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EVALUATION OF VARIOUS MORPHO-PHYSIOLOGICAL AND GROWTH TRAITS OF DUAL PURPOSE WHEAT UNDER EARLY SOWING DATES

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Abstract

The use of wheat as dual purpose crop (for fodder and grain) is considered as promising agronomic management practice fulfilling human and animal need at same time. These expectations are largely found on positive experiences by growing wheat as dual purpose crop throughout the world. However, the validity of these results in Pakistan needs confirmation from field experiments under various sowing date and potential cultivars. The impact of cutting and sowing date on morphological and physiological traits of already existing wheat cultivars was evaluated at Agricultural Research Farm of The University of Agriculture, Peshawar Pakistan in winter 2010-2011 and 2011-2012. Three sowing dates i.e. 15th October, 30th October and 14th November and six wheat cultivars (Ghaznavi-98, Fakhre-Sarhad (FS)-99, Ghaznavi-98, Saleem-2000, Uqab-2000 and Siran-2008) were compared for dual purpose wheat production during the course of experiment. Findings showed that significant reduction were recorded in nodes tiller^{-1}, plant height, spike weight and grains weight spike^{-1} when sowing of wheat delayed from 15th and 30th October to 15th November. Considerable variations were also noted in nodes tiller^{-1}, internodes length and leaf area index, plant height and lodging score among wheat cultivars but it was mainly due to their genetic characteristic not because of cutting treatment. It was observed that cutting caused 5.5, 12.1, 6.2, 4.1, 25.9, 7.1, 6.6% reduction in wheat leaf area, leaf area index, internode length, plant height, lodging score, spike weight and grains weight spike^{-1} , respectively over non cut plots in both year of the experiment. Interestingly, no-significant change was noted in spike length and number of nodes tiller^{-1} under cut and no cut plots. The conclusive findings suggested that optimum sowing date (15th and 30th October) for all wheat cultivars could be utilized as potential source of dual purpose wheat for substantial reduction of lodging without compromising on important morphological and physiological characteristics.

Key words: Dual purpose wheat, food security, forage production, land utilization and sowing dates.

Introduction

The ever increasing populations and need for higher quantity of food grains is compelling to reduce the fodder area for livestock particularly in fall season where severe shortage of quality fodder occurs due to the hard environmental conditions (Naveed *et al*., 2014 and Khan *et al*., 2003). Also increasing wheat yield to manage food requirements for ever increasing population is real challenge for agriculture scientists (Ali *et al*., 2015). To tackle this, the application of production technology like dual purpose wheat system that will not only provide quality fodders for livestock at early stage but will also provide grain later at maturity with least or no substantial reduction from the same crop and thus can be employed for reduction in space competition among forage and grain crops. This system can be properly utilized by appropriate planting time and selection of wheat cultivars with improved fodder and grain traits (Arzadun *et al*., 2006). Leaf area index is one the significant traits for dry matter estimation and economic yield of a crop (Akhtar *et al*., 2007) and thus can be used for the relative contribution in the assessment of growth performance of wheat cultivars sown at different dates and cutting. It varies due to agronomic measures and thus become limited factor for growth and wheat yield (Bavec *et al*., 2007). A positive significant association of grain yield with leaf area, spike weight, stems weight and leaf weight was reported by Ergul & Soylu (2009) and the significant improvement in these characters among the wheat cultivars results in increased fodder yield. Likewise, Icoz & Kara (2009) suggested that grain yield of wheat had positively correlated with increase in leaf number, stem diameter and spike weight whereas Iptas & Yavuz (2008) found negative association between dry matter yield and stem and leaf characteristic.

Lodging is considered to be a serious problem in achieving higher yield; the degree of lodging severely altered yield and can be reduced up to 75%. Wheat losses due to lodging were in the range of 12-66% whereas in case of barley and oat, losses were 40% and 35-40%, respectively. Greatest yield reductions occur when lodged at anthesis or early grain filling. Cutting of wheat at vegetative stage can be used as one of the alternatives for reduction of lodging and can be done before culm elongation (Redmon *et al*., 1996; Taylor *et al*., 2010). Cutting is successful in controlling lodging and in certain cases caused subsequent increase in grain yield as reported by number of scientists. Berry *et al*. (2004) reported gradual increase in the percentage of lodging in wheat from 100 to 400 plants m^{-2}. Cutting of wheat at stem elongation stage may not only reduce lodging but should be used as dual purpose system where both fodder and grain are produced from the same piece of land without significant decrease in grain yield. Likewise, Usman *et al*. (2007) reported that clipping of wheat at vegetative stage is one of the profitable ways for enhancing yield, with the additional benefit of reduction in lodging and the excessive vegetative growth as green fodder without considerable decrease in grain yield.

