 and L-880 with their mean value and standard deviation (SD), about 88 lines performed better than 'Prodip' for various yield contributing characters. But analyzing all these 88 lines in second year experiment is difficult and impractical. Based on yield parameters, yield per plant and 100-grain weight, about 37 lines

which performed better than 'Prodip' were selected for next year experiment.

Sl no.	Genotypes	Lines	Source
1	L-885	L-885-10	BINA, Mymensingh
2	L-61	L-61-7	BINA, Mymensingh
3		L-61-12	BINA, Mymensingh
4		L-61-15	BINA, Mymensingh
5		L-61-18	BINA, Mymensingh
6		L-61-28	BINA, Mymensingh
7		L-61-33	BINA, Mymensingh
8		L-61-34	BINA, Mymensingh
9		L-61-35	BINA, Mymensingh
10		L-61-37	BINA, Mymensingh
11	L-879	L-879-1	BINA, Mymensingh
12		L-879-2	BINA, Mymensingh
13		L-879-4	BINA, Mymensingh
14		L-879-5	BINA, Mymensingh
15		L-879-11	BINA, Mymensingh
16		L-879-22	BINA, Mymensingh
17		L-879-32	BINA, Mymensingh
18		L-879-33	BINA, Mymensingh
19		L-879-34	BINA, Mymensingh
20	L-880	L-880-1	BINA, Mymensingh
21		L-880-5	BINA, Mymensingh
22		L-880-7	BINA, Mymensingh
23		L-880-10	BINA, Mymensingh
24		L-880-11	BINA, Mymensingh
25		L-880-13	BINA, Mymensingh
26		L-880-14	BINA, Mymensingh
27		L-880-15	BINA, Mymensingh
28		L-880-17	BINA, Mymensingh
29		L-880-18	BINA, Mymensingh
30		L-880-19	BINA, Mymensingh
31		L-880-20	BINA, Mymensingh
32		L-880-26	BINA, Mymensingh
33		L-880-27	BINA, Mymensingh
34		L-880-34	BINA, Mymensingh
35		L-880-36	BINA, Mymensingh
36		L-880-38	BINA, Mymensingh
37		L-880-43	BINA, Mymensingh

Table 2. List of the wheat genotype selected by Francis and Kannenberg's (1978) method.

Dehghani *et al*. (2006) had explored the effect of genotype and genotype environment interaction on the grain yield of 19 barley genotypes via Francis and Kannenberg's (1978) method. Usually a large number of genotypes were tested across a number of sites and years and it is often difficult to determine the pattern of genotypic response across environments without the help of graphical presentation of the data. Considering mean performance and standard deviation (SD) of all yield contributing characters, especially more emphasize given on 100 grain weight and yield per plant, one line from L-885, 9 lines from L-61, 9 lines from L-879 and 18 lines from L-880 were selected for growing in 2nd year experiment (Table 1, Table 2).

Conclusion

The genetic variability analysis of wheat mutants of this study, mostly focusing on the 100-grain weight and yield per plant, suggests 37 mutants as superior genotypes compared to 'Prodip' for non-saline soil. The results obtained from this study leads us to further evaluation to understand, whether the environmental factors have any influence on these traits of these selected mutants. Therefore, estimation of heritability, genetic advance and selection index of these selected mutants is our next research agenda. These 37 selected lines, from the present study, can be used for our further screening process in salt affected areas for selecting the best salt tolerant genotypes which can produce remarkable amount of yield both in saline and non-saline land areas of Bangladesh.

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