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Evaluation of Yield Attributing Trait of Spring Wheat Genotypes Under Normal and Late Sowing Condition

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Abstract. Wheat (*Triticum aestivum*) is the third most important cereal crop in Nepal after rice and maize. The research is carried out during the winter season in agronomic field of the Institute of Agriculture and Animal Science (IAAS), Bhairahawa, Nepal. Sowing is carried out 28th November 2020 and 24th December 2020 on alpha lattice design with two replication of twenty wheat genotype under normal and late sowing respectively. In the late sowing condition, all genotype's performance is reduced as compared to normal sowing. Under late sown condition, high temperatures reduced the days to booting (15.64%), days to heading (14.97%), days to maturity (14.16%), chlorophyll content (15.99%), plant height (8.59%), spike length (7.03%), number of spikelet per spike (9.21%), number of grain per spike (10.6%), spike weight (15.32%), effective tiller/m^2 (9.92%), thousand kernel weight (10.3%) and grain yield (22.5%). NL 1420 presented higher 4118 kg/ha and 3310.5 kg/ha yield respectively and BL 4407 presented early maturity 119.2 DAS and 100.6 DAS respectively in normal sowing and late sowing condition. In a combined environment, maximum grain yield is recorded in NL1420. The result suggested that the tolerant line against the late sowing condition can be used as genetic resource for crop improvement and promote for grain yield.

Keywords: grain yield, heat stress, trait, wheat, Nepal

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1. Introduction

Wheat is the most important cereal crop in world under cultivation (215.9 million hectares) and production (765.76 million tons) with a productivity of 3.54 tons/hectare [1]. Until 2050, there is necessary to increase the production of wheat by 77% to meet the growing demand for food and there will be a need for an additional 198 million tons of wheat [2]. Wheat is a good source of nutrients and minerals which contains 60-70% carbohydrate, 6-26% protein, 2.1% fat, 2.1% minerals, and vitamins [3]. Wheat is the third most important cereal crop after rice and maize in Nepal. It is cultivated in 0.7 million hectares of land and production is 2 million tons [4]. The productivity of wheat in Nepal is 2.85 tons/hectare which is lower than the world's productivity. According to [5] in Nepal, the productivity of wheat in the irrigated and rainfed area were 2.71

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metric ton/hectare (MT/ha) and 1.12 MT/ha respectively. Similarly, the yield from the improved seeds is 2.34 MT/ha, whereas that from the local seeds is 1.12 MT/ha. Due to global warming temperature of the world is increasing by 0.18 ℃ per year [6]. The normal temperature regime for wheat grain filling is 15-18 ℃. Wheat production is decreased by 3-4% when the temperature rises by 1℃ [7]. According to [8], under heat stress and drought conditions 29.99% and 52.98% grain yield is decreased as compared to irrigated conditions. Similarly, at late sowing condition 47.58% grain yield is decreased than in normal sowing condition. The effect of high temperature during the anthesis and reproduction stage is called terminal heat stress. The grain yield of wheat is dependent upon the sowing date. In late sown conditions, there is terminal heat stress during the reproductive stage of wheat and the reproductive stage is very susceptible to high temperature. High temperature during the reproduction stage has a detrimental effect on fertilization and post-fertilization stages leading to lower grain production. The grain yield of wheat is decreased by 50% in late sown conditions [9]. Heat stress causes morphological, physiological, biochemical, and molecular alterations in wheat. Under heat stress conditions, crop duration is reduced and there is a reduction of the assimilation of photosynthate thus results in lower biomass production. There is poor pollen tube development, high pollen mortality and shrinkage of grains due to short grain filling duration [10]. Under heat stress conditions, high temperature alters the source to sink relationship that causes poor photosynthetic accumulation in grain. High temperatures cause an alternation of water relations and affect the physiological and metabolic activities of the plant. Photosynthesis is a highly affected physiological process under heat stress conditions. High temperature causes disintegration of chlorophyll content and photosynthetic activity in a crop is reduced [11]. There is an urgent need to develop wheat varieties that are tolerant to heat stress conditions. The genotypes with short crop duration and stay green characters are less affected at late sowing conditions. Selection of wheat genotype that can give higher grain yield, good quality grain and early maturing genotype is done under heat stress condition. So, evaluation of yield and yield attributing characters of wheat genotypes is done under normal and heat stress conditions.

