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Sowing Dates Effects and Varieties Comparison and Their Interaction on Yield and Yield Components of Wheat (*Triticum aestivum* L.)

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A R T I C L E I N F O

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A B S T R A C T

Wheat (*Triticum aestivum L.*) growth is directly affected by sowing dates. However, the yield of wheat in Afghanistan is significantly lower than the global standard. Several factors including fertilizers, sowing dates, seeds and cultivation methods, contribute to this low yield. The objective of this research was to address this critical issue by comparison of the effects of different sowing dates on wheat yield and its components under Kabul climatic conditions. The same experiment was conducted at two sites in 2020 using a randomized complete block design (RCBD) with three replications and twelve treatments. The varieties used were Darolaman-07 (V_1), Mazar- 99 (V_2), and Chunta-1 (V_3) as factor one, and sowing dates of November 10th (S_1), November 18th (S_2), November 26th (S_3), and December 4th (S_4) as factor two. Growth and yield parameters measured and analyzed included plant height, number of leaves plant^{-1}, total number of tillers plant^{-1}, leaf area index (LAI), leaf nitrogen content (N), spike length, number of spikelets spike^{-1}, number of grains spike^{-1}, grain weight spike^{-1}, thousand- grain-weight, days to maturity, number of spikes plant^{-1}, biological yield, grain yield, straw yield, and harvest index. Sowing dates had significant effects on some wheat growth and yield parameters. Sowing on November 10th, 2020, resulted in the highest plant height and leaves number per plant compared to later sowing dates. There was a significant interaction between sowing date and variety at ($P<0.01$) in both growth and yield parameters. ANOVA analysis highlighted significant differences among wheat varieties in spike length, grain weight spike^{-1}, thousand grain-weight, and harvest index, with notable variations observed among different varieties. Based on the results, the longest duration to maturity and the highest grain yield were observed on sowing date of November 10, 2020.

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Introduction

Wheat (*Triticum sativum* L.) is one of the economically important crops in Afghanistan, which is used as bread, cake, cokes, and consumed with so many different varieties of food Wheat is cultivated as rain-fed and irrigated in Afghanistan but due to the dry climate and low precipitation; most farmers cultivate it in irrigated land. Wheat is planted in broadcast and line system followed by technologies and animal power. Wheat is a staple crop in Afghanistan, it estimated the 70 percent of the production in Afghanistan (FAO, 2003). Wheat cultivation area was estimated at 2.55 million hectares produced 4.26 million tons in 2023 (Habibi, 2023).

The annual need for wheat in Afghanistan estimated at about seven –million-ton to achieve self-sufficiency (Waziri et al., 2013; Sharma and Nang, 2018). A multipronged strategy utilizing more widespread use of improved seed and fertilizer, date of cultivation, better crop management and an effective research and extension system is needed to achieve self-sufficiency in wheat production (Waziri et al., 2013).

The wheat possess very low yield in Afghanistan than the world countries like the USA (3539), China (5409) and India-(3093) kg-ha^{-1}, respectively (FAOSTAT, 2016). Causes of low yield in Afghanistan are the use of poor-quality seed, improper sowing time, pest infestation, scarcity of irrigation water and less use of fertilizers, especially phosphorus. Increasing temperatures are also adding to this reduction (Aslam, 2016). Therefore, this study seeks to fill this critical gap by evaluating the effects of different sowing dates on wheat yield. Uncertainty of wheat cultivation date is one of the problems of farmers in Afghanistan. Low yield of wheat per unit area regarding lack of awareness and information is the biggest problem of wheat production.

Wheat growth is directly affected by sowing time and climate, which act as critical components of crop production. The optimum time of wheat sowing results in a maximum number of secondary branches (tillers), the height of the plant, races development, thousand grains weight, grain yield, and total dry matter that gradually decrease with late sowing time (Baloch et al., 2010).

Cultivation date and climatic conditions can adversely affect wheat yield by effecting dry matter, leaf index, 1000-grain weight as well as harvest index. All the components involving in crop production are very sensitive to climatic factors and all the processes in crop production from germination to harvesting will have a direct effect on any alteration in weather change (Asseng et al., 2017).

