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Research Article

Evaluation of Wheat Genotypes under Timely and Late Sowing Conditions

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Abstract

A field experiment was conducted at Institute of Agriculture and Animal Science (IAAS), Bhairahawa during winter season of 2019/2020 to find out the performance of wheat genotypes under timely sown (November 29, 2019) and late sown (December 25, 2019) conditions. The research was carried out in two environments (timely sown and late sown) following alpha lattice design with two replications. Each replication consists of five blocks with four plots in each block. The results revealed that all genotypes performance was decreased in late sowing environment. In late sown condition, there was significant difference among genotypes for all the traits under study and under timely sown condition, there was significant difference among genotype for all traits under study except weight of grains per spike and grain yield. The maximum yield was recorded in NL 1179 and Bhirkuti in timely and late sown conditions respectively. It was found that the mean grain yield in timely sown condition is 90.77 % higher than in late sown condition. The maximum grain yield was recorded in NL 1179 across combine environment.

Introduction

Wheat (*Triticum aestivum L.*) belongs to family Poaceae and is one of the major cereal crop contributing basic calories for 85 % of the world population (Chaves *et al.*, 2013). Wheat is the staple food in more than 40 countries of the world (Sharma *et al.*, 2019). In Nepal, wheat is grown in 754243 hectares of land and accounts for 20.13 % of total cereal production with productivity of 2.29 ton ha^{-1} (MoAD, 2014). There are various factors responsible for low production of wheat; sowing time and varietal selection are of primary importance. Wheat has its own definite abiotic and biotic requirement for its growth and development. Optimum sowing time helps plant to attain favorable environment. Timely sowing of wheat increases number of tiller, spikes, grains per spike and grain weight, which ultimately increases the grain yield (Qasim *et al.*, 2008). Delay sowing reduces the yield due to decrease in number

of tillers, number of grains per spike and weight of grain (Ansary *et al*., 1989). Singh and Uttam (1999) has estimated grain yield loss @ 39 kg ha^{-1} per day for each day delay in sowing from optimum sowing time. Plant under delay sowing experiences terminal heat stress. Heat stress affects the various physiological, biological and biochemical process in wheat (Asseng *et al*., 2015). High temperature cause decrease in grain filling duration, photosynthetic capacity and rate of assimilate translocation (Bala *et al*., 2014; Farooq *et al*., 2011; Raines, 2011). Many high yielding varieties that have been recommended in the past are now loosing their yield capacity due to changes in various edaphic and environmental conditions. Thus, continuous selection of high yielding varieties that can cope to changing environmental condition is necessary (Tahir *et al*., 2009). In late sowing, the wheat genotype should be short duration that can escape from high temperature at the grain filling stage (Phadnawis & Saini, 1992).

In order to feed the projected population of 9.1 billion by 2050, crop production and productivity should be increased significantly(P. B. Poudel & Poudel, 2020). Keeping this in mind, the present study was carried out to evaluate the wheat genotypes under timely and late sown condition.

Material and Methods

Experimental site

A field experiment entitled "Evaluation of Wheat Genotypes under Timely and Late sowing conditions" was conducted at Institute of Agriculture and Animal Science (IAAS), Rupandehi Nepal, geographically located at 27° 30' N latitude and 83° 27' E longitude at an altitude of 79 meter above sea level (Fig. 1). The experimental site falls under the humid subtropical climate.

Soil Properties

Soil samples were taken from the field after land preparation. This soil samples was air-dried, ground well and sieved through 2mm sieve. The soil characteristics were analyzed in soil laboratory of IAAS, Rupandehi. The soil analysis showed that the soil was clay loam having 0.47 kg ha^{-1} nitrogen, 185 kg ha^{-1} phosphorous, 122.5 kg ha^{-1} potash and 3.5% organic matter. The soil found acidic with pH 5.3.

Weather Condition

The maximum and minimum temperature and total rainfall during the crop growth period (November 2019 to April 2020) is presented in Fig. 2.

Experimental design and Planting material

Experimental design: Alpha lattice design

Number of replications: 2

Number of Blocks in each replication: 5

Number of plots per block: 4

Size of each plot: 10 m^2

Space between blocks in each replication: 1 m

Space between two replications: 1 m

Environment: Timely sown and Late sown

The planting materials (genotypes) were taken from National Wheat Research Program (NWRP), Bhairahawa. Among twenty genotypes, there were three Bhairahawa lines (BL), fifteen Nepal lines (NL) and two commercial varieties (Bhirkuti and Gautam).