2. Materials and Methods

2.1. Genotypes Collection for the Study

Among 20 wheat genotypes used in this research, 15 Nepal Lines (NL), 3 Bhairahawa Lines (BL) were breeding line and two released varieties Gautam and Bhirkuti were check varieties. All genotypes were collected from National Wheat Research Program (NWRP) Bhairahawa, Nepal. All the name of genotypes is listed below Table 1.

Table 1. Genotypes Used for a Research Program

S.N	Genotypes	Origin	Genotypes status	Source
1	Bhrikuti	CIMMYT, Mexico	Released variety	NWRP, Bhairahawa
2	BL 4407	Nepal	Breeding line	NWRP, Bhairahawa
3	BL 4669	Nepal	Breeding line	NWRP, Bhairahawa
4	BL 4919	Nepal	Breeding line	NWRP, Bhairahawa
5	Gautam	Nepal	Released variety	NWRP, Bhairahawa
6	NL 1179	CIMMYT, Mexico	Breeding line	NWRP, Bhairahawa
7	NL 1346	CIMMYT, Mexico	Breeding line	NWRP, Bhairahawa
8	NL 1350	CIMMYT, Mexico	Breeding line	NWRP, Bhairahawa
9	NL 1368	CIMMYT, Mexico	Breeding line	NWRP, Bhairahawa
10	NL1369	CIMMYT, Mexico	Breeding line	NWRP, Bhairahawa
11	NL 1376	CIMMYT, Mexico	Breeding line	NWRP, Bhairahawa
12	NL1381	CIMMYT, Mexico	Breeding line	NWRP, Bhairahawa
13	NL 1384	CIMMYT, Mexico	Breeding line	NWRP, Bhairahawa
14	NL 1386	CIMMYT, Mexico	Breeding line	NWRP, Bhairahawa
15	NL 1387	CIMMYT, Mexico	Breeding line	NWRP, Bhairahawa
16	NL 1404	CIMMYT, Mexico	Breeding line	NWRP, Bhairahawa
17	NL 1412	CIMMYT, Mexico	Breeding line	NWRP, Bhairahawa
18	NL 1413	CIMMYT, Mexico	Breeding line	NWRP, Bhairahawa
19	NL 1417	CIMMYT, Mexico	Breeding line	NWRP, Bhairahawa
20	NL 1420	CIMMYT, Mexico	Breeding line	NWRP, Bhairahawa

Source: NWRP, Bhairahawa

2.2. Field Experimentation

The agronomy farm of the Institute of Agriculture and Animal Science (IAAS) Paklihawa, Bahirahawa, Nepal is used for filed experimentation. The coordinates of the research site is 27º30'N and 83º27' E and 79 masl. Research is conducted on sub-humid tropical region of Nepal where winter is cold and summer is hot. Alpha Lattice design is used for research program (Figure 1). In this experiment there were 5 blocks with 4 plots in each block and 2 replications for heat stress condition. Each genotype is sown on 4.5 m^2 (3 m × 1.5 m) plot. Within the plot, spacing between rows is 25 cm and between plants is 2-3 cm. Infield experimental design, gap between two plots and replication is 0.5 m and 1 m respectively. Similarly, the distance between two blocks is 0.5 m within replication.

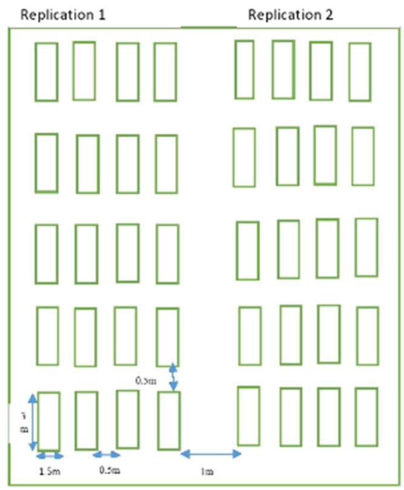

Figure 1. Layout of a Field Experiment Plot

2.3. Weather Condition

The agro-metrological data required for the research is obtained from National Wheat Research Programme (NWRP), Bhairahawa, Nepal located near to the research site (Figure 2). During research minimum temperature is in January (T_{max}19.2℃ and T_{min} 10.32℃) at crown root initiation stage and maximum temperature is in March (T_{max} 34.37°C and T_{min} 15.86℃) at anthesis and grain filling stage. Maximum rainfall is in March (15 mm) at grain filling stage.