Crop sown on November*15, had better produce than early and late planting time (Subhan et al., 2004). Therefore, it is very valuable to describe the ideal date of sowing, due to the variation in weather parameters of environments (Kristo et al., 2007). Different stages of wheat improvement are impacted by genetic and climate factors (Sial et al., 2005). The crop sown at an ideal time is the best practice to enable the crops growing under prevailing climatic conditions (El-Gizawy, 2009). Higher yield can be achieved by given long maturation period to crop due to early sowing than late sowing. Late sowing of crop increases chance to face the hot weather conditions during critical stages such as grain formation stage that is important parameter in low yield of wheat (Turk and Tawaha, 2002). Climatic conditions of November favor the seed germination, dense crop stand and ultimately reduce the weed infestation (Khan and Salim, 1986).

The observed data shows that it is economically unfavorable to increase the seed rate at an optimum sowing time, but it is favorable in respect to delay sowing to overcome the yield losses increasing the seed rate (Pan et al., 1994). High temperature (up to 30ºC) can limit the crop growth period as it limits days to booting, an-thesis, physiological maturity and ultimately total maturation period (Ishibashi et al., 2008). The high temperature then its normal range at grain filling stage can reduce the crop yield (Maçãs et al., 2000). The net-grain weight decreased due to rise in temperature which ultimately reduces the total grain yield (Humphreys et al., 2001). Poor stand establishment also reduced the total grain yield (Farooq et al., 2008).

The produce and output components of wheat are influenced by various sowing times among varieties (Tahir et al., 2009).

Best time of sowing shows the satisfactory length of growing season, but the growth rate may be slower than the crop sown at the optimum time. Cultivation time is one of the important factors among of all agricultural practices (El-Gizawy, 2009).

Both soil and climate are required for germination and emergence rate as well as for the development of the crop. The suitable sowing time and temperature contribute plant protection (Pavlova et al., 2014).

Wheat is becoming susceptible to climate variability all over the world (Hossain and Da Silva, 2012). They concluded their results from two sowing dates and three cultivars for growth, phenology and yield.

Sowing date meaningfully influenced on all the parameters of crop except harvest index [HI (Lak et al., 2013)].

Late sowing reduces LAI during the early season. The different thermal times will cause differences in LAI development among sowing dates (Milford et al., 1985).

Conducted a field experiment having three wheat varieties (Chakwal-50, Wafaq-2001, and an advance line NR-268) and four sowing dates from 20th of October, 5th November, 20th of November and 5th of December in winter season of 2008-2009 in a (RCBD) using factorial arrangements (Nawaz et al., 2013).

Tools for crop growth modeling are used to extend agriculture research by supporting in planning and decision making in agriculture (Fakhar and Khaid, 2023).

The plant growth modeling is used to assess CGR, in the developmental stages and the allocation of dry mass into various growing components of the plant. Due to the vibrant nature of all these processes, they are affected by cultivar-specific and environmental factors. The description of all these vital processes provides an approach to figure out the cultivars differences and a system of simulation and grain yield forecasting by means of crop models.

Most of the climate associated factors like daily sunshine hours, maximum-minimum temperature ranges, rainfall, the water holding capacity of the soil and various factors which are related to crops (White et al., 2011).

For 60% of the cultivated area, there was a variation of less than one month between observed and simulated sowing times (Waha et al., 2012). Five months variation was observed in a tropical climate where climatic conditions stay favorable all over the year.

The overall objectives of this study were to study the effects of sowing dates on growth and yield of three varieties of wheat, to determine the yield potential in these wheat varieties under various sowing dates and to find out the suitable dates for planting of wheat in Kabul climatic conditions. Research Hypothesis was as following:

H_0: Different dates of sowing don't have effects on yield and yield component of wheat.

H_1: Different dates of sowing have significant effects on yield and yield components of wheat.

Materials and Methods

Two cultivars of wheat were sown in a factorial design (Factorial RCBD) with three replications and 12 treatments, which three wheat cultivars such as Darolaman-07, Mazar- 99 and Chunta-1, and for dates of cultivation such as 10th, 18th, 26th, of November and 4th of December.

This experiment was conducted into two sites at the Experimental Research Farm of Agriculture Faculty of Kabul University in 2020.