Keeping in view the importance of study, it is evident that plant traits related to morphology and physiology might be evaluated for its significant role in the growth behavior of dual purpose wheat, thus one might consider these traits for obtaining both higher forage and grain yield from the same crop. For this reason, the objectives of this study were to assess morphological and physiological characteristics of various wheat cultivars aimed for both fodder and grain yield under different planting dates.

Materials and Methods

Experimental site: The experiments were held at Agricultural Research Farm of the University of Agriculture Peshawar during winter from 2009-10 to 2010-11. The Farm is situated at 34.1°'21"North and 71°28'5" East about 359 m above sea level .The climatic conditions of the region is warm to hot, semi-arid, sub-tropical having average annual rainfall of 360 mm from October to May during 2009-10 and 300 mm during 2010-11 with mean maximum and minimum temperature of 28.4^{o}C and 6.4^{o}C, respectively. The greatest rainfall occurred in month of February during both the years. The site was deficient in nitrogen and phosphorus whereas potash content was moderate.

Experimental design: The experiment were consisted on three sowing times (Mid Oct., 30th Oct. and 14th Nov.), six high yielding cultivars (Saleem-2000, FS-99, Uqab-2000, Ghaznavi-98, Bathoor-2007 and Siran-2008) and cutting treatments (cut and no-cut) was conducted in RCB design with split plot arrangement having three replications in both the years. The sowing dates and cutting treatments were arranged in main plots while wheat cultivars were kept in subplots. A cut to the respective subplots was given after 70 days of sowing when the crop reached to stem elongation stage but before the formation of 1st node.

Experimental layout: The crop was sown on leveled and well prepared soil at field capacity having seed rate of 120 kg ha^{-1} in each sub plot (4 m x 3 m) with 30 cm row to row distance. Half of the nitrogen in the form of Urea and all phosphorus as DAP was applied at the rate of 120 and 100 kg ha^{-1} as basal doses whereas the remaining nitrogen applied soon after imposition of cut treatment to each subplot. Recommended agronomic measures like irrigations, use of herbicides (Buctril Super and Puma Super for control of broad leaves and grassy weeds, respectively) etc was kept uniform for each experimental unit.

Procedure for data recording: Data on leaf area tiller^{-1}, leaf area index, nodes tiller^{-1}, internodes length, plant height, lodging score, spike length, spike weight and grains weight spike^{-1} were recorded during the course of experiments. Number nodes stem^{-1} was determined by counting number of nodes in five representative tillers in each experimental unit and was then averaged. Plant height and internodes length was recorded by measuring the height and length of five tillers in each plot from the base to the tip and the average was worked out. Data on leaf area were recorded by passing the leaves of five randomly selected tillers through leaf area meter and leaf area tiller^{-1} was worked out. Leaf area index was determined non destructively by sun scan canopy analyzer (LI- 2000, LI- COR, USA). Data on lodging score were estimated from surface area of lodged crop. Lodging was based on scale where 1 indicates no lodging to 5 showed completely lodged (Pedersen & Lauer, 2002). Spike lengths of five randomly selected tillers were measured from the basal joint to the tip of the spike and the mean was recorded. Spike weight was determined by weighing five dry spikes in each experimental unit and was then averaged. Data on grain weight spike^{-1} was recorded by weighing the grains in five randomly chosen spikes and mean was calculated.

Statistical analysis: The statistical analysis of the data were carried out combined over years in RCB design with spilt plot arrangement using the statistical software Gen Stat release 8.1 (Gen Stat, 2005) UK, and significant means of sowing dates and wheat cultivars were compared using LSD test at 0.05 level of probability (Jan *et al*., 2009).