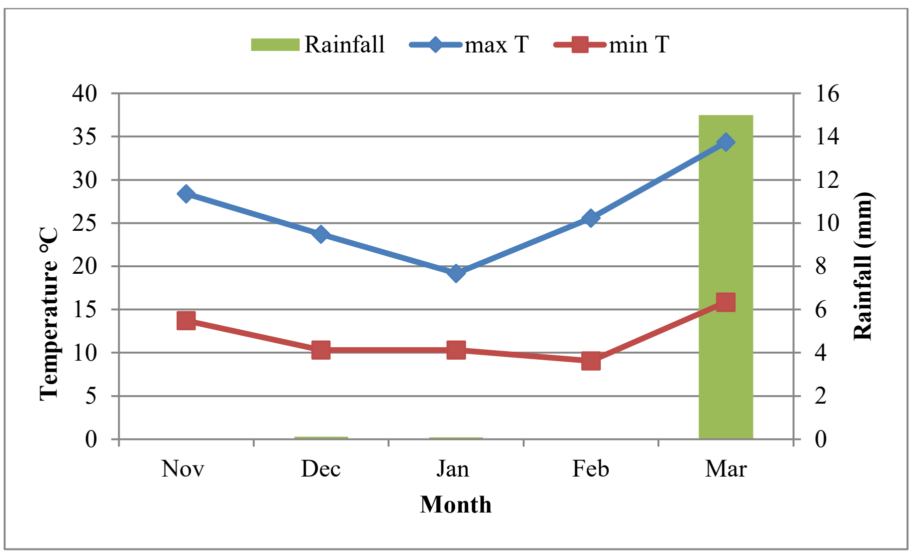

Figure 2. Layout of a Field Experiment Plot

2.4. Agronomic Practice

2.4.1. Field Preparation and Sowing

The field preparation is done by using a tractor for deep ploughing two times and manually labeling at last time. The seed has sown in line sowing method on 24th December 2020. Late sowing varieties should be faced heat stress at the flowering period due to the high temperature is present at flowering time.

2.4.2. Nutrient Management

Twelve soil samples were taken in W shape at 20-25 cm depth from the field. After thoroughly mixing and air drying and soil sample were sieved to 2 mm sieve. The soil samples were analysed in the soil laboratory of IAAS Paklihawa campus, Rupandehi. The soil analysis result showed that soil is clay loam containing 0.39, 160, 130 kg/ha nitrogen, phosphorus and potash respectively. The soil is found slightly acidic (pH 6.7) and organic matter content is 4.5%. Compost manure @ 5 ton/ha and NPK as recommended dose @ 100:50:30 kg/ha is applied on each plot. All recommended dose of phosphorus and potash is broadcasted during field preparation while only half dose of nitrogen fertilizer is applied. The remaining dose of nitrogen is applied in two splits, at 30 days after sowing (DAS) and at 70 DAS.

2.4.3. Irrigation

Irrigation is done as in irrigated farming system. Total five irrigations by flooding method, were done during this research period. 1^{st} irrigation is done at Critical Root Initiation (CRI) stage, 2^{nd} and 3^{rd} in jointing stage, 4^{th} in booting stage and 5^{th} in heading stage of wheat. At grain filling stage in March 15 mm rainfall occurred. The irrigation schedule is present in Table 2.

Table 2. Irrigation Schedule in Wheat at Heat Stress Condition

No. of Irrigation	Date	Phonological Stage of Wheat
1	15^{th} January 2021	Crown root initiation
2	30^{th} January 2021	Jointing stage
3	12^{th} February 2021	Jointing stage
4	25^{th} February 2021	Booting stage
5	9^{th} March 2021	Heading stage

2.4.4. Harvesting and Post-Harvesting Operations

Harvesting is done manually with the help of sickles at the harvesting stage of wheat. Harvesting 1 m^2 of each plot is done and tagged while 1 row on both sides is removed before harvesting 1 m^2. Threshing is done manually.

2.5. Observation Record

Twelve different yield and yield attributing characters were recorded. Yield attributing characters were recorded from randomly selected 10 plants for each plot excluding border crops.

