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PERFORMANCE OF WHEAT GENOTYPES UNDER OPTIMUM AND LATE SOWING CONDITION

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ABSTRACT

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A field experiment was conducted in research farm of Wheat Research Centre, Dinajpur (25°38´ N, 88°41´ E and 38.20 m above sea level), Bangladesh, during wheat season of 2003-04 with 10 wheat genotypes (Gen/3/Gov, PB 81/PVN, Fang 60, Kanchan, Sari 82, HI 977, HAR 424, PF 70354, Opata and Fyn/Pvn) sown on optimum (November 17) and late (December 21) condition in a randomized complete block design with three replications to evaluate the performance of these genotypes under optimum and late sown condition and to find out the suitable time of sowing for a specific genotypes. Under optimum sown condition, differences among the genotypes were found to be significant in respect of grain yield, biomass at anthesis, ground cover at 4-5 leaf stage, days to anthesis, maturity and flag leaf emergence, plant height, grain filling duration and 1000-grain weight, and insignificant for biomass at final harvest, ground cover at anthesis, chlorophyll content of the flag leaf and differences in temperature (DT) between canopy and ambient. While for the late sown condition, grain yield, biomass at anthesis, ground cover at 4-5 leaf and DT were the only characters affected non-significantly due to variation among the treatments. For almost all the traits, reduction was caused due to late sowing with a maximum and pronounced effect noticed for grain yield (26.30%). Genotype 'Gen/3/Gov' seemed to be the best entry for late planting with reasonably high yield, moderate grain size and growth period. Correlation studies revealed that under timely-sown condition, biomass at final harvest and chlorophyll content (SPAD) were strongly and positively correlated with grain yield. Under late-sown condition, grain yield was positively and significantly correlated with biomass, ground cover at anthesis, days to anthesis, flag leaf emergence and maturity as well as SPAD and DT.

Keywords: *Wheat, genotypes, sowing time*

INTRODUCTION

The topography, climatic condition and cropping pattern of Bangladesh are such that seeding of wheat starts at the first week of November and continues up to late December due to wheat is usually grown after transplanted aman rice, since transplanted aman rice is not usually harvested until December (Ahmed *et al.*, 1976; Hossain and Alam, 1986). Sowing time is very important for obtaining higher yield of wheat because of short duration of growing season (winter) in Bangladesh. The optimum time of sowing of wheat cultivars between mid November and first week of December (Hossain and Alam, 1986) and over 1 percent grain yield loss per day occurs for delay after the first day of December (Ahmed, 1986). Saunders (1988) also reported a yield reduction of 1.2% ha^{-1} day^{-1} for delayed wheat sowing after December 1 compared to optimum time (November 15 to 1st week of December) for potential yield. According to Wardlaw *et al.* (1980) and Sofield *et al.* (1977), grain weight of wheat is reduced by high temperatures as mediated by a reduction in both duration and rate of its grain filling period. Sometimes, in addition to reduce grain weight, grain number may also be reduced due to high temperature (Warrington *et al.*, 1977). Optimum temperature for grain development lies within the temperature range of 10-15°C to 13-18°C with in the increase in temperature from 10-21°C to 25-30°C and duration on grain growth is reduced by 38%, as a result, grain size reduced significantly (Chowdhury and Wardlaw, 1978) and maturity attained earlier specially in late sown wheat. This is primarily due to rising of temperature in late February coinciding with heading which adversely influences grain filling. The adverse effect of temperature could be minimized by adjusting sowing time to an optimum date to ensure high grain yield.

Therefore, the study was undertaken to see the performance of some wheat genotypes particularly under late sowing condition and find out the losses or reduction in yield and different yield attributes due to delayed wheat plantation. Attempts were also made to identify genotypes with lower rate of decline in yield and different physiological parameters and therefore more capable germplasm tolerate to late heat without substantial loss in grain yield.