Fig. 1: Location of Experimental site

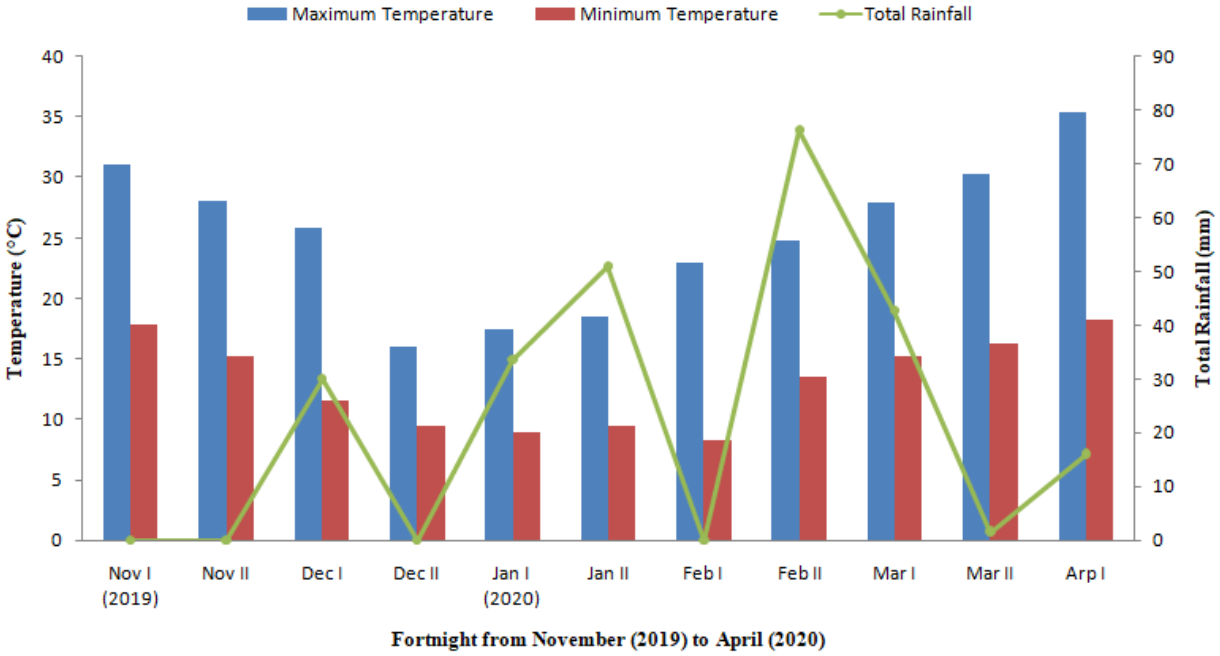

Fig. 2: Fortnightly average Maximum Temperature and Minimum Temperature and Total Rainfall from November (2019) to April (2020)

Agronomical Practices

Deep ploughing of land is done by tractor followed by harrowing with disc harrow. Leveling of land was done manually. The recommended dose of 100:50:25 kg NPK per hectare was applied. Full dose of nitrogen, phosphorous and potassium were applied during land preparation in late sown condition. While in timely sown condition, full dose of phosphorous, potassium and half dose of nitrogen were applied during land preparation and remaining half dose of nitrogen were applied after 1st irrigation. Continuous line sowing method was used and sowing was done maintaining spacing of 25 cm between rows. The sowing was done on November 29, 2019 and December 25, 2019 for timely sown and late sown conditions respectively. Irrigation was given at crown root initiation stage and heading stage and the remaining water requirement was fulfilled by natural rainfall. Weeding, harvesting and threshing were done manually.

Observation Recorded

Five plants per plot were randomly selected excluding border rows to obtain data for plant height (PH), spike length (SL), spikelets per spike (SPS), spike weight (SW), weight of grains per spike (WGPS), number of grains per spike (NGPS). The other observations taken from field are as follows:

Days to Booting (DTB): DTB of each plot was recorded as the duration in days from sowing to the time when more than 50% of the plants in a plot had swollen flag leaf sheath.

Days to Heading (DTH): DTH of each plot was recorded as the duration in days from sowing to the time when more than 50% of the plants in a plot had ear half emerged.

Days to Maturity (DTM): DTM of each plot was recorded as the duration in days from sowing to the time when more than 80% of the plants in a plot had spike and flag leaf turned golden yellow and the grain is not dented by thumbnail.

Grain Yield (GY): Crop was harvested from 1 m^2 area of each plot. The grain yield obtained from 1 m^2 is converted to kilogram per hectare (kg ha^{-1}).

Thousand Grain Weight (TGW): 1000 grains were counted at random from bulk produce of each plot and weight was recorded in gram on electronic balance.

Result and Discussion

Days to Booting

There was significant difference among genotypes for DTB under timely and late sown conditions and across combine environment (Table 1). Under timely sown condition, the maximum mean DTB was observed in NL 1350 and NL 1368 (84 days), while minimum mean DTB was recorded in BL 4919 (75 days) . Under late sown condition, the maximum mean DTB was observed in NL 1420 (74.5 days), while minimum mean DTB was recorded in BL 4919 and BL 4407 (66.5 days). Mean DTB in timely sown condition is 14.86% higher than in late sown condition. Reduction in DTB under late sown condition was also reported by Hossain *et al*. (2012) and Nahar *et al*. (2010).

Table 1: Differential response of genotypes for DTB, DTH and DTM undertimely and late sown conditions.