Table 3. Yield Attributing Characters

Yield Attributing Characters	Description
Days to Booting (DTB)	DTB is recorded between Days After Sowing (DAS) to 50% of plants in the plot have swollen flag leaf sheath.
Days to Heading (DTH)	DTH is recorded between DAS to 50% of plant in the plot has half ear emerged.
Days to Maturity (DTM)	DTM is recorded between DAS to 75% of plants in plot show golden yellow color in flag leaf, spike, and peduncle
Chlorophyll Content (CC)	Chlorophyll value is observed by using SPAD (Soil Plant Analysis Development) after flag leaf emergence and each leaf with three readings at the top, middle, and bottom of the leaf.
Plant Height (PH)	PH is measured as height of culm from the soil surface to the tip of the spike excluding awn.
Spike Length (SL)	SL is measured from attachment of the lowest spikelet to tip of the spike excluding awn.
Spike Weight (SW)	Spike is detached from lowest spikelet and then averaged.
Number of Spikelet per Spike	Number of spikelet is counted from lowest spikelet attached to lower rachis to top without awn.
Number of Grain per Spikelet	Grain is counted manually by threshing spikelet.
Effective Tiller/m^2	The number of effective tillers presents per meter square is counted.
Thousand Kernel Weight (TKW)	TKW of grain is recorded by weighing 1000 grains obtained from the bulk of grain for each plot.
Grain Yield (GY)	GY is recorded by averaging the values obtained from two sample plot of 1 m^2 area for each plot.

2.6. Statistical Analysis

Microsoft Office Excel 2010 is used for data entry and processing. For analysis of variance of the parameters and estimation of their means, R3.5.0 a software package for alpha lattice design by ADEL-R (CIMMYT, Mexico) is used.

3. Results and Discussion

3.1. Days to Booting (DTB)

Under normal and late sowing, DTB shows the highly significant difference among genotypes, and also combined environment shows the significant difference among genotypes (Table 3). Under normal sowing, maximum DTB mean is in Gautam, NL1368, and NL1386 (81 days) and minimum DTB mean is in NL1350, NL1404 (75 days). Under late sowing conditions, the maximum DTB mean is in NL1386 (72 days) and the minimum DTB mean is recorded in NL 1350. Mean DTB in late sowing conditions is 15.64% lower than in normal sowing conditions.

Under late sowing conditions, DTB is reduced than in normal sowing conditions. A similar result is reported by [12]; [13]. According to [13]; [14], reproductive phage, booting, fertilization, and gametogenesis are most sensitive to high temperatures during late sowing conditions, which reduces yield than in normal sowing condition.

3.2. Days to Heading (DTH)

Normal sowing, late sowing, and combined environment show a significant difference within genotypes (Table 3). Under normal sowing, maximum DTH mean is recorded in NL1386 (85days) and minimum DTH mean is in NL1350 (79 days). Under late sowing, maximum DTH mean is recorded in NL1386 (75 days) and minimum DTH mean is in NL1350 and BL4919 (67 days). Mean DTH in late sowing conditions is 14.97% lower than in normal sowing conditions.

Table 4. DTB, DTH, and DTM were Under Normal and Late Sowing Conditions among Genotype

Genotype	Days to booting			Day to heading			Days to maturity		
	Normal sown	Late sown	Overall	Normal sown	Late sown	Overall	Normal sown	Late sown	Overall
Bhirkuti	77	66	71.40	81	70	75.36	120.2	103.5	111.77
BL _4407	76	63	69.64	80	68	73.99	119.2	100.6	110.11
BL _4919	76	63	68.98	79	67	72.41	119.5	101.0	110.11
BL_4669	79	67	72.93	83	70	76.49	119.5	102.8	110.94
Gautam	81	69	74.69	84	73	78.53	120.7	104.8	112.66
NL _1179	79	68	73.15	83	70	76.71	120.3	103.4	111.82
NL _1346	78	64	70.96	82	68	74.67	119.7	101.2	110.49
NL _1350	75	62	68.54	79	67	72.63	119.0	101.2	110.16
NL _1369	80	68	73.81	83	70	76.93	120.2	102.7	111.47
NL _1381	79	64	71.40	82	68	75.12	120.2	101.2	110.80
NL _1384	80	68	73.81	84	71	77.61	119.3	103.0	111.18
NL _1386	81	72	76.45	85	75	80.33	120.6	106.3	113.34
NL _1387	79	68	73.59	83	72	77.61	120.6	104.5	112.51
NL _1413	80	65	72.28	84	71	77.38	120.2	102.9	111.59
NL _1417	79	67	73.15	83	70	76.70	119.9	102.6	111.26
NL _1420	80	67	73.37	83	71	76.93	120.5	102.9	111.76
NL_ 1368	81	68	74.25	84	71	77.61	120.2	104.8	112.47
NL_ 1376	80	66	72.93	83	69	76.25	119.9	101.6	110.80
NL_ 1404	75	64	69.86	80	69	74.43	119.3	102.7	111.01
NL_ 1412	80	68	74.03	84	72	78.29	120.2	103.3	111.76
Mean	78.75	66.18	72.46	82.48	70.13	76.3	120.0	103	111.4
CV%	1.50	2.77	1.77	2	3.14	1.8	0.67	2	1.1
$LSD_{0.05}$	2.40	3.83	1.71	3	4.99	1.5	2	5.21	1.4
F-test	***	***	***	**	**	***	**	**	*