Results

Leaf area tiller^{-1}: Leaf area tiller^{-1} was considerably influenced by cutting treatment whereas no significant variation in leaf area tiller^{-1} was recorded among wheat cultivars and planting dates (Table 1). The year effect was not significant. None of the interactions was found significant for leaf area tiller^{-1}. Imposition of cutting decreased leaf area tiller^{-1} and hence leaf area tiller^{-1} (123.22 cm^2) was higher in no-cut than cut treatment (116.42 cm^2).

Leaf area index: Wheat cultivars and cutting significantly varied for leaf area index of wheat. Sowing dates did not significantly influence the leaf area index. Year had also significant influence on leaf area index. All the interactions were found non significant except DxV and VxC. Leaf area index was more during 1st year (4.16) than 2nd year (3.30). Wheat cultivar Saleem-2000 had greater leaf area index (3.89) that was at par to Uqab-2000, Siran-2008 and Ghaznavi-98, however Bathoor-2007 had lower leaf area index (3.53) which was statistically similar to FS-99 and Uqab-2000 (Table 1). Cutting reduced LAI and lower LAI was found in cut treatment (3.49) than no-cut (3.97). The reduction in leaf area index could be due to the removal of main stem with leaves for fodder yield thus suppressed leaf area index in cut treatment. Sowing dates and cultivars interaction revealed that Uqab-2000, Siran-2008 and Ghaznavi-98 had higher leaf area index when sown on 15th October, while Saleem-2000, Bathoor-2007 and FS-99 had higher leaf area index when sown on 30th October (Fig. 1a). The interaction between cultivars and cutting exhibited that leaf area index significantly reduced by cutting in all cultivars except Uqab-2000 and FS-99 (Fig. 1f).

Table 1. Leaf area, leaf area index, number of nodes tiller^{-1} and internode length of wheat cultivars as affected by planting dates and cutting.

Planting dates	Leaf area (cm^2)	Leaf area index	nodes tiller^{-1}	Internode length (cm)
15th Oct	117.89	3.70	6.17 a	15.61
30th Oct	121.54	3.76	6.09 a	15.50
14th Nov	120.04	3.73	5.96 b	14.72
$LSD_{0.05}$	Ns	Ns	0.12	Ns
Cultivars				
Saleem-2000	120.63	3.89 a	6.06 bc	14.25 d
Bathoor-2007	119.03	3.53 c	6.12 ab	15.61 ab
Fakhre Sarhad-99	119.10	3.63 bc	6.25 a	14.65 cd
Uqab-2000	120.37	3.68 abc	6.01 bc	16.09 a
Siran-2008	120.10	3.87 ab	6.08 b	15.74 ab
Ghaznavi-98	119.69	3.78 abc	5.92 c	15.29 bc
$LSD_{0.05}$	Ns	0.26	0.15	0.68
Cutting				
Cut	116.42	3.49	6.08	14.78
No-cut	123.22	3.97	6.07	15.76
Significance	**	**	Ns	**
Year				
2009-10	118.70	3.30	6.07	14.39
2010-2011	120.94	4.16	6.08	16.15
Significance	Ns	**	Ns	**
Interactions				
D x C	Ns	Ns	Ns	Ns
D x V	Ns	* (Fig. 1a)	**(Fig. 1b)	**(Fig.1c)
V x C	Ns	**(Fig. 1f)	Ns	Ns
D x V x C	Ns	Ns	Ns	Ns

Means for each category followed by different letters are significantly different from each other at 5% level of probability,
** = Significant at 1% level of probability, * = Significant at 5% level of probability, ns = Non-significant

Number of nodes tiller^{-1}: Planting dates had considerable effect on number of nodes tiller^{-1} whereas the effect of cutting was found not significant on nodes tiller^{-1}. There was no considerable difference among cultivars for nodes tiller^{-1}. The effect of year was also not significant. None of the interaction was significant except D x V (Table 1). The cultivation of wheat on 15th and 30th Oct. had more nodes tiller^{1} while the lesser number of nodes tiller^{-1} (5.96) was recorded under later sowing (14th Nov.). Wheat cultivar FS-99 and Bathoor-2007 had more nodes tiller^{-1} followed by Siran-2008, Saleem-2000 and Uqab-2000 being statistically similar among each other. Ghaznavi-98 had the least number of nodes tiller^{-1}(5.92). Interaction between DxV showed that Bathoor-2007, FS-99 and Siran-2008 resulted in higher number of nodes tiller^{-1} under early planting in mid October whereas Saleem-2000 and ghaznavi-98 produced more number of nodes tiller^{-1} when sown on 30th October (Fig. 1b).