Genotype	Days to Booting			Days to Heading			Days to Maturity		
	Timely sown	Late sown	Overall	Timely sown	Late sown	Overall	Timely sown	Late sown	Overall
Bhirkuti	78	70	74.1978	83	73	78.1583	122.5	117	114.9361
BL 4407	76.5	66.5	72.0221	82.5	70	76.6256	121.5	106	114.1271
BL 4669	76.5	68.5	72.8924	82	71.5	77.0635	123.5	105	114.5316
BL 4919	75	66.5	71.3694	79.5	71	75.7498	119.5	105.5	113.1157
Gautam	79	70.5	74.8505	83	73.5	78.3773	124.5	108	116.1498
NL 1179	81.5	72	76.5911	86.5	75.5	80.7858	124.5	107	115.7452
NL 1346	78.5	68	73.5451	83.5	71.5	77.7204	123.5	105	114.5316
NL 1350	84	71	77.2438	88	74	80.7858	124	106	115.1384
NL 1368	84	72	77.6790	88.5	75	81.4427	126	107	116.3520
NL 1369	80	68	74.1978	84	71.5	77.9394	124	108.5	116.1498
NL 1376	81.5	71.5	76.3735	85	75	79.9100	124.5	108	116.1498
NL 1381	83	70.5	76.5911	85.5	73.5	79.4721	123	106	114.7339
NL 1384	82	71	76.3735	85.5	74	79.6910	124.5	108	116.1498
NL 1386	82.5	71	76.5911	85.5	75	80.1289	125.5	108.5	116.7566
NL 1387	82	70	75.9384	86	73.5	79.6910	124.5	108	116.1498
NL 1404	81.5	71.5	76.3735	85	74.5	79.6910	124	107.5	115.7452
NL 1412	82	70	75.9384	85	73	79.0341	125.5	107.5	116.3520
NL 1413	82	71.5	76.5911	85.5	75	80.1289	124.5	108.5	116.3520
NL 1417	82.5	71.5	76.8087	86	74.5	80.1289	126.5	109	117.3634
NL 1420	83	74.5	78.3317	88.5	78.5	82.9754	126.5	110.5	117.9702
Mean	80.75	70.3	75.525	84.9	73.65	79.275	124.125	107.325	115.725
CV (%)	1.1748	1.1468	1.0782	1.5129	1.0946	1.2311	0.7955	0.76551	0.7722
$LSD_{0.05}$	1.9789	1.6817	1.5614	2.6794	1.6817	1.4098	2.0597	1.71377	1.1745
F-test	***	***	***	***	***	***	*	**	***
	Mean DTB in Timely sown condition is 14.86% higher than in Late sown condition			Mean DTH in Timely sown condition is 15.27% higher than in Late sown condition			Mean DTM in Timely sown condition is 15.65% higher than in Late sown condition		

CV: Coefficient of Variation, LSD: Least Significance Differences, * significant at 0.05 level of significance, ** significant at 0.01 level of significance, *** significant at 0.001 level of significance

Days to Heading

There was significant difference among genotypes for DTH under timely and late sown conditions and across combine environment (Table 1). Under timely sown condition, the maximum mean DTH was observed in NL 1420 (88.5 days), while minimum mean DTH was recorded in BL 4919 (79.5 days) . Under late sown condition, the maximum mean DTH was observed in NL 1420 (78.5 days), while minimum mean DTH was recorded in BL 4407 (70 days). Mean DTH in timely sown condition is 15.27 % higher than in late sown condition. The present study shows reduction in DTH under late sown condition which is in close conformity with that of Shah *et al*.(2006), Mondini *et al*. (2014) and Liyas *et al*. (2013).

Days to Maturity

There was significant difference among genotypes for DTM under timely and late sown conditions and across combine environment (Table 1). Under timely sown condition, the maximum mean DTM was observed in NL 1417 and NL 1420 (126.5 days), while minimum mean DTM was recorded in BL 4919 (119.5 days). Under late sown condition, the maximum mean DTM was observed in Bhirkuti (117 days), while minimum mean DTM was recorded in NL 1346 and BL 4669 (105 days). Mean DTM in timely sown condition is 15.65 % higher than in late sown condition. Reduction in DTM under late sown condition was also reported by Connor *et al*.(1992) and Dokuyucu *et al* (2004).

Plant Height

There was significant difference among genotypes for PH under timely and late sown conditions and across combine environment (Table 2). Under timely sown condition, the maximum mean PH was observed in BL 4919 (101 cm), while minimum mean PH was recorded in NL 1417 (86 cm). Under late sown condition, the maximum mean PH was observed in BL 4919 (87.5 cm), while minimum mean PH was recorded in NL 1420 (71.5 cm). Mean PH in timely sown condition is 17.39 % higher than in late sown condition. Reduction in PH under late sown condition was also reported by Kumar *et al*. (2013) and Mukherjee (2012). The difference in plant height among genotype might be associated to their genetic diversity Shahzad *et al*. (2002). Taller plant in timely sown condition is due to long vegetative growth period and better temperature and solar radiation (Qasim *et al*., 2008).

Table 2: Differential response of genotypes for PH, SL and SPS under timely and late sown conditions.