CV: Coefficient of Variation, $LSD_{0.05}$: Least Significant Difference, * significant at 0.05 level of significance, **significant at 0.01 level of significance, *** significance at 0.001 level of significance

Under late sowing conditions, DTH is reduced than normal sowing conditions. A similar result is reported by [8]; [12]; [12]. Under late sowing condition, early heading avoid terminal heat stress for enhancing grain yield through early maturity of grain [15]; [16].

3.3. Days to Maturity (DTM)

There is significant difference among genotypes in DTM under normal sowing, late sowing, and combined environment (Table 3). Under normal sowing maximum DTM mean is recorded in Gautam (120.7 days) and the minimum in BL4919, BL4669 (119.2 days). Under late sowing, the maximum DTM mean is recorded in NL 1386 (106.3 days) and the minimum in BL 4407(100.6 days). Mean DTM in late sowing condition is 14.16% lower than normal sowing condition.

The reduction of DTM under late sowing than normal sowing condition is also reported by [17]; [8]; [12]. Under late sowing conditions, increased 5°C temperature above 20°C reduces grain filling duration by 5-12 days [18]. In wheat, night temperature is more responsive to reduced grain filling duration and grain yield than the day temperature. Reduction of Grain filling duration by 3-7 days at 20°C and 23°C night temperature is recorded by [19]. Recently, [20] reported that day/night temperature of 32/22°C when compared with that of 25/15°C significantly reduces grain filling period.

3.4. Chlorophyll Content (CC)

Chlorophyll content shows a significant difference among genotypes in late sowing condition and non-significant difference in normal sowing and combined environment (Table 4). Under normal sowing conditions, the maximum CC mean is recorded in NL 1381 (43.31) and minimum in Bhirkuti (40.6). Under late sowing, the maximum CC mean is recorded in NL 1387 (39.2) and minimum in NL 1376 (29.6). Mean CC in late sowing is 15.99% lower than normal sowing condition.

The reduction of chlorophyll content in leaf at late sowing condition is also reported by [21]; [22]; [23]. Under late sown condition chlorophyll content and leaf area index are significantly decreased in heat-sensitive genotype but proline content is increased in heat-tolerant genotype [24]. According to [25] Photosystem II ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco) and oxygen-evolving complex are affected under high-temperature conditions.

Table 5. CC, PH, and SL Response Under Normal and Late Sowing Conditions among Genotype

Genotype	Chlorophyll content			Plant height			Spike length		
	Normal sown	Late sown	Overall	Normal sown	Late sown	Overall	Normal sown	Late sown	Overall
Bhirkuti	40.6	35.9	38.05	94.5	87.1	89.89	11.5	10.4	11.0
BL _4407	42.5	36.3	39.17	86.4	81.5	84.23	10.1	9.9	10.0
BL _4919	41.8	30.4	37.50	94.9	80.7	87.46	10.5	9.1	9.8
BL_4669	42.5	35.9	39.07	86.4	82.3	84.55	10.1	9.9	10.0
Gautam	42.4	38.8	39.63	87.8	83.5	85.60	10.1	9.1	9.6
NL _1179	42.9	35.1	39.07	84.3	76.7	81.40	10.1	9.1	9.6
NL _1346	42.2	31.7	37.96	85.5	79.9	83.18	10.5	9.9	10.2
NL _1350	40.7	33.0	37.50	100.9	84.3	91.43	11.2	10.8	11.0
NL _1369	42.4	37.6	39.35	87.3	81.5	84.55	10.8	9.6	10.2
NL _1381	43.3	33.8	38.98	87.7	74.3	81.81	9.8	9	9.4
NL _1384	41.8	33.4	38.15	87.7	80.7	84.36	10.1	9.5	9.8
NL _1386	42.9	37.2	41.76	89.2	81.5	85.33	10.1	10.0	10.0
NL _1387	42.9	39.2	40.00	86.1	80.7	83.71	10.5	10.0	10.2
NL _1413	41.1	36.3	38.42	87.9	82.7	85.25	10.5	9.9	10.2
NL _1417	43.1	34.6	39.07	89.1	81.9	85.42	10.8	9.9	10.4
NL _1420	42.0	30.4	37.59	87.9	83.5	85.58	10.5	9.1	9.8
NL_ 1368	41.3	38.8	39.07	87.7	79.1	83.75	10.1	9.6	9.8
NL_ 1376	41.5	29.6	37.13	90.7	83.9	86.98	10.1	9.1	9.6
NL_ 1404	41.5	33.4	37.96	90.4	81.1	85.65	9.8	9.1	9.4
NL_ 1412	41.0	35.1	38.05	91.0	83.5	86.87	10.5	9.9	10.2
Mean	42.02	35.3	38.67	89.17	81.52	85.3	10.38	9.65	10
CV%	6.07	8.39	6.84	4.78	3	3.5	4.68	3.21	4
LSD0.05	5.32	6.2	2.95	8.9	4.5	3.8	0.61	0.65	0.46
F-test	NS	**	NS	**	**	*	*	***	***

