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EVALUATION OF WHEAT (*Triticum aestivum* L.) FOR AGRO-MORPHOLOGICAL AND YIELD RELATED TRAITS UNDER NORMAL AND LATE SOWING CONDITIONS IN CHITWAN, NEPAL

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ABSTRACT

A field investigation was carried out during wheat season of 2019-2020 under normal and late sowing conditions at the research farm of the Agriculture and Forestry University, Rampur, Chitwan, Nepal to evaluate the agro-morphological and yield related traits of spring wheat. A set of thirty elite spring wheat genotypes were evaluated. The experiment was laid out in an Alpha lattice design with three replications. Each replication consisted of 30 treatments of wheat with altogether 90 treatments in three replications. Wheat was sown in two sowing dates that normal sowing date (22nd November, 2019) and late sowing date (23rd December, 2019). Significant differences were observed between two sowing dates for heading and maturity days, plant height, grains spike^{-1}, thousand kernel weight, grain yield, biomass yield, harvest index and SPAD reading. Generally, almost all the traits manifested superiorly on normal sowing date. The mean plant height was 92.71 cm for normal and 88.3 cm for late sown condition. The mean grain yield was 2.94 t ha^{-1} in normal and 1.91 t ha^{-1} in late sown condition. Gautam had maximum grain yield that 3.84 t ha^{-1} followed by Bhrikuti, Vijaya and Aditya under normal sown condition. Bhrikuti had maximum grain yield (2.34 t ha^{-1}) followed by Vijaya, Gautam and NL 297 under late sowing conditions. Significant positive correlation was found between grain yield and investigated attributes. Days to maturity, plant height, spikes per m^2, grains per spike, and thousand kernel weight showed significant positive correlations with grain yield.

Keywords: Alpha lattice design, Grain yield, Season, Wheat

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important and strategic cereal crop for the majority of the world's populations and has been described as the 'King of cereals' because of its large area cultivation, high production potential, good nutritional profile, and the prominent position in international food grain trade.

It is the third largest crop of Nepal after rice (*Oryza sativa* L.) and maize (*Zea mays* L.) both in area and production. Majority of wheat i.e., 80% is grown in rice-wheat cropping pattern. At present, wheat occupies 20.4% of total cereal area and contributes 18.76% of the total cereal production in the country. Presently, area under cultivation, production and productivity of wheat is 703,992 hectares, 2 million metric tons and 2.85 t ha^{-1} respectively (MoALD, 2018/19).

Generally sowing of wheat in Nepal starts from November and ends in late December depending on the land availability due to preceding crops, especially under the 'Rice-Wheat Cropping System' and soil moisture status. The optimum seeding time for the major wheat production areas is from mid-November to mid-December. Under late sown conditions, wheat crops are exposed to heat stress during the critical growth stages, i.e., flowering and grain filling and cause production losses. Yields of late-sown wheat are reduced by as much as 40% in Nepal (Sharma and Duveiller, 2004).

Temperature has potential impacts on the phasic development and grain yield of crops. Wheat, being a winter cereal, requires particular environmental conditions for better emergence, growth and flowering (Dabre et al., 1993) and is more vulnerable if exposed to high temperatures during reproductive stages (Kalra et al., 2008). Temperatures above 30ºC, during floret formation, may cause complete sterility (Saini and Aspinal, 1983). With delayed planting, the development of plant organs and transfer mechanism from source to sink were remarkably affected, which was reflected by overall shortening of plant height, reduction in number of internodes, days to heading, days to maturity and grain filling period and ultimately in the reduction of yield and yield components (Sial et al., 2005; Singh et al., 2011). Therefore, when temperatures are elevated between anthesis to grain maturity, grain yield is reduced because of the reduced grain filling time to capture resources.

In order to minimize the production losses due to high temperature, future wheat varieties must have enhanced adaptability to high temperature. Thus, this study is for assessing the genetic variability of heat adaptive traits along with important agro-morphological and yield related traits in wheat.

MATERIALS AND METHODS

Thirty bread wheat (twenty genotypes and ten released varieties) varieties were used in this study. Twenty genotypes used were NL 1164, RR 21, BL 4316, NL 1190, BL 4341, WK 2123, NL 1193, NL 971, NL 1178, BL 4350, WK 1183, BL 3872, NL 297, WK 2415, BL 4406, BL 4463, NL 1055, WK 1204, NL 1006 and BL 4347. Ten released varieties used were Vijaya, Swargadwari, Gautam, Ban Ganga, Danphe, Tilottama, Gaura, Dhaulagiri, Aditya and Bhrikuti. They were obtained from the National Wheat Program, Bhairahawa, Nepal. The field experiment was carried out at the research farm of Agriculture and Forestry University, Faculty of Agriculture, Rampur, Chitwan, Nepal, from November 2019 to April 2020.