MATERIALS AND METHODS

The study was carried out during 2003-04 wheat season in the research field of Wheat Research Centre (WRC), Bangladesh Agricultural Research Institute (BARI) Nashipur, Dinajpur, Bangladesh. The Agro Ecological Zone (AEZ) of the area is Old Himalayan Piedmont Plain (AEZ-1). The geographical position of the area is between 25°38´ N, 88°41´ E and 38.20 m above sea level. The soil is sandy-loam and reaction is strongly acidic (pH ranges from 4.5 to 5.5). The organic matter content of the soil is 1.0% and fertility is poor (Bodruzzaman, *et al*., 2005). Treatments were 10 wheat genotypes (Gen/3/Gov, Pb 81/Pvn, Fang 60, Kanchan, Sari 82, Hi 977, Har 424, Pf 70354, Opata and Fyn/Pvn) sown on optimum (November 17) and late (December 21) condition in randomized complete block design

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with three replications. For both optimum and late-sown conditions, management and inputs were same except the seeding date. Each unit plot size was 8 m^2 with 8 rows of 5 m length of each. Seeds were sown continuously in 20 cm apart rows at a seed rate of 120 kg ha^{-1}. Recommended fertilizer doses 100-27-40-20-1 kg ha^{-1} of N-P-K-S-B respectively was applied. All fertilizers were applied during final land preparation except one-third of nitrogen was top dressed after 1st irrigation. Irrigations were applied at crown root initiation, booting and grain filling stages. Intercultural operations were done properly as per WRC recommendation and when necessary.
Data on grain yield (kg ha^{-1}), 1000-grain weight (g), biomass (kg ha^{-1}), ground cover (%), days to anthesis, maturity, grain filling duration and flag leaf emergence, plant height at harvest (cm), difference in temperature between canopy and ambient (DT °C) and chlorophyll content (SPAD) were collected as per following rules. Grain yield in kg ha^{-1} was calculated following harvest of an area of 3.9 m^2, and then it was converted into kg ha^{-1} at 12% moisture. Thousand grain weight (g) was also calculated at 12% moisture. Data on plant biomass (kg) were recorded at 50% anthesis from an area of 0.6 m^2 and at final harvest from an area of 4 m^2 (4 m long 5 rows). In both cases, collected samples were sun-dried for a few days before weighting, and then it was converted into kg ha^{-1}. Ground coverage by foliage in a plot was eye-estimated and expressed in per cent at 4-5 leaf stage and at anthesis. Days to anthesis, maturity, grain filling duration and flag leaf emergence were recorded at the specific stage of plant. Plant height was taken in cm before harvest from five places in a plot and averaged for each genotype. Data of DT (differences of temperature between canopy and ambient) was measured two times before anthesis. The canopy temperature was recorded with the instrument called IR-GUN by keeping it in hand 0.5 m above the plants at an angle of 45º to the horizontal. This instrument showed calculated difference between canopy and ambient temperatures which was ultimately DT value. The canopy temperature was always a few degrees lower than the ambient temperature and therefore, DT value was always with negative sign. Mean of two DT values taken twice for a genotype in each replication for analysis. Data on chlorophyll content (SPAD) was collected five times at 7, 14, 21, 28 and 35 days after anthesis. At each time, randomly 20 flag leaves were chosen wherefrom 20 readings with averaged for each replication of a genotype. SPAD meter was used holding it at the mid point of leaf blade of a flag leaf.

The data were complied and subjected to analyze statistically with the help of computer package MSTATC. Analysis of variance was done through the formulas of Gomez and Gomez, (1984) and mean separation test was done according to Duncan's Multiple Range Test (Duncan, 1955). Correlation coefficient and reduction percentages were also determined between grain yield and yield attributes compared with optimum and late sown condition.