NS: statistically non –significance

3.5. Plant Height (PH)

Plant height shows a significant difference in normal sowing, late sowing, and combined environment among genotypes (Table 4). Under normal sowing conditions, the maximum PH mean is recorded in NL1350 (100.9 cm) and the minimum in NL 1387 (86.1 cm). Under late sowing, the maximum PH mean is recorded in NL1350 (84.3 cm) and the minimum in NL 1381 (74.3 cm). Mean PH in late sowing condition is 8.99% lower than in normal sowing condition.

Plant height is reduced in late sowing conditions. A similar result is reported by [26]; [27]. The air temperature increased in late sowing stops vegetative development and shortens the organs [28]. GA-insensitive Rht1 (Rht-B1b) and Rht2 (Rht-D1b) reduce plant height and lodging in the favorable environment which enhances grain number and grain yield [29]. Under stress condition tall plants are preferred because when the plant comes to stress condition it shows reduction in height due to poor vegetative growth [30].

3.6. Spike Length (SL)

There is a significant difference among genotypes in normal sowing, late sowing, and combined environment (Table 4). Under normal sowing maximum SL mean is recorded in Bhirkuti (11.5 cm) and the minimum in NL1381 and NL1404 (9.8 cm). Under late sowing, the maximum SL mean is recorded in NL1350 (10.8 cm) and the minimum in NL1381 (9 cm). Mean SL in late sowing is 7.03% lower than in normal sowing conditions. Spike length is reduced under late than normal sowing condition. This result is similar to [31]; [26]; [12]. The date of planting and temperature is responsible for the reduction of spike length [32].

3.7. Number of Spikelet per Spike (NSPS)

NSPS shows a significant difference in normal sowing, late sowing, and combined environment (Table 5). Under normal sowing, the maximum NSPS mean is recorded in NL1381 (17.2) and the minimum in NL1376 (15.1). Under late sowing, the maximum NSPS mean is recorded in BL 4669(16.85) and the minimum in NL1376 (13). Mean NSPS in late sowing conditions is 9.21% lower than in normal sowing conditions.

Table 6. NSPS, NGPS, and SW Response Under Normal and Late Sowing Condition among Genotypes