The experiment was conducted in alpha lattice design. Altogether, there were 30 treatments, each replicated 3 times. Each replication consisted of 6 blocks and with 5 plots in each block. Each plot was 2m in length and 1m in width. The net plot area of each replication is $60m^2$ while the total net plot area is $180m^2$. The total gross area of the experiment field was $310m^2$.

The rate of seed application was 120 kg per hectare. 24 grams of seed was used for each plot. The normal season planting was done in 22nd November 2019 and late planting was done in 23rd December 2019. All agronomic practices were kept uniform for comparative study in both sowing dates. The chemical fertilizers were applied at the rate of 120:60:60 kg NPK per hectare. Well decomposed farm yard manure was applied at the rate of 5 ton per hectare. Half dose of nitrogenous fertilizer, urea, and full dose of DAP and Potash fertilizers were applied at the time of sowing. The remaining half dose of nitrogen was applied during the first irrigation which was done at the crown root initiation (CRI) stage. Irrigation was done at two important stages, crown root initiation (CRI) stage and flowering stage. Manual weeding and hoeing were done twice during tillering stage and booting stage. Harvesting, threshing, drying and storing seeds of each plot were done separately. Data was recorded for following characters.

The number of days to heading and maturity were counted from the date of sowing to when 75% of the plants in a plot had their spikes emerged out completely from the flag leaf and been visible, and when glumes had lost chlorophyll and turned yellow in all the spikes, respectively. For measuring average plant height and spike length, ten plants were selected randomly from each plot. The effective number of spikes in each plot were counted at the time of maturity and converted in square meters. Chlorophyll content was measured at three different stages after heading from the flag leaf of randomly selected five plants and Area Under SPAD Retreat Curve (AUSRC) value was calculated using Self-calibrating Minolta Meter (SPAD-502, Minolta Inc.). To count the number of grains per spike, ten spikes of ten randomly selected plants from each plot were hand threshed. After harvesting and sun drying, 500 random seeds from each plot were counted and weighed. The value was then converted to thousand kernel weights. For biomass and grain yield, plants from the whole plot were harvested separately for each treatment and sun dried. Whole biomass from each pot was weighed in grams and the weight was converted into tons per hectare. The weight of grains per plot was recorded in grams and grain yield was calculated in tons per hectare. Moisture content of the grain for each plot was measured using a moisture meter (HTM 42) and hence, the actual grain yield was calculated using the formula:

$$GY = \frac{100 - MC}{100 - SM} \times Plot\ yield$$

where, GY= Grain yield (tons/ha)

MC= Moisture content of grain

SM= Standard moisture content of wheat grain (12%)

Harvest index was calculated as the proportion of grain yield to the total biomass yield.

Statistical analysis

Analysis of variance and mean comparison between genotypes based on LSD was done by using RStudio software package. Pearson's correlation analysis was performed using SPSS v.16.

RESULTS AND DISCUSSION

Analysis of variance showed significant genotypic effects under both normal (22nd November) and late (23rd December) sown conditions for all characters i.e. plant height, spike length, spike per square meter, grain per spike, thousand kernel weight, heading and maturity days, biomass yield, harvest index, grain yield and SPAD reading. The interaction effect of sowing date and genotypes was found non-significant for plant height, spike length, number of spikes per square meter, number of grains per spike whereas interaction effect of sowing date and genotypes was found significant for thousand kernel weight, grain yield, biomass yield, harvest index, heading and maturity days and SPAD reading (Table 1 and Table 2).

Table 1. Interaction effect of sowing date and genotypes (SD × Gen.) on plant height (PH), spike per meter square (Spikes/m^2), spike length (SL), days to heading (DH), days to maturity (DM) and AUSRC of thirty wheat genotypes under normal and late sown conditions at Rampur, Chitwan (2019-2020)

	PH	Spikes/m^2	SL	DH	DM	AUSCR
Grand mean	90.5	222.5	8.7	69.3	114.1	551.2
F-Statistic	1.18^{ns}	0.78^{ns}	0.87^{ns}	2.54**	2.19**	1.68*
CV(b) %	4.93	21.2	5.42	1.12	1.53	3.35
$LSD_{0.05}$	6.52^{ns}	68.28^{ns}	1.18^{ns}	1.23	1.98	32.08

*: significant in 5% level of significance; **: significant in 1% level of significance; ^{ns}: non-significant

Table 2. Interaction effect of sowing date and genotypes (SD × Gen.) on number of grains per spike (NGPS), thousand kernel weight (TKW), biomass yield (BY), harvest index (HI) and grain yield (GY) of thirty wheat genotypes under normal and late sown conditions at Rampur, Chitwan (2019-2020)