	Plant Height (cm)			**Spike Length (cm)**			**Spikelets per Spike**		
Genotype	**Timely sown**	**Late sown**	**Overall**	**Timely sown**	**Late sown**	**Overall**	**Timely sown**	**Late sown**	**Overall**
Bhirkuti	87	72.5	80.7533	10.85	10.55	10.6822	18.3	18.25	18.2545
BL 4407	96.5	85.5	90.2362	10.7	9.95	10.3336	18.9	18.4	18.6036
BL 4669	94	80	86.8645	11.2	10.45	10.8329	17.3	17.1	17.2536
BL 4919	101	87.5	92.9757	12.2	11.55	11.8161	16.6	16.7	16.7416
Gautam	96	83	88.9718	12.1	11.9	11.9406	19.3	18.1	18.6502
NL 1179	95.5	83	88.7611	9.8	9.5	9.6487	17.1	16.6	16.9278
NL 1346	94	75.5	84.9679	9.65	9.25	9.4645	17.2	18	17.6260
NL 1350	95.5	81.5	88.1289	10.5	10.4	10.4353	18.2	18.2	18.1847
NL 1368	96.5	82.5	88.9718	9.95	9	9.5107	17.3	16.7	17.0674
NL 1369	93.5	76.5	85.1787	9.8	9	9.4311	18	17.5	17.7657
NL 1376	87	74	81.3855	9.9	9.65	9.7907	18.3	18.25	18.2545
NL 1381	96.5	76	86.2323	9.85	9.55	9.7122	17.2	16.5	17.0674
NL 1384	91	80	85.6001	10.75	9.95	10.3463	18.4	17.7	18.0450
NL 1386	95.5	77.5	86.4431	10.65	10.8	10.6952	18.8	18.9	18.7898
NL 1387	89.5	74.5	82.6499	10.9	10.2	10.5540	18.8	18.8	18.7433
NL 1404	95.5	79	87.0753	10.4	10	10.1909	18.4	18.3	18.3243
NL 1412	88	81	84.7572	10.6	10.4	10.4794	19.6	19.4	19.3950
NL 1413	90.5	75.5	83.4928	10.15	10.05	10.1069	16.6	16.4	16.6019
NL 1417	86	74.5	81.1748	9.4	9.1	9.3035	19.2	19.3	19.1622
NL 1420	95.5	71.5	88.1289	10.1	9.2	9.6751	18.3	17.9	18.0915
Mean	93.225	79.05	86.1375	10.4725	10.0225	10.2475	18.09	17.865	17.9775
CV (%)	2.2436	2.8002	2.3723	2.8606	3.5169	3.02226	2.7528	2.6403	2.5667
$LSD_{0.05}$	4.3631	4.6174	2.9533	0.6249	0.7352	0.3282	1.0388	0.9839	0.4659
F-test	**	**	***	***	***	***	**	**	***
	Mean PH in Timely sown condition is 17.93% higher than in Late sown condition			Mean SL in Timely sown condition is 4.48% higher than in Late sown condition			Mean SPS in Timely sown condition is 1.25% higher than in Late sown condition		

NS: statistically not significant.

Spike Length

There was significant difference among genotypes for SL under timely and late sown conditions and across combine environment (Table 2). Under timely sown condition, the maximum mean SL was observed in BL 4919 (12.2 cm), while minimum mean SL was recorded in NL 1417 (9.4 cm) . Under late sown condition, the maximum mean SL was observed in Gautam (11.9 cm), while minimum mean SL was recorded in NL 1368 and NL 1369 (9 cm). Mean SL in timely sown condition is 4.48 % higher than in late sown condition. This result is similar to finding of Kamrozzaman *et al*. (2016) and Mukherjee(2012).

Spikelets Per Spike

There was significant difference among genotypes for SPS under timely and late sown conditions and across combine environment (Table 2). Under timely sown condition, the maximum mean SPS was observed in NL 1412 (19.6), while minimum mean SPS was recorded in NL 1413 and BL 4919 (16.6) . Under late sown condition, the maximum mean SPS was observed in NL 1412 (19.4), while minimum mean SPS was recorded in NL 1413 (16.4). Mean SPS in timely sown condition is 1.25 % higher than in late sown condition. Reduction in SPS under late sown condition was also reported by Yajam and Madani (2013) and Hossain *et al*. (2017).

Spike Weight

There was significant difference among genotypes for SW under timely and late sown conditions and across combine environment (Table 3). Under timely sown condition, the maximum mean SW was observed in BL 4919 (3.3 g), while minimum mean SW was recorded in NL 1381 (1.8 g) . Under late sown condition, the maximum mean SW was observed in BL 4407 (2.58 g), while minimum mean SW was recorded in NL 1412 and NL 1381 (1.44 g). Mean SW in timely sown condition is 19.97 % higher than in late sown condition.

Table 3: Differential response of genotypes for SW, NGPS and WGPS under timely and late sown conditions.