Genotype	No. of spikelet per spike			No. of grain per spike			Spike weight		
	Normal sown	**Late sown**	**Overall**	**Normal sown**	**Late sown**	**Overall**	**Normal sown**	**Late sown**	**Overall**
Bhirkuti	16.7	15.7	16.28	42.3	37.8	40.12	20.4	17.0	19.11
BL _4407	16.2	14.5	15.34	38.7	37.2	37.65	18.6	15.9	17.01
BL _4919	16.7	14.1	15.53	45.3	38.1	42.01	20.8	16.1	18.96
BL_4669	17.0	16.5	16.85	42.6	39.8	41.64	19.0	16.4	17.61
Gautam	15.4	14.6	14.78	40.0	36.6	38.03	18.6	17.0	17.61
NL _1179	16.7	15.0	15.91	42.6	38.4	40.69	19.3	16.1	17.76
NL _1346	17.0	14.2	15.72	44.3	37.2	40.88	18.8	14.5	16.41
NL _1350	15.9	13.8	14.78	40.0	35.4	37.27	20.0	17.5	19.11
NL _1369	16.2	15.4	15.72	39.0	36.0	37.08	19.0	16.7	17.76
NL _1381	17.2	15.4	16.47	49.9	39.2	45.43	19.3	16.1	17.76
NL _1384	16.2	15.0	15.53	43.0	37.8	40.50	19.2	15.6	17.31
NL _1386	16.2	14.6	15.34	40.0	35.4	37.27	19.5	17.2	18.51
NL _1387	16.4	15.4	15.91	44.0	40.4	42.77	19.7	17.8	18.96
NL _1413	16.2	15.3	15.72	43.3	38.7	41.26	19.3	16.7	18.06
NL _1417	16.7	15.3	16.09	43.0	37.8	40.50	20.6	16.1	18.81
NL _1420	15.7	14.5	14.97	39.4	35.1	36.70	18.5	15.0	16.41
NL_ 1368	16.4	14.6	15.53	41.7	38.1	39.93	18.5	15.6	16.71
NL_ 1376	15.1	13.0	13.84	40.0	36.0	37.65	18.3	15.9	16.71
NL_ 1404	16.7	15.0	15.91	40.0	37.2	38.41	18.5	15.6	16.71
NL_ 1412	17.0	15.3	16.28	40.0	36.9	38.22	19.2	17.2	18.21
Mean	16.38	14.87	15.6	41.95	37.5	39.7	19.25	16.3	17.8
CV%	6.31	4.38	5.5	8.05	6	7.2	12.24	8.78	10.9
$LSD_{0.05}$	1.11	1.35	0.8	4.10	4.6	2.8	2.10	2.98	1.6
F-test	*	**	**	*	NS	**	*	*	*

NSPS and NGPS are reduced at late sown condition than normal sown condition. Similar result is reported by [34]. Semenov reported that temperatures above 20°C speed up the development of the spike initiation and anthesis which reduces the number of spikelet and grain per spike [35]. There will not be floret development above 30°C that may cause complete sterility based on wheat genotype [36]. According to [37] structurally abnormal and nonfunctional floret are produced under 3 days heat stress condition during anthesis.

3.8. Number of Grain per Spike (NGPS)

NGPS has a significant difference in normal sowing and combined environment and non-significant difference in late sowing condition among genotype (Table 5). Under normal sowing, maximum NGPS mean is found in NL 1381(49.9) and minimum in NL 1369 (39). Under late sowing, the maximum NGPS mean is recorded in NL1387 (40.4) and the minimum in NL 1420 (35.1). Mean NGPS in late sowing conditions is 10.6% lower than in normal sowing conditions.

3.9. Spike Weight (SW)

SW shows a significant difference among genotypes in normal sowing, late sowing, and combined environment (Table 5). Under normal sowing, maximum SW mean is recorded in BL 4919 (20.8 gm) and minimum in NL 1376 (18.3 gm). Under late sowing, the maximum SW mean is recorded in NL 1387 (17.8 gm) and the minimum in NL1346 (14.5 gm). Mean SW in late sowing conditions is 15.32% lower than normal sowing conditions. Spike weight reduces at late sowing than normal sowing condition. This result is similar to [12]. According to [33] phytohormone ethylene production in spike at high-temperature stress condition reduce spike weight.

3.10. Effective Tiller/m^2 (ET)

ET shows a significant difference in early sowing, late sowing, and combined environment among genotype (Table 6). Under normal sowing, maximum mean ET is recorded in NL1368 (476.7) and minimum in NL1350 (344.1). Under late sowing, maximum mean ET is recorded in NL1420 (395.7) and minimum in NL 1350 (305.5). Mean ET in late sowing conditions is 9.92% lower than normal sowing conditions.

ET is reduced under late sowing conditions than in normal sowing conditions. This result is similar to [12]; [8]. In wheat, *tin genes* are responsible for avoiding late tillering at the grain filling stage. Drought and heat stress suppress tillering capacity during the early growth phase [38]; [39]

3.11. Thousand Kernel Weight (TKW)

TKW has a significant difference in normal sowing, late sowing, and combine environment among genotypes (Table 6). Under normal sowing, the maximum mean TKW is recorded in NL1350 (43 gm) and the minimum in NL 1179 and NL1346 (31 gm). Under late sowing, the maximum mean TKW is recorded in NL1350 (39 gm) and the minimum in NL 1368 and NL1384 (28 gm). Mean TKW in late sowing conditions is 10.3% lower than normal sowing conditions.