RESULTS AND DISCUSSION

As shown in table 1 for optimum sown wheat, significant differences were found for grain yield, biomass at anthesis, ground cover at 4-5 leaf stage, days to anthesis and maturity as well as flag leaf emergence, 1000-grain weight, grain filling duration and plant height. For the late-sown condition, the genotypes showed significant differences for all parameters except grain yield, biomass at anthesis, ground cover at 4-5 leaf stage and DT value. On the basis of grain yield, the genotypes were arranged in a descending order in both optimum and late-sown condition. Late sowing resulted in the highest reduction (26.30%) for grain yield, which was closely followed by biomass (22.60%) at final harvest. Extent of reduction for other parameters varied from 0-20%. Only ground cover percent (at 4-5 leaf stage), which was an eye estimation, went up for the late-sown crop. According to Moniruzzaman (1986), late wheat seeding (beyond December 5) reduces grain yield because of high temperature in late February coinciding with heading and adversely affecting the grain filling. Fisher and Maurer (1976) stated that development of wheat is hastened by heat. They also opined that grain yield reduction due to delayed sowing resulted in a decrease in the duration of grain filling stage. In the present experiment, reduction due to late sowing in the number of days to anthesis, maturities as well as grain filling period were 8.90, 12.80 and 20.10%, respectively. This clearly demonstrated a greater effect of heat on the duration of grain filling period by reducing yields than either the anthesis period or total number of days to maturation. It is notable to mention here that during the season the daily average temperature in the months of December 2003, January 2004, February and March 2004 were 19.20, 18.40, 22.70 and 25.10 ºC, respectively. Chowdhury and Wardlaw (1978) reported that optimum temperature for grain development lies within the temperature range of 10-15°C to 13-18°C. In contrast, increase in temperature from 10-21°C to 25-30°C resulted in reduction of grain growth duration by 38%, as a result, grain size reduced significantly and maturity attained earlier specially in late sown wheat. High temperature during the latter part of the season forced the crop to complete its life cycle quicker, as opined by Fisher and Maurer (1976). In this context, it may be referred that Randall and Moss (1990) obtained a negative correlation between grain yield and maximum mean temperature. Musich and Dusek (1980) showed that increased temperatures resulted in an earlier termination of grain filling.

It was interesting to note that the differences in temperature between canopy and the ambient (DT) were markedly lower (14.40%) for the late-sown wheat in the present experiment (Annexure 1 Table 1). This indicated that probably respiration loss due to higher temperature was greater for the late-sown crop which explains the reduced grain production ability contributing to a lower yield. The other physiological attribute, chlorophyll content of the flag leaf

(SPAD), was lower (9.80%) in magnitude in the case of late-sown crop. It was, therefore, clear that a wheat crop, when sown late instead of at optimum time, is most likely to give lesser values for most of the yield and other physiological parameters of wheat; the ones with the greatest reduction being found in the present investigation were grain yield, biomass at final harvest and grain filling duration.

For the trial sown at optimum time (Annexure 1 Table 1), correlation coefficients with grain yield were significant for biomass at final harvest and SPAD only. While for the late-sown condition, significant correlation coefficients with grain yield were obtained for biomass at both final harvest and anthesis, ground cover at anthesis, days to anthesis, maturity and flag leaf emergence, and SPAD as well as DT. Of these physiological parameters, chlorophyll content seemed to be most important one as a potential criterion for bringing under consideration. The positive correlation between grain yield and DT value was significant under only late-sown condition. The associations between grain yield with days to anthesis and maturity were positive as well as significant for the late-sown condition, in contrast to negative and non-significant correlations for the timely sown condition. Thus, grain yield was found to increase with longer duration in late-sown situation, while the reverse seemed true for timely sowing wheat. Biomass at final harvest seemed to be the most important character because it showed the highest degree of correlation with grain yield under both situations. Biomass at anthesis was also an important character, particularly for late-sown crop. Ground cover by foliage was an important characteristic too, particularly at anthesis stage under late sowing; indicating that having more crop canopy is a determining factor for high yield. Correlation studies conducted at CIMMYT, Mexico with 16 wheat genotypes, revealed that biomass at harvest and ground cover at anthesis stages were the best correlated parameters with grain yield (Anonymous, 1992). They also recommended that there was a tendency for lateness conferring high yields. They obtained a significant positive correlation (r = 0.4) between grain yield and chlorophyll content of the flag leaf. Leaf chlorophyll contents have been indicated as a parameter for heat tolerance in hot environment (Acevedo *et al.,* 1991). Late planting (December 22) reduced grain yield on an average of 1.2 t ha^{-1} or 19% in upper Egypt, as compared with the optimum (November 25) sowing date (Abd Elshafi and Ageeb, 1992). From their research they also reported that late sowing reduced 1000-grain weight and heading days significantly. In the present investigation, the genotype “Gen/3/Gov” seemed to be the best line under late planting, with reasonably high yield, moderate grain size and growth period, followed by “Fang 60” with more or less similar characteristics. Genotype “Fyn/Pvn” and Kanchan were also similar to the above genotypes. Opata and Seri had the lowest size grain, although they were in the top position regarding grain yield and biomass production. Duration of grain filling was significantly shorter for these two genotypes. Under timely-sown condition, “Opata and Seri 82” took the least time for grain filling. Seeds of “Pf 70354” were also small like those of “Opata and Seri 82”.