Genotype	Spike Weight (gram)			Number of Grains per Spike			Weight of Grains per Spike (gram)		
	Timely sown	Late sown	Overall	Timely sown	Late sown	Overall	Timely sown	Late sown	Overall
Bhirkuti	2.5	2.17	2.3145	51.5	48.1	47.6000	1.91	1.74	1.7978
BL 4407	2.82	2.58	2.6296	50.2	45	46.0641	2.18	1.96	2.0048
BL 4669	2.64	2.38	2.4656	49.3	49	47.2946	1.98	1.92	1.9034
BL 4919	3.3	2.47	2.7893	52.2	39.6	44.8039	2.48	1.86	2.0893
Gautam	2.77	2.19	2.4397	48.5	39.5	43.3467	1.96	1.6	1.7598
NL 1179	2.14	2.09	2.1246	39.9	39	39.8082	1.73	1.57	1.6500
NL 1346	2.38	1.92	2.1549	45.6	39.9	42.3197	1.89	1.53	1.7007
NL 1350	1.94	1.75	1.8916	46.2	45	44.5641	1.5	1.46	1.5063
NL 1368	2.28	1.92	2.1117	44.7	43.7	43.5070	1.71	1.48	1.6035
NL 1369	2.53	1.77	2.1549	53.3	30.5	41.6819	1.94	1.39	1.6626
NL 1376	1.95	1.75	1.8959	41.8	43.1	42.1006	1.53	1.37	1.4810
NL 1381	1.8	1.44	1.6974	42.6	38.6	40.6798	1.4	1.13	1.3247
NL 1384	2.49	1.61	2.0685	43.7	26.8	36.6594	1.82	1.19	1.5274
NL 1386	2.64	2.13	2.3577	42.6	33.9	38.9655	1.91	1.6	1.7387
NL 1387	2.57	2.29	2.3965	40.9	38.1	39.9431	1.87	1.74	1.7809
NL 1404	2.32	2	2.1635	44.5	40.7	42.1790	1.79	1.56	1.6711
NL 1412	1.97	1.44	1.7708	26.2	14.6	25.3751	1.29	0.79	1.1345
NL 1413	2.03	1.88	1.9865	41	40	40.6335	1.48	1.37	1.4598
NL 1417	2.03	1.93	2.0081	34.1	34.3	35.8853	1.47	1.4	1.4683
NL 1420	2.58	2.03	2.2886	43	34.8	39.4384	1.89	1.6	1.7302
Mean	2.384	1.987	2.1855	44.075	38.21	41.1425	1.7865	1.513	1.64975
CV (%)	10.4681	11.6559	10.9578	9.8398	13.0871	11.2824	12.6050	14.3957	12.6913
$LSD_{0.05}$	0.5205	0.4831	0.2328	9.0466	10.4310	5.7294	0.4697	0.4543	0.2014
F-test	*	*	***	*	**	**	NS	*	***
	Mean SW in Timely sown condition is 19.97% higher than in Late sown condition			Mean NGPS in Timely sown condition is 15.34% higher than in Late sown condition			Mean WGPS in Timely sown condition is 18.07% higher than in Late sown condition		

Number of Grains Per Spike

There was significant difference among genotypes for NGPS under timely and late sown conditions and across combine environment (Table 3). Under timely sown condition, the maximum mean NGPS was observed in NL1369 (53.3), while minimum mean NGPS was recorded in NL 1412 (26.2). Under late sown condition, the maximum mean NGPS was observed in BL 4669 (49), while minimum mean NGPS was recorded in NL 1412 (14.6). Mean NGPS in timely sown condition is 15.34 % higher than in late sown condition. The result shows decrease in NGPS under late sown condition, which is similar to the finding of Tahir *et al*. (2009) and Poudel *et al*. (2020). The reduction in number of grains under late sown condition might be due to decrease in photosynthates production in shorter growing period (Baloch *et al*., 2012). The difference among genotypes for NGPS might be due to their genetic variability.

Weight of Grains Per Spike

There was significant difference among genotypes for WGPS under late sown condition and across combine environment and non-significant under timely sown condition (Table 3). Under timely sown condition, the maximum mean WGPS was observed in BL 4919 (2.48 g), while minimum mean WGPS was recorded in NL 1412(1.29 g). Under late sown condition, the maximum mean WGPS was observed in BL 4407 (1.96 g), while minimum mean WGPS was recorded in NL 1412 (0.79 g). Mean WGPS in timely sown condition is 18.07 % higher than in late sown condition. The result of present investigation shows reduction of WGPS under late sown condition. This result is line up with result of Khokhar *et al*. (2010) and Ercoli *et al*. (2009). Wardlaw *et al*. (1980) has reported that increasing temperature from 21/16°C to 30/25°C during the period from anthesis to maturity reduced the grain dry weight by 25%. Bahar *et al*. (2008) has reported non-significant differences in bread and durum wheat for grain weight per spike.

Table 4: Differential response of genotypes for GY and TGW under timely and late sown conditions.