Internode length (cm): Data regarding internode length of wheat is reported in Table 1. Planting dates had no significant influence on internodes length, whereas there was significant variation among the wheat cultivars, year and cutting treatment regarding internodes length. All interactions was found non significant except D x V. There was an increase in internodes length (16.15 cm) during 2010-11 than 2009-10 (14.39 cm). Uqab-2000 had longer internodes (16.09 cm) followed by Siran-2008 and Bathoor-2008 being non significant among each other. Saleem-2000 had the shortest internodes (14.25 cm) among all cultivars. Imposition of cutting had reduced internode length (14.78 cm) when compared to no-cut treatment (15.76 cm). The significant D x V interaction revealed that all wheat cultivars except Ghaznavi-98 and Uqab-2000 produced longer internodes under early planting in mid of October whereas FS-99 was least influenced by planting dates for internodes length (Fig. 1c).

Plant height (cm): Planting dates, cultivars, year and cutting considerably varied plant height of wheat. There were no significant interactions for plant height except D x V. Long stature plants (99.1 cm) were noted during 2nd year of the study than 1st year (93.2 cm). Early planting of wheat in mid October resulted in long stature plants similar to the 30th October planting (97 cm), however later sowing in mid November had the lower plant height (94 cm). Comparing various cultivars, greater plant height (99 cm) was achieved by Uqab-2000 followed by all other cultivars being non significant among each other except Ghaznavi-98 and Saleem-2000. Cutting reduced plant height by 4 cm as compared to no-cut plots (98 cm). Significant D x V interaction indicated that mid October sowing resulted in drastic reduction in plant height of Ghaznavi-98 and increase in plant height of Bathoor-2007 compared to other cultivars (Fig. 1e).