Results of the present experiment were found very much similar to the findings of different authors mentioned above. However, under Bangladesh environment, biomass, ground coverage, crop duration as well as the two physiological parameters seemed important for considering them as selection criteria under late planting situation. The losses in grain yield and other attributes due to late plantation of wheat possibly can not be avoided but minimize by judicial use of the parameters as well as varieties.

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APPENDIX 1

Table 1. Yield and others physiological attributes of wheat genotypes under optimum and late-sown condition

Genotypes	Grain yield (kg ha^{-1})		1000-grain weight (g)		Biomass at harvest (kg ha^{-1})		Biomass at anthesis (kg ha^{-1})		Ground cover at 4-5 leaf stage (%)		Ground cover at anthesis stage (%)		Days to anthesis	
	Optimum	late sown	Optimum	late sown	Optimum	late sown	Optimum	late sown	Optimum	late sown	Optimum	late sown	Optimum	late sown
Gen/3/Gov	3371 a	2625	34.70 b	21.20 f	10589	8017 a	5526 bcd	5112	18 ab	22	88	95 a	58 g	68 b
Pb 81/Pvn	3281 ab	2443	36.50 b	20.70 f	9179	8299 a	5754 bc	5303	25 a	22	90	93 ab	57 g	72 a
Fang 60	3169 abc	2395	41.30 a	30.20 d	8350	7778 ab	3871 d	5672	20 ab	22	86	88 a-d	65 de	57 f
Kanchan	3148 abc	2211	36.20 b	25.20 e	10470	7444abc	4738 cd	5867	23 a	27	91	89 abc	65 de	61 e
Seri 82	3023 abc	2186	27.70 c	38.20 a	10572	7068a-d	7062 ab	5494	15 ab	23	94	89 abc	86 a	61 e
Hi 977	2956 abc	2182	44.00 a	32.8 bcd	7880	7624 ab	4618 cd	4724	22 ab	25	84	95 a	63 ef	65 c
Har 424	2688 abc	2178	34.20 b	36.70 ab	8769	8282abc	5543 bcd	4755	23 a	22	87	88 bcd	67 d	61e
Pf 70354	2588 bc	1800	26.00 c	30.30 d	8863	5966 cd	3930 d	4599	25 a	22	87	86 cd	61 f	54 g
Opata	2567 c	1786	24.80 c	31.8 cd	9153	6658bcd	7128 ab	5114	18 ab	22	91	84 cd	82 b	63 d
Fyn/Pvn	2482 c	1752	34.20 b	34.8 abc	9723	6248 cd	8369 a	4513	23 a	22	91	82 d	78 c	60 e
F-test	**	ns	**	**	ns	**	**	ns	**	ns	ns	**	**	**
CV (%)	12.50	16.10	5.90	7.50	14.30	8.90	15.50	13.90	17.60	13.70	4.00	4.10	2.50	1.5
% Reduction	26.30		10.90		22.60		9.50		6.60		0.00		8.90	