Genotype	Grain Yield (kg ha^{-1})			Thousand Grain Weight (gram)		
	Timely sown	Late sown	overall	Timely sown	Late sown	overall
Bhirkuti	4398.5	3279	3543.4356	34.2	31.8	33.1476
BL 4407	4888	2799	3545.6112	40	37.8	38.5750
BL 4669	3877	2948	3348.2017	42	37.3	39.1758
BL 4919	4413	2616	3394.9204	49.3	41.5	44.5549
Gautam	3962	2477	3259.8025	43.3	38.6	40.5908
NL 1179	5252.5	2726	3612.3686	38.7	26.6	32.8975
NL 1346	4820	2038.5	3355.8736	36.3	26.1	31.7156
NL 1350	4312.5	2792	3412.2109	32.1	23.9	28.5870
NL 1368	4466.5	2782.5	3445.3034	40.2	31.6	35.9112
NL 1369	3983	2295	3222.9313	33.1	27.7	30.6434
NL 1376	4504.5	2022.5	3279.9557	30.5	28.2	29.6791
NL 1381	3957.5	1830.5	3110.7147	32.6	25.3	29.4737
NL 1384	3970.5	1547	3048.7666	38.8	35.4	36.9611
NL 1386	4452.5	1356.5	3115.5240	39.8	32	35.9235
NL 1387	4158	1936.5	3180.9074	39.5	33.9	36.5869
NL 1404	4476	2209.5	3316.2543	41.1	36.9	38.5706
NL 1412	4144	754.5	2907.0073	41.2	35.5	38.1735
NL 1413	4241	2324	3288.6582	34.7	29.6	32.3670
NL 1417	3597.5	1684.5	2994.8339	38.2	34.6	36.4121
NL 1420	4568	2893.5	3493.9687	37.2	33.5	35.3539
Mean	4322.125	2265.6	3293.863	38.14	32.39	35.265
CV (%)	8.7220	14.2751	10.1328	8.7235	5.0410	7.0428
$LSD_{0.05}$	786.3643	674.6363	440.9854	6.9403	3.4059	2.7044
F-test	NS	**	NS	**	***	***
	Mean GY in Timely sown condition is 90.77% higher than in Late sown condition			Mean TGW in Timely sown condition is 17.75% higher than in Late sown condition		

Grain Yield

There was significant difference among genotypes for GY under late sown condition and non-significant under timely sown condition and across combine environment (Table 4). Under timely sown condition, the maximum mean GY was observed in NL 1179 (5252.5 kg ha^{-1}), while minimum mean GY was recorded in NL 1417(3597.5 kg ha^{-1}) . Under late sown condition, the maximum mean GY was observed in Bhirkuti (3279 kg ha^{-1}), while minimum mean GY was recorded in NL 1412 (754.5 kg ha^{-1}). Mean GY in timely sown condition is 90.77 % higher than in late sown condition. Reduction in GY under late sown condition was also reported by Sharma-Natu *et al*. (2006), Poudel *et al*.(2020) and Khokhar *et al.* (2010). Wheat under late sowing face terminal heat stress. This heat stress during grain formation stage leads to abnormal/shriveled grain and low production (Baloch *et al*., 2012). The higher grain yield in timely sown condition is due to maximum number of spikes/m^2, more number of grains per spike, maximum weight of grain per spike and favorable solar radiation (Ali, 1999).Difference in grain yield among genotypes might be due to inherent quality of genotypes.

Thousand Grain Weight

There was significant difference among genotypes for TGW under timely and late sown conditions and across combine environment (Table 4). Under timely sown condition, the maximum mean TGW was observed in BL 4919 (49.3 g), while minimum mean TGW was recorded in NL 1376 (30.5 g) . Under late sown condition, the maximum mean TGW was observed in BL 4919 (41.5g), while minimum mean TGW was recorded in NL 1350 (23.9 g). Mean TGW in timely sown condition is 17.75 % higher than in late sown condition. Reduction in GY under late sown condition was also reported by Akhtar *et al*. (2006), Marasini *et al*. (2016) and Adam and Jahan (2019). Plant grown under late sown condition faces heat stress at anthesis stage which generally decreases weight per grain (Ortiz-Monasterio *et al*., 1994). Decrease in TGW is also due to shortening of grain filling duration in delayed sowing, which ultimately reduce grain weight (Spink *et al*., 2000).

Conclusion

From the above study, it can be concluded that the late sowing significantly affects the yield and yield component of wheat. In late sown condition, there was significant difference among genotypes for all the traits under study and the highest grain yield was recorded in Bhirkuti. Under timely sown condition, there was significant difference among genotype for all traits under study except WGPS and Grain yield and the highest grain yield was recorded in NL 1179. The maximum grain yield was recorded in NL 1179 across the combine environment.

Author's Contribution

Padam Bahadur Poudel & Mukti Ram Poudel designed the research plan; Padam Bahadur Poudel, Uttam Kumar Jaishi & Laxmi Poudel performed experimental works, collected the required data & analysed the data. Padam Bahadur Poudel prepared the manuscript. Mukti Ram Poudel critically revised and finalized the manuscript. Final form of manuscript was approved by all authors.

Conflict of Interest

The authors declare that there is no conflict of interest with present publication.

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References

Adam AG & Jahan N (2019) Effects of sowing time on growth and yield performance of six high yielding varieties of wheat (*Triticum Aestivum* L.). *Bangladesh Journal of Botany* **48**(1): 43–51. DOI: 10.3329/bjb.v48i1.47415

Akhtar M, Cheema MS, Jamil M. & Ali L (2006) Effect of time of sowing on some important characters of wheat, Triticum aestivum genotypes. *Journal of Agricultural Research (Pakistan)* **44**(4): 255–259.

Ali R (1999) Radiation interception, growth and yield of wheat as affected by sowing date and nitrogen application. University of Agriculture, Faisalabad.

Ansary A, Khushak A, Sethar MA, Ariam N & Emon MY (1989) Effect of sowing dates on growth and yield of wheat cultivars. *Pakistan Journal of Scientific and Industrial Research* **32**: 39–42.

Asseng S, Ewert F, Martre P, Rötter RP, Lobell DB, Cammarano D, … Zhu Y (2015) Rising temperatures reduce global wheat production. *Nat Clim Change* **5**: 143–147. DOI: 10.1038/nclimate2470

Bahar B, Yildirim M, Barutcular C & Ibrahim GENC (2008) Effect of canopy temperature depression on grain yield and yield components in bread and durum wheat. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca* **36**(1): 34–37.

Bala S, Asthir B & Bains N (2014) Effect of terminal heat stress on yield and yield attributes of wheat. *Indian J Applied Res* **4**(6): 1–2. DOI: 10.15373/2249555X/June2014/1

Baloch MS, Nadim MA, Zubair M, Awan IU, Khan EA & Ali S (2012) Evaluation of wheat under normal and late sowing conditions. *Pakistan Journal of Botany* **44**(5): 1727–1732.

Chaves MS, Martinelli JA, Wesp-Guterres C, Graichen FAS, Brammer SP, Scagliusi SM, … Chaves ALS (2013) The importance for food security of maintaining rust resistance in wheat. *Food Secur* **5**: 157–176. DOI: 10.1007/s12571-013-0248-x

Connor D, Theiveyanathan S & Rimmington G (1992) Development , Growth , Water-use and Yield of a Spring and a Winter Wheat in Response to Time of Sowing. *Australian Journal of Agricultural Research* **43**(3): 493–516. DOI: 10.1071/AR9920493

Dokuyucu T, Akkaya A & Yigitoglu D (2004) The Effect of Different Sowing Dates on Growing Periods , Yield and Yield Components of Some Bread Wheat (*Triticum aestivum* L .) Cultivars Grown in the East-Mediterranean Region of Turkey. *Journal of Agronomy* **3**(2): 126–130. DOI: 10.3923/ja.2004.126.130

Ercoli L, Masoni A, Mariotti M & Arduini I (2009) Accumulation of dry matter and nitrogen in durum wheat during grain filling as affected by temperature and nitrogen rate. *Italian Journal of Agronomy* **4**(1): 3–13. DOI: 10.4081/ija.2009.1.3

Farooq M, Bramley H, Palta JA & Siddique KHM (2011) Heat stress in wheat during reproductive and grain-filling phases. *Crit Rev Plant Sc* **30**(6): 491–507. DOI: 10.1080/07352689.2011.615687

Hossain A, da Silva J, Lozovskaya M & Zvolinsky V (2012) The Effect of High Temperature Stress on the Phenology, Growth and Yield of Five Wheat (*Triticum aestivum* L.) Varieties. *Asian and Australasian Journal of Plant Science and Biotechnology* **6**(1): 14–23.

Hossain A, Islam MR, Rahman KAMM, Rashid MH & Anwari A (2017) Comparative performance of three wheat (*Triticum aestivum* L .) varieties under heat stress varieties under heat stress. *International Journal of Natural and Social Sciences* **4**(3): 16–24.

Kamrozzaman MM, Khan MAH, Ahmed S & Sultana N (2016) Growth and yield of wheat at different dates of sowing under chrland ecosystem of Bangladesh. *Journal of the Bangladesh Agricultural University* **14**(2): 147–154. DOI: 10.3329/jbau.v14i2.32688

Khokhar Z, Hussain I, Khokhar B & Sohail M (2010) Effect of Planting Date on Yield of Wheat Genotypes in Sindh. *Pakistan Journal of Agriculural Research* **23**(3–4): 103–107.

Kumar S, Alam P & Ali N (2013) Response of wheat (Triticum aestivum L. emend. Fori & Paol.) varieties to sowing dates. *Journal of Research* **25**(1): 56–59.

Liyas M, F. Mohammad I, Khalil H, Arif M, Khan W, Saifullah & Azam SM (2013) Yield potential of F 4:7 bread wheat (*Triticum aestivum* L.) lines under normal and late planting. *International Journal of Basic and Applied Sciences* **13**(5): 7–11.

Marasini D, Marahatta S, Dhungana SM & Acharya R (2016) Effect of date of sowing on yield and yield attributes of different wheat varieties under conventional tillage in sub-humid condition of Chitwan district of Nepal. *International Journal of Applied Sciences and Biotechnology* **4**(1): 27–31. DOI: 10.3126/ijasbt.v4i1.14335

MoAD (2014) Statistical information on Nepalese Agriculture 2014: Ministry of Agriculture and Development, Agribusiness Promotion and Statistics Division, Kathmandu, Nepal

Mondini L, Grausgruber H & Pagnotta MA (2014) Evaluation of European emmer wheat germplasm for agro-morphological, grain quality traits and molecular traits. Genetic resources and crop evolution. *Genetic Resources and Crop Evolution* **61**(1): 69–87. DOI: 10.1007/s10722-013-0016-y

Mukherjee D (2012) Effect of different sowing dates on growth and yield of wheat (Triticum aestivum) cultivars under mid hill situation of West Bengal. *Indian Journal of Agronomy* **57**(2): 152–156.

Nahar K, AHAMED KU & FUJITA M (2010) Phenological Variation and its Relation with Yield in several Wheat (*Triticum aestivum* L.) Cultivars under Normal and Late Sowing Mediated Heat Stress Condition. *NOTULAE SCIENTIA BIOLOGICAE* **2**(3): 51–56. DOI: 10.15835/nsb234723

Ortiz-Monasterio R JI, Dhillon SS & Fischer RA (1994) Date of sowing effects on grain yield and yield components of irrigated spring wheat cultivars and relationships with radiation and temperature in Ludhiana, India. *Field Crops Research* **37**: 169–184. DOI: 10.1016/0378-4290(94)90096-5

Phadnawis BN & Saini AD (1992) Yield models in wheat based on sowing time and phenological developments. *Annals of Plant Physiology* **6**(1): 52–59.

Poudel MR, Ghimire S, Pandey MP, Dhakal KH, Thapa DB & Poudel HK (2020) Evaluation of Wheat Genotypes under Irrigated , Heat Stress and Drought Conditions. *Journal of Biology and Today's World* **9**(1): 212.

Poudel PB & Poudel MR (2020) Heat Stress Effects and Tolerance in Wheat: A Review. *Journal of Biology and Today's World* **9**(4): 217. DOI: 10.35248/2322-3308.20.09.217

Qasim M, Qamer M, Alam M & Alam M (2008) Sowing dates effect on yield and yield components of different wheat varieties. *Journal of Agricultural Research* **46**(2): 135–140.

Raines CA (2011) Increasing photosynthetic carbon assimilation in C3 plants to improve crop yield: Current and future strategies. *Plant Physiol* **155**: 36–42. DOI: 10.1104/pp.110.168559

Shah WA, Bakht J, Ullah T, Khan AW, Zubair M & Khakwani AA (2006) Effect of Sowing Dates on the Yield and Yield Components of Different Wheat Varieties. *Journal of Agronomy* **5**(1): 106–110. DOI: 10.3923/ja.2006.106.110

Shahzad K, Bakht J, Shah WA, Shafi M & Jabeen N (2002) Yield and Yield Components of Various Wheat Cultivars as Affected by Different Sowing Dates. *Asian Journal of Plant Sciences* **1**(5): 522–525. DOI: 10.3923/ajps.2002.522.525

Sharma-Natu P, Sumesh KV, Lohot VD & Ghildiyal MC (2006) High temperature effect on grain growth in wheat cultivars: an evaluation of responses. *Indian Journal of Plant Physiology* **11**(3): 239–245.

Sharma D, Singh R, Tiwari R, Kumar R & Gupta V (2019) Wheat Responses and Tolerance to Terminal Heat Stress: A Review. In M Hasanuzzaman, K Nahar & MA Hossain (Eds.), *Wheat Production in Changing Environments: Responses, Adaptation and Tolerance* (pp. 149–173). Springer. DOI: 10.1007/978-981-13-6883-7_7

Singh VP & Uttam SK (1999) Influence of sowing dates on yield of wheat cultivars under saline sodic conditions in Central Utter Pradesh. *Ind. Agric* **38**(1): 64–68.

Spink JH, Kirby EJM, Frost DL, Sylvester-Bradley R, Scott RK, Foulkes MJ, Clare RW & Evans EJ (2000) Agronomic implications of variation in wheat development due to variety, sowing date, site and season. *Plant Varieties & Seeds* **13**(2): 91–108.

Tahir M, Ali A, Nadeem MA, Hussain A & Khalid F (2009) Effect of Different Sowing Dates on Growth and Yield of Wheat (*Triticum aestivum* L .) Varieties in District Jhang , Pakistan. *Pakistan Journal of Life and Social Sciences* **7**(1): 66–69.

Wardlaw I, Sofield I & Cartwright P (1980) Factors Limiting the Rate of Dry Matter Accumulation in the Grain of Wheat Grown at High Temperature. *Australian Journal of Plant Physiology* **7**(4): 387–400. DOI: 10.1071/PP9800387

Yajam S & Madani H (2013) Delay sowing date and its effect on Iranian winter wheat cultivars yield and yield components. *Annals of Biological Research* **4**(6): 270–275.