TKW is reduced at late sowing condition. This result is similar to [40]; [41]. Dias et al. reported that shrinking of grains due to change in structures of the aleurone layer and cell endosperm occur at high temperature (31/20°C during day/night) [42]. During the reproductive stage or post-anthesis stage, high-temperature stress results in a reduction of kernel weight and also short-grain filling period of wheat [43]; [44]; [45].

3.12. Grain Yield (GY)

GY shows a non-significant difference among genotype in normal sowing, late sowing, and combined environment (Table 6). Under normal sowing, the maximum mean GY is recorded in NL 1420 (4118 kg/ha) and the minimum in NL1346 (3155 kg/ha). Under late sowing, the maximum GY mean is recorded in NL1420 (3310.5 kg/ha) and the minimum in NL 1386 (2499 kg/ha). Mean Grain yield in late sowing conditions is 22.5% lower than normal sowing conditions.

GY is reduced at late sowing than normal sowing condition. This result is similar to [40]; [46]. In general, in late sowing conditions wheat genotype faces high-temperature stress, moistures stress, and other abiotic stress which shortens the heading, grain filling duration, and maturation, ultimately reducing grain yield and grain quality [47].

Table 6. ET, TKW, and GY Response Under Normal and Late Sowing Conditions among Genotype

Genotype	Effective tiller/m^2			Thousand kernel weight			Grain yield		
	Normal sown	Late sown	Overall	Normal sown	Late sown	Overall	Normal sown	Late sown	Overall
Bhirkuti	370.1	355.4	362.29	37	30	33.56	3810	2803.5	3307
BL _4407	362.7	351.6	356.28	36	31	33.33	3479	2752	3115
BL _4919	376.7	353.7	364.57	32	29	30.27	3577	2930.5	3254
BL_4669	385.0	365.7	375.97	29	26	27.44	3492	2803	3147
Gautam	429.6	386.1	410.59	32	29	30.49	3797	3053	3425
NL _1179	411.0	384.0	400.02	31	28	29.55	3628	3071	3349
NL _1346	435.8	395.3	419.30	31	27	28.61	3155	2628	2891
NL _1350	344.1	305.5	319.18	43	39	40.85	3954	2657	3306
NL _1369	375.1	323.8	345.71	32	31	31.70	3596	2806.5	3201
NL _1381	389.6	370.2	380.95	29	26	27.23	3517	2732.5	3125
NL _1384	459.0	384.3	424.27	28	26	26.98	3765	3058.5	3412
NL _1386	385.4	345.8	364.16	32	30	30.99	3640	2499	3070
NL _1387	383.8	348.9	365.19	34	30	32.16	3466	2869	3167
NL _1413	428.8	378.8	405.82	30	27	28.38	4027	2962.5	3495
NL _1417	378.4	337.5	355.66	36	29	32.38	3485	2809.5	3147
NL _1420	438.3	395.7	420.75	32	29	30.74	4118	3310.5	3714
NL_ 1368	476.7	358.9	417.85	28	23	25.35	3769	2759	3264
NL_ 1376	374.3	363.7	369.34	32	29	30.06	3548	2718	3133
NL_ 1404	418.1	359.9	389.03	29	28	28.40	3739	2886.5	3313
NL_ 1412	363.5	328.6	342.81	36	32	33.80	3632	2609	3121
Mean	399.3	359.68	379.5	32.4	28.83	30.61	3659.68	2835.9	3247.80
CV%	6.4	7.53	6.8	3.9	5.23	4.19	9.30	11	10.33
LSD	34.6	56.5	28.6	1.8	3.14	1.82	391.78	671	531.61
F-test	***	*	***	***	***	***	NS	NS	NS

4. Conclusion

Heat stress and moisture stress occur at late sowing conditions which interfere with the physio-morphological and yield potential trait of wheat genotype. For wheat production in many parts of the world including Nepal, drought and heat stress are major problems. After this research, we can conclude that late sowing significantly affects the yield and yield attributing character of wheat genotypes. At late sowing condition, NL 1420 shows higher grain yield and BL1407 show early maturity among genotypes. NL 1420 and BL 1407 showed higher grain yield and early maturity at normal sown conditions. Maximum grain yield is recorded in NL1420 under combined environment. Thus this result suggested that the tolerant line against the late sowing condition and early maturing genotypes can be used as genetic resource for crop improvement and promote for grain yield.

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