Seedbed was prepared by one application of rotator followed by two plowing and planking. The distances were 20 cm row to row and 120 kg ha^{-1} seed rate. Fertilizers (N: DAP) were applied at 250: 125 $kg.ha^{-1}$, respectively. The whole recommended amount of DAP and half of the nitrogen was applied at the time of sowing. The remaining nitrogen was applied into two equal splits at the time of 1st and 2nd irrigations.

Vernier Clipper was used to measure the seed length and width. A chlorophyll meter (SPAD-502) made in Japan was used to indicate the nitrogen level in the leaves.

Growth parameters such as plant height, number of leaves $plant^{-1}$. Number of tillers $plant^{-1}$, number of spike $plant^{-1}$, spike length, leaf area index, and leaf nitrogen content as well as and yield parameters including number of grain $spike^{-1}$, number of spikelet $spike^{-1}$, grain weight $spike^{-1}$, thousand grain-weight, grain yield, straw yield and biological yield were measured by sampling method randomly. Data were analyzed using Excel and Statistical Tool for Agricultural Research (STAR), version 2.0.1, January 2014. Least Significant Difference (LSD) has also been used for comparing the treatments.

Results and Discussion

Growth Parameters

Based on statistical analysis, sowing dates and varieties interaction significantly affected plant height, number of leaf $plant^{-1}$, spike length, leaf area index and leaf nitrogen content at ($P<0.01$) (Table 1). The interaction of different sowing dates and varieties had no significant effect at ($P<0.01$) on the number of tillers per plant as well as the number of spikes per plant (Table 1). Treatment nine (V_3S_1) exhibited the tallest plants average (88.8 cm) and treatment four (V_1S_4) the shortest plant height average (66.6 cm). The largest number of leaves per plant was obtained (5.3) from treatment five (V_2S_1) and the lowest number (4.7) from treatment eleven. Treatment nine (V_3S_1) performed the largest number of tillers (6.8) and the lowest (5.2) in treatment four (V_1S_4). The largest number of spikes per plant was (6.8) in treatment five (V_2S_1) and (5.2) lowest in treatment four (V_1S_4). The longest leaf length (9.4 cm) observed in treatment two (V_1S_2). Treatment four (V_1S_4) performed the widest leaf area index and treatment ten (V_3S_2) the narrowest leaf area index (24). Highest amount of nitrogen (48.8 mg) was obtained from treatment four (V_1S_4) and the lowest amount (41.5 mg) from treatment nine (V_3S_1) (Table 1). As a conclusion the different sowing dates in a combination with three promise varieties of wheat exhibited differences among treatments. We can say that the time of cultivation has an important role in wheat productivity. Time of cultivation of different agro-climatic zones is different for wheat cultivation in Afghanistan.

V1: Darolaman-07, V_2: Mazar-99, V_3: Chunta-1, S_1: Sowing on 10-11-2020; S_2: Sowing on 18-11-2020; S_3: Sowing on 2, 6-11-2020; S_4: Sowing on 05-12-2020.

Plant height is one of the important parameters in the determination of yield. Plant height was influenced by interaction of sowing dates and varieties at ($P<0.01$). Treatment nine (V_3 S_1) exhibited the tallest plant (88.8 cm) and treatment four (V_1S_4) the shortest plant height (66.6 cm) (Table 1).

Yield Parameters

Sowing dates performed significant effects ($P<0.01$) on grains $spike^{-1}$, spikelet $spike^{-1}$, grain weight $spike^{-1}$, grain yield and different sowing dates had not significant influence ($P<0.01$) on 1000 grains weight, straw and biological produces (Table 2). The largest grains $spike^{-1}$ was obtained from treatment number four (V_2S_3), which is (46 grains per spike) and the lowest in treatment nine (38 grains per spike).

Treatment nine exhibited the largest number of spikelet $spike^{-1}$ (16.9) and the less in treatment four (14.2). Treatment two performed the heaviest grains per spike (12.6 g) and the lightest in treatment twelve (9.6 g). The heaviest 1000-grain weight was observed in treatment nine (29.5 g) and the lightest in treatment eight (24.6 g). The largest grain yield (3416.6 $kg.ha^{-1}$) obtained from treatment five, and treatment four performed the lesser yield (1648.3 $kg.ha^{-1}$). Treatment Four had the largest straw yield kg ha^{-1} and treatment five the lesser (10083.3); it means a negative correlation between yield and straw is existed. The largest biological yield (20722.2.kg ha^{-1}) was obtained from treatment four and the lowest in treatment twelve (6555.5). Based on the above discussion the sowing dates highly affected on yield parameters such as number of grains $spike^{-1}$, number of spikelet $spike^{-1}$, grains weight $spike^{-1}$(g) thousand grain-weight (g) and grain yield ($kg.ha^{-1}$) but no significant influence on straw yield ($kg.ha^{-1}$) and biological yield ($kg.ha^{-1}$) at ($P<0.01$) (Table 2).