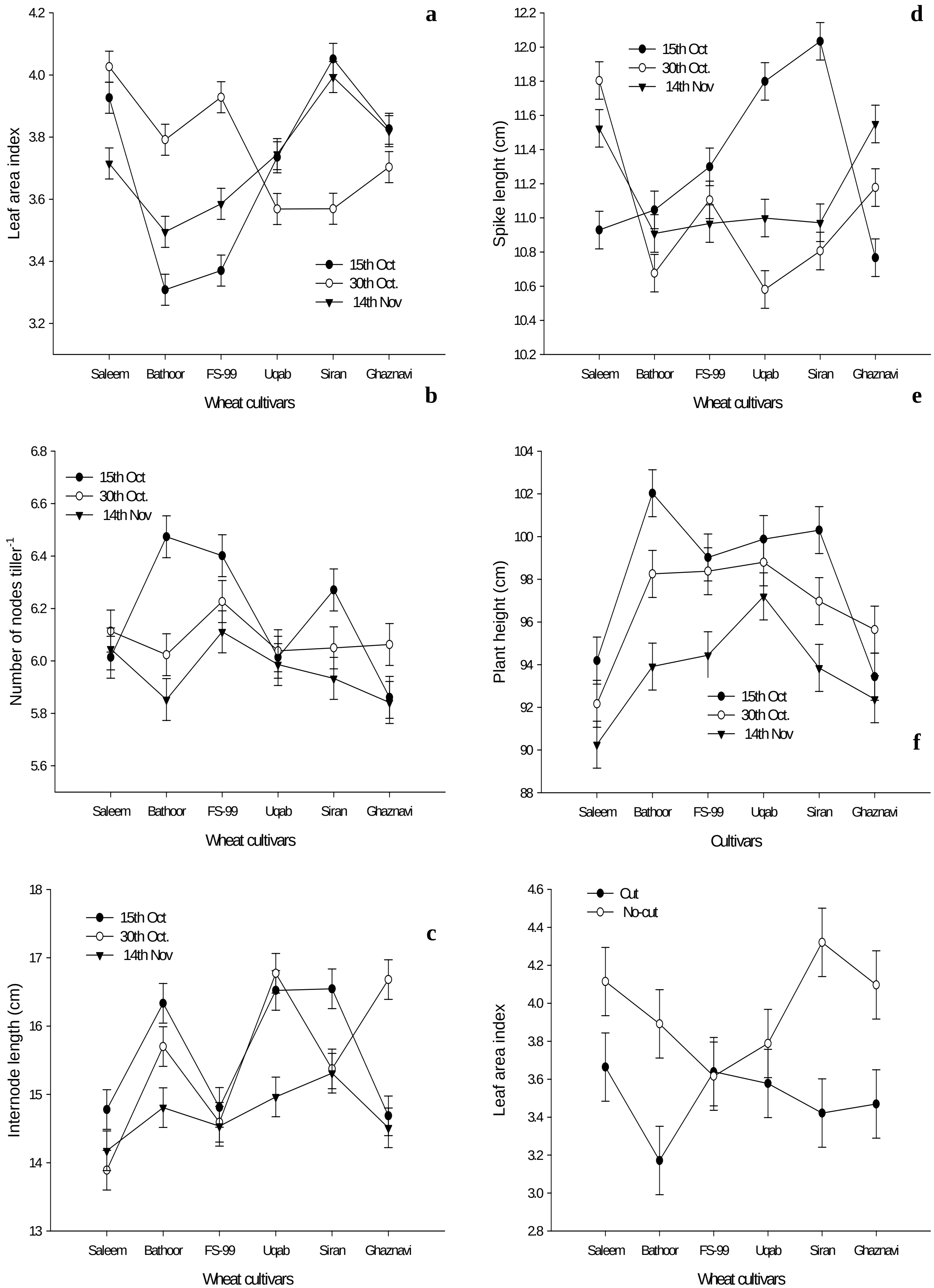

Fig. 1. Interaction between D x V for a) spike length of wheat b) number of nodes tiller^{-1} of wheat c) internode length and d) Leaf area index of wheat e) plant height and f) Interaction between V x C for leaf area index of wheat. Vertical bar denotes standard error of difference value.

Table 2. Plant height, lodging score, spike length, spike weight and grains weight spike[1] of wheat cultivars as affected by planting dates and cutting.

Planting dates	Plant height(cm)	Lodging score	Spike length (cm)	Spike weight (g)	Grains weight spike^{-1} (g)
15th Oct	98 a	1.9 b	11.31	3.70 a	1.88 a
30th Oct	97 a	2.3 b	11.02	3.51 b	1.81 a
14th Nov	94 b	2.9 a	11.15	3.03 c	1.56 b
LSD0.05	1.99	0.5	Ns	0.18	0.10
Cultivars					
Saleem-2000	92 d	2.6 a	11.42	3.41	1.74
Bathoor-2007	98 ab	2.6 a	10.88	3.47	1.76
Fakhre Sarhad-99	97 b	2.3 ab	11.12	3.23	1.68
Uqab-2000	99 a	2.3 ab	11.30	3.41	1.78
Siran-2008	97 b	2.2 b	11.10	3.48	1.78
Ghaznavi-98	94 c	2.2 b	11.16	3.48	1.76
LSD0.05	1.69	0.35	Ns	ns	Ns
Cutting					
Cut	94	2.0	11.09	3.29	1.69
No-cut	98	2.7	11.23	3.54	1.81
Significance	**	**	Ns	**	**
Year					
2009-10	93.2	2.0	10.69	3.31	1.69
2010-2011	99.1	2.7	11.64	3.52	1.81
Significance	**	**	*	*	*
Interactions					
D x C	Ns	Ns	Ns	ns	Ns
D x V	*(Fig. 1d)	Ns	**(Fig.1e)	ns	Ns
V x C	Ns	Ns	Ns	ns	Ns
D x V x C	Ns	Ns	Ns	ns	Ns

Means for each category followed by same letters are not significantly different from each other at 5% level of probability
** = Significant at 1% level of probability, * = Significant at 5% level of probability, ns = Non-significant

Lodging score: The lodging score of wheat was considerably influenced by sowing