	NGPS	TKW	BY	HI	GY
Grand mean	44.9	38.8	7.1	0.34	2.4
F-Statistic	0.54^{ns}	4.85**	1.81**	5.84**	7.23**
CV(b) %	13.44	7.35	14.83	8.24	13.23
$LSD_{0.05}$	9.21^{ns}	3.76	1.37	0.06	0.64

*: significant in 5% level of significance; **: significant in 1% level of significance; ^{ns}: non-significant

Vijaya and Gautam were used as check varieties in this experiment because they are commonly used wheat varieties due to their good yield and environmental suitability in the present research locality. The mean maturity days was 123 days for normal and 106 days for late sown wheat. The mean plant height was 92.71 cm in normal sowing and 88.3 cm in late sowing. Plant height was measured maximum in Gaura (106 cm) and minimum in NL 1190 (80.46 cm) in normal sowing while it was measured maximum in RR21 (100.14 cm) and minimum in NL 1190 (76.27 cm) in late sowing. The mean spike length was 9.15 cm in normal sowing and 8.33 cm in late sown condition. The average number of spikes per m^2 was 233 in normal and 213 in late sown conditions respectively. The mean number of grains per spike was found 47 and 44 in normal and late sown condition. The mean thousand kernel weight was found 41.81 in normal and 35.86 in late sown condition. There was significant reduction in grains per spike and thousand kernel weight under late sown condition.

Harvest index, grain yield per hectare and biomass yield were also reduced significantly in late season planting. The mean grain yield was 2.94 t ha^{-1} in normal sowing and 1.91 t ha^{-1} in late sown condition. Gautam (3.84 t ha^{-1}) followed by Bhrikuti (3.6 t ha^{-1}), Vijaya (3.43 t ha^{-1}), Aditya (2.31 t ha^{-1}) and NL 297 (3.16 tha^{-1}) had the highest grain yield in normal sown condition. In late sown condition, Bhrikuti (2.34 t ha^{-1}) followed by Vijaya, NL 297 and Gautam gave the highest yield. The mean biomass yield was 8.29 t ha^{-1} in normal sowing and 6.02 t ha^{-1} in late sowing.

The expression of mean performance for all traits was significantly higher under normal than late sown condition (Table 3). The highest percentage reduction in late sowing compared to normal sown condition was found for grain yield (35.03%), biomass yield (27.38%) and SPAD reading (15.25%).

Table 3. Range, mean, % decrease, LSD and coefficient of variation of thirty wheat for different traits under normal (22nd Nov) and late (23rd Dec) sowing at Rampur, Chitwan, Nepal.

	Sowing date	Minimum	Maximum	Mean	% decrease	$LSD_{0.05}$	CV%
PH (cm)	Normal	80.46 (NL 1190)	106 (Gaura)	92.71	4.76	4.03**	2.65
	Late	76.27 (NL 1190)	100.14 (RR 21)	88.3		3.74**	2.58
SL (cm)	Normal	7.23 (NL 1055)	10.79 (BL 4463)	9.15	8.96	0.96**	6.43
	Late	6.57 (NL 1055)	10.4 (BL 4463)	8.33		0.79**	5.79
Spk/m^2	Normal	208.67 (BL 4406)	250 (WK 2415)	232.25	8.37	27.7^{ns}	7.29
	Late	190 (BL 4406)	233 (WK 2415)	212.8		23.93**	6.87
DH	Normal	64.33 (NL 297)	82.33 (Danphe)	71.57	6.23	3.27**	2.79
	Late	59.67 (NL 297)	75 (Danphe)	67.11		3.43**	3.12
DM	Normal	108 (Vijaya)	124 (Danphe)	122.64	13.86	4.25**	2.21
	Late	91 (Vijaya)	117 (Danphe)	105.64		4.25**	2.45
NGPS	Normal	39.2 (Danphe)	52.73 (Bhrikuti)	46.6	7.31	4.71**	6.17
	Late	36.47 (Danphe)	49.07 (Bhrikuti)	43.19		4.19**	5.93
TKW (gm)	Normal	33.06 (BL 4347)	47.9 (Gautam)	41.81	14.23	1.9**	2.79
	Late	27.33 (BL 4347)	42.27 (Gautam)	35.86		2.05**	3.5
AUSRC	Normal	532.38 (BL 4406)	653.13 (WK 1183)	596.7	15.25	18.5**	1.89
	Late	453.21 (Vijaya)	547.83 (NL 1178)	505.7		21.14*	2.55
HI ($t\ ha^{-1}$)	Normal	0.27 (NL 1190)	0.45 (Gautam)	0.36	11.11	0.03**	6.43
	Late	0.25 (NL 1190)	0.38 (Aditya)	0.32		0.029**	5.59
BY ($t\ ha^{-1}$)	Normal	6.86 (WK 1183)	9.66 (Vijaya)	8.29	27.38	0.86**	6.37
	Late	4.03 (NL 1055)	7.38 (Gaura)	6.02		0.87**	8.92
Yield	Normal	2.22 (Danphe)	3.84 (Gautam)	2.94	35.03	0.26**	5.46
	Late	1.35 (Danphe)	2.34 (Bhrikuti)	1.91		0.19**	5.99