Table 1. Continued

Genotypes	Days to maturity		Duration of grain filling (days)		Days to flag leaf emergence		Plant height at maturity (cm)		Difference of canopy and ambient temperature (DT)		Chlorophyll content on flag leaf (SPAD)	
	Optimum	late sown	Optimum	late sown	Optimum	late sown	Optimum	late sown	Optimum	late sown	Optimum	late sown
Gen/3/Gov	107 ab	95 a	49 a	27 c	49 f	62 a	98 cd	82 de	-5.00	-4.70	40.40	40.40 a
Pb 81/Pvn	101 c	95 a	44 b	23 d	45 g	59 ab	95 d	78 c	-6.20	-5.50	40.50	41.20 a
Fang 60	104 bc	91 b	39 c	34 a	55 de	52 cd	96 d	90 b	-5.80	-5.50	39.00	35.90 b
Kanchan	108 ab	91 b	43 b	30 b	55 de	52 cd	102 bc	89 bc	-5.90	-4.90	41.20	36.30 b
Seri 82	112 a	91 b	36 de	30 b	64 b	51 de	95 d	85 cd	-6.60	-4.50	39.50	34.90 b
Hi 977	101 c	96 a	39 cd	31 b	55 d	56 bc	96 d	90 b	-5.40	-4.90	39.80	35.80 b
Har 424	103 c	94 a	36 de	33 a	52 e	51 de	108 ab	88 bc	-5.40	-5.30	41.20	34.70 b
Pf 70354	102 c	89 b	41 bc	35 a	53 de	46 e	98 cd	89 bc	-5.20	-4.00	40.30	35.10 b
Opata	111 a	92 b	29 f	29 b	69 a	54 cd	92 e	95 a	-5.60	-4.60	38.90	34.40 b
Fyn/Pvn	111 a	89 b	33 e	29 b	58 c	50 de	110 a	81 de	-6.30	-4.90	40.80	34.00 b
F-test	*	*	**	*	*	**	**	**	ns	ns	ns	*
CV (%)	2.30	1.30	5.20	4.40	3.50	5.10	3.50	2.7	12.80	17.30	5.90	5.20
% Reduction	12.80		20.10		4.10		12.30		14.40		9.80	

ns = Non significant,* & ** = Significant at 5% and 1% level.

Within a character in column, means followed by different small letter(s) significantly different at 1% and 5% level by DMRT and same small letter(s) or without letter are not significantly different at 1% level by DMRT.

N.B. Last rows of above two tables indicate % reduction in different parameters due to late sowing

APPENDIX 1

Table 2. Correlation coefficients between grain yield and others physiological attributes of wheat genotypes under optimum and late-sown condition

Parameter	1000-grain weight (g)		Biomass at harvest (kg ha^{-1})		Biomass at anthesis (kg ha^{-1})		Ground cover at 4-5 leaf stage (%)		Ground cover at anthesis stage (%)		Days to anthesis	
	Optimum	late sown	Optimum	late sown	Optimum	late sown	Optimum	late sown	Optimum	late sown	Optimum	late sown
Grain yield	0.31ns P = 0.09	-0.24ns P = 0.19	0.49** P = 0.00	0.91** P = 0.00	0.08ns P = 0.68	0.45** P = 0.01	-0.27ns P = 0.14	-0.04ns P = 0.81	0.35ns P = 0.06	0.53** P = 0.00	-0.28ns P = 0.13	0.39* P = 0.03

Parameter	Days to maturity		Duration of grain filling (days)		Days to flag leaf emergence		Plant height at maturity (cm)		Difference of canopy and ambient temperature (DT)		Chlorophyll content on flag leaf (SPAD)	
	Optimum	late sown	Optimum	late sown	Optimum	late sown	Optimum	late sown	Optimum	late sown	Optimum	late sown
Grain yield	-0.14ns P = 0.46	0.45** P = 0.01	0.33ns P = 0.07	-0.23ns P = 0.22	-0.33 P = 0.07	0.43** P = 0.01	-0.15ns P = 0.44	-0.17ns P = 0.35	0.32ns P = 0.08	0.41* P = 0.02	0.43** P = 0.01	0.56** P = 0.00

N = 30; ‘P’ is the level of significance

ns = Non significant,* & ** = Significant at 5% and 1% level