Table 1. Cultivation dates and varieties influence on wheat growth parameters.

Treatments	Plant height (cm)	Number of leaves $plant^{-1}$	Number of tillers $plant^{-1}$	Number of spikes $plant^{-1}$	Spike length (cm)	Leaf area index	Leaf nitrogen content (mg)
V1S1	83.5^{a}	5.2^{ab}	6.7^{a}	6.7^{a}	8.9^{abc}	27.3^{ab}	46.4^{ab}
V1S2	74.5^{ab}	5.0^{ab}	5.9^{a}	6.4^{a}	9.4^{a}	44.2^{ab}	46.2^{ab}
V1S3	74.7^{ab}	5.0^{ab}	5.6^{a}	6.0^{a}	9.3^{ab}	45.8^{ab}	46.0^{ab}
V1S4	61.7^{b}	5.0^{ab}	5.2^{a}	5.2^{a}	9.0^{abc}	49.9^{a}	48.8^{a}
V2S1	85.6^{a}	5.3^{a}	6.6^{a}	6.8^{a}	8.5^{abc}	28.1^{ab}	45.4^{ab}
V2S2	76.5^{ab}	5.1^{ab}	6.0^{a}	6.0^{a}	9.1^{abc}	30.4^{ab}	43.1^{ab}
V2S3	79.0^{ab}	4.9^{ab}	6.6^{a}	6.7^{a}	9.3^{ab}	26.4^{ab}	42.9^{ab}
V2S4	75.7^{ab}	5.2^{ab}	6.4^{a}	6.6^{a}	8.4^{bc}	25.9^{ab}	46.2^{ab}
V3S1	88.7^{a}	5.0^{ab}	6.8^{a}	6.7^{a}	8.1^{c}	30.9^{ab}	41.5^{b}
V3S2	76.7^{ab}	5.0^{ab}	6.4^{a}	6.2^{a}	8.4^{bc}	24.1^{b}	42.2^{ab}
V3S3	79.1^{ab}	4.7^{b}	6.1^{a}	7.0^{a}	8.7^{abc}	25.0^{ab}	44.5^{ab}
V3S4	74.5^{ab}	5.0^{ab}	6.4^{a}	6.4^{a}	8.4^{bc}	26.3^{ab}	43.9ab
SD	7.8	0.2	1.1	1.4	0.6	13.9	4.0
CV (%)	10.7	3.9	18.4	21.6	6.7	41.2	8.9
ANOVA	**	**	ns	ns	**	**	**

Table 2. Interaction between cultivation and variety on yield and yield components of wheat.

Treatments	NGPS	NSPS	GWPS (g)	1000GW (g)	GY (kg.ha^{-1})	SY (kg.ha^{-1})	BY (kg.ha^{-1})
V1-S1	40.3^{ab}	16.5^{ab}	12.1^{ab}	27.1^{ab}	2995.5^{ab}	7948.8^{a}	10944.4^{a}
V1-S2	45.0^{ab}	16.4^{ab}	12.6^{a}	28.1^{ab}	1940.0^{c}	5393.3^{a}	7333.3^{a}
V1-S3	44.1^{ab}	16.3a^{bc}	12.1^{ab}	27.6^{ab}	2170.0^{bc}	5441.1^{a}	7611.1^{a}
V1-S4	39.5^{ab}	14.2^{c}	11.1^{ab}	28.6^{ab}	1648.3^{c}	19073.8^{a}	20722.2^{a}
V2-S1	40.1^{ab}	16.7a^{bc}	11.0^{ab}	27.8^{ab}	3416.6^{a}	10083.3^{a}	13500.0^{a}
V2-S2	41.8^{ab}	16.2^{abc}	10.1^{ab}	27.1^{ab}	2155.0^{bc}	5733.8^{a}	7888.8^{a}
V2-S3	46.0^{a}	16.9^{a}	11.8^{ab}	25.5^{ab}	2205.5^{bc}	6961.1^{a}	9166.6^{a}
V2-S4	38.3^{ab}	14.5^{bc}	9.8^{b}	24.6^{b}	1803.8^{c}	5307.2^{a}	7111.1^{a}
V3-S1	38.0^{b}	16.6^{ab}	10.8^{ab}	29.5^{a}	3393.8^{a}	7717.2^{a}	11111.1^{a}
V3-S2	41.3^{ab}	15.4^{abc}	11.1^{ab}	27.5^{ab}	2179.4^{bc}	5487.2^{a}	7666.6^{a}
V3-S3	44.1^{ab}	16.7^{a}	12.3^{ab}	27.5^{ab}	2141.1^{c}	5136.6^{a}	7277.7^{a}
V3-S4	38.8^{ab}	15.1^{abc}	9.6^{b}	27.0^{ab}	2435.5^{abc}	4120.0^{a}	6555.5^{a}
SD	4.9	1.3	1.4	3.0	587.6	4571.7	4759.5
CV (%)	12.0	8.2	13.3	11.0	24.6	41.4	35.2
ANOVA	**	**	**	ns	**	ns	ns

Number of grains per spike (NGPS), Number of spikelet per spike (NSPS), Grain weight per spike (GWPS), 1000 grain-weight (GW), Grain yield (GY), Straw yield (SY), Biological yield (BY) and Harvest index (HI), Standard error (SD), Coefficient of variation (CV), Variety (V) and Sowing (S), V_1: Darolaman-07, V_2: Mazar-99, V_3: Chunta-1, S_1: Sowing on 10-11-2020; S_2: Sowing on 18-11-2020; S_3: Sowing on 26-11-2020; S_4: Sowing on 05-12-2020.

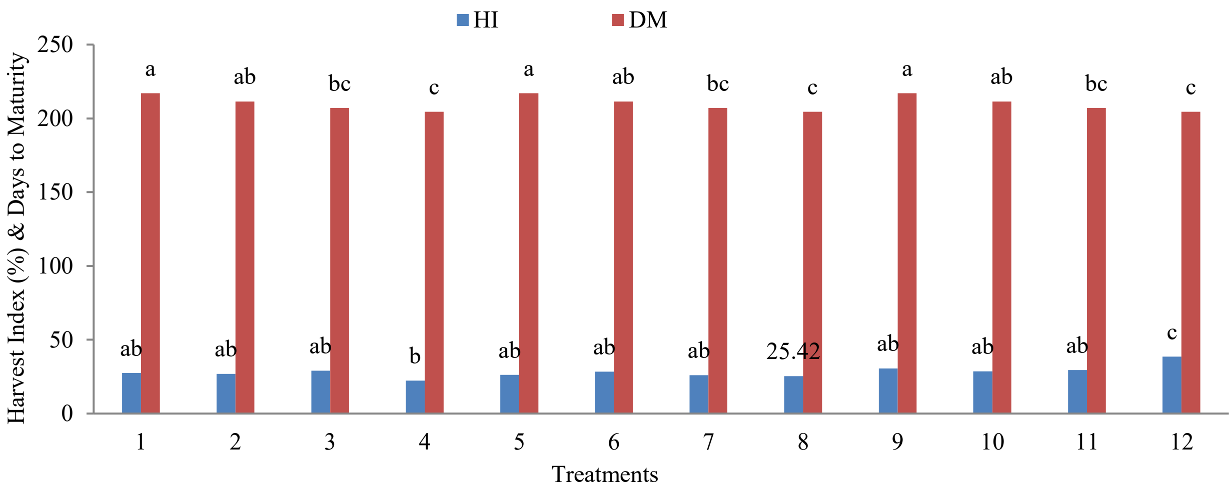

Figure 1. Combining effects of sowing dates and varieties on harvest index and days to maturity. Figure 1?

Harvest Index and Days to Maturity

Based on statistical analysis of harvest index data, significant differences from interaction of cultivation times and varieties among treatments on harvest index were not observed at (P<0.01) but sowing dates and verities combination exhibited variation among treatments at (P<0.01) (Figure 1).

Correlation among the different quantitative traits of wheat

Correlations among traits were analyzed based on the mean value of each parameter. A significant positive correlation was among most of the traits (Figure 2). The highest significant correlation was obtained between biological yield and straw yield (r=1). The plant height at 90 days after sowing exhibited strong significant positive correlation with plant height at 60 days after sowing (r=0.88) and plant height at 120 days after sowing (r=0.75). A significant linear correlation was observed among the number of spikes per plant, the total number of tillers per plant (r=0.72), the plant height at 30 days after sowing and the number of days to maturity (r=0.72), the number of grains per spike and spike length (r=0.71). Plant height at 60 days after sowing and the number of spikelet per spike (r=0.69) and the number of spikelet per spike and the number of grains per spike (r=0.67) performed a positive correlation.

A moderate correlation was observed in spike length among treatments and spikelet spike^{-1} (r=0.59), grain yield, plant height at 15 days after sowing (r=0.56), grain yield, plant height at 30 days after sowing (r=0.51), grain yield and plant height at 60 days after sowing (r=0.46), grain yield and plant height at 90 days after sowing (r=0.62), grain yield and plant height at 120 days after sowing (r=0.47). Moderate positive correlation was also observed among the leaves plant^{-1} at 15 days and plant height at 15 days (r=0.51), plant tallness at 60 days (r=0.52), plant height at 90 days (r=0.51). Negative significant correlations were observed between straw yields and harvest index (r=-0.50), biological yield and harvest index (r=-0.46), and leaf nitrogen content and plant height at 90 days after sowing (r=-0.44) (Figure 2).

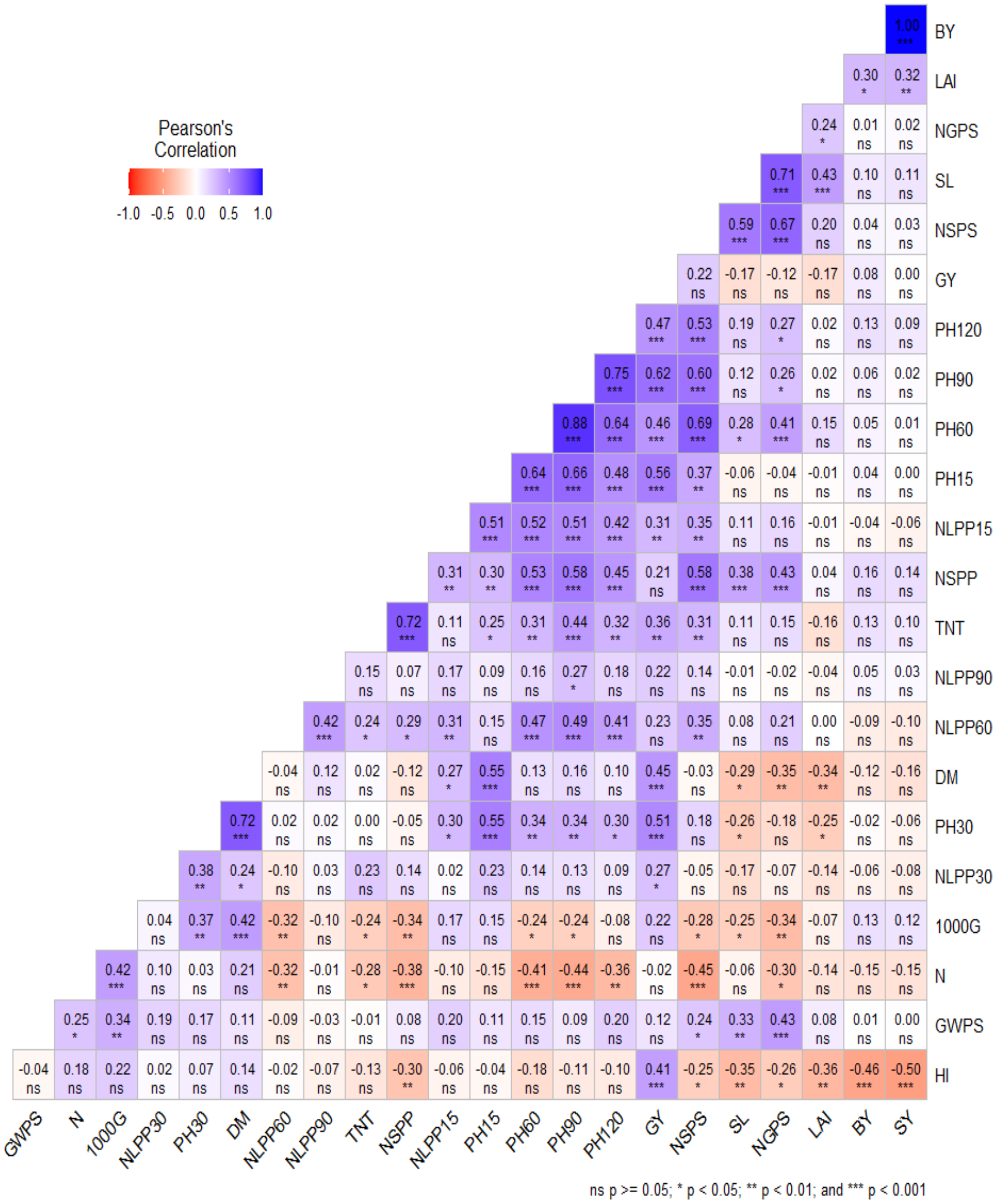

Figure 3. Pearson linear correlation coefficients among the different traits of wheat.

Conclusion

This study focused on sowing dates and three promising varieties of wheat to evaluate their growth and yield. Statistical analysis revealed that sowing dates and varieties affected plant height, number of leaves per plant, spike length, leaf area index, and leaf nitrogen content, but there was no significant effect (P<0.01) on the number of tillers per plant and number of spikes per plant. The results showed that sowing date has a significant influence on the growth parameters of wheat. Among these parameters, plant height, number of leaves per plant, and leaf nitrogen content were the most important. Sowing time influenced plant height at 15, 30, 60, 90, and 120 days after sowing, as well as the number of leaves per plant at 15 and 90 days after sowing, and leaf nitrogen content. Cultivation on November 10th, 2020, resulted in the tallest plants at various growth stages. While sowing on December 4th, 2020, led to the shortest plant height. Additionally, sowing on November 10th also produced the largest number of leaves per plant at 15 and 90 days after sowing. ANOVA results for post-harvest and yield parameters indicated highly significant differences among the three wheat varieties for spike length (P<0.01), as well as for sowing dates. Significant differences were observed in grain weight per spike, spikelets per spike, grain weight per spike, thousand-grain weight, and seed yield; however, sowing dates and varieties did not significantly influence straw and biological yield (P<0.01). Specifically, V_1S_2 yielded the highest grain weight per spike (12.6 g), while V_2S_4 had the lowest (9.8 g). Additionally, V_3S_1 had the heaviest thousand-grain weight (29.5 g), whereas V_2S_4 had the lightest (24.6 g). Notably, V_3S_4 achieved the highest harvest index (38.6%), while V_1S_4 had the lowest (22.29%). The findings also revealed highly significant effects (P<0.01) of sowing dates on spike length, spikelets spike^{-1}, grains per spike, seed weight per spike, days to maturity, and yield. Sowing on November 26th, 2020 (sowing 3) resulted in the longest spike length, highest number of spikelets per spike, grains per spike, and seed weight per spike, while sowing on November 10th, 2020 (Sowing 1) led to the shortest spike length. Sowing on December 4th, 2020 (Sowing 4) produced the lowest number of spikelets per spike, grains per spike, and grain weight per spike. Regarding days to maturity, sowing 1 required the longest duration (217 days), while sowing 4 had the shortest (204 days). Additionally, the highest yield was achieved with V_2S_1 (3416.6 $kg.ha^{-1}$), while the lowest yield (1962.59 $kg.ha^{-1}$) was obtained from V_1S_4. Significant positive correlations were observed among most evaluated growth and yield parameters of wheat, highlighting key associations that could inform breeding and management strategies aimed at maximizing wheat productivity and quality in Afghanistan. Overall, these findings underscore the critical impact of sowing time on wheat production, emphasizing the need for careful consideration in agricultural planning to optimize crop productivity in Afghanistan. Given that wheat is a staple crop in Afghanistan and the country faces a wheat deficiency, with imports from neighboring countries annually, further research on factors that can increase wheat productivity in Afghanistan is recommended.

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