*, **Significant at 5% and 1% levels of significance, respectively and ^{ns}: non-significant.

Correlation analysis

Pearson's correlation analysis showed that there were significant correlations among the studied variables (Table 4). In most of the cases, correlation patterns were similar for normal and late sown crops. Plant height showed significant positive correlations with grain yield, spikes per m^2, biomass yield and thousand kernel weight under both sowing conditions. Spikes per m^2 had significant positive correlation with grain yield ($r = 0.240^{**}$ and 0.336^{**}) in normal and late sown conditions, respectively. Thousand kernel weight had significant positive correlations with grain yield ($r = 0.232^{**}$ and 0.197^{**}) and biomass yield ($r = 0.346^{**}$ and 0.298^{**}) in normal and late sown conditions, respectively. Grain yield had positive and significant correlations with days taken to maturity, test weight and number of spikes per meter row length (Kumar and Sharma, 2003). Subhani and Chowdhry (2000) reported positive and significant correlations between grain yield and plant height, tillers per plant, thousand grain weight, biomass per plant and harvest index under irrigated and drought conditions. Correlation analysis provides information about association of plant characters and therefore, leads to a directional model for yield prediction.

Table 4. Pearson's correlation coefficients among different traits under normal and late sowing conditions at Chitwan, Nepal

	Sowing date	PH	SL	DH	DM	NGPS	TKW	AUSRC	HI	BY	Yield
Spk/m^2	Normal	$.149^{**}$	.047	-.041	.025	.048	-.202	.042	.171	$.141^{**}$	$.240^{**}$
	Late	$.130^{*}$	$.219^{*}$	-.104	.090	$.198^{*}$	.114	.006	.117	$.228^{**}$	$.336^{**}$
PH	Normal	1	.073	.009	$.136^{*}$	$-.310^{*}$	$.250^{**}$	$.213^{*}$	.136	$.108^{**}$	$.157^{**}$
	Late	1	.039	.021	.117	$-.211^{*}$	$.307^{**}$	$.312^{**}$	$.259^{*}$	$.124^{**}$	$.161^{**}$
SL	Normal		1	-.055	$.230^{*}$	.027	.048	-.193	.019	$.380^{*}$	.185
	Late		1	$-.253^{*}$	$.313^{*}$ *	.184	-.037	-.049	.075	$.408^{*}$	.252
DH	Normal			1	$.364^{*}$	-.043	.033	$.312^{*}$	-.126	-.161	$-.621^{**}$
	Late			1	$.404^{*}$	-.140	.065	.171	-.153	$-.244^{*}$	$-.566^{**}$
DM	Normal				1	.033	-.159	$.955^{**}$	.245	0.09	$.221^{*}$
	Late				1	.032	.073	$.643^{**}$	.029	.198	$.456^{**}$
NGPS	Normal					1	$.359^{*}$	.008	.313	.081	$.290^{*}$
	Late					1	-.102	.052	.293	.185	$.387^{**}$
TKW	Normal						1	-.131	$.212^{*}$	$.346^{**}$	$.232^{**}$
	Late						1	-.024	.351	$.298^{**}$	$.197^{**}$
AUSCRC	Normal							1	.149	-.046	-.120
	Late							1	.049	-.077	-.141
HI	Normal								1	.246	$.629^{**}$
	Late								1	.230	$.512^{*}$
BY	Normal									1	$.408^{**}$
	Late									1	$.343^{**}$

CONCLUSION

It can be concluded from the results that almost all of the traits performed superiorly on a normal date of sowing. In normal conditions, checks: Gautam and Vijaya along with Bhrikuti, NL 297, Aditya performed best. However, Bhrikuti, NL 297, Aditya, BL 4463, NL 1164, NL 1193, Swargadwari including checks; Vijaya and Gautam showed better and stable performance under late sown conditions. Considering the genetic diversity for different agro-morphological characteristics and genotype × sowing date interactions, it becomes important to choose the right genotype for the specific sowing time. Similarly, the positive correlations observed between some traits and yield. Thus, these yield related traits are important for better crop performance and ultimately to higher grain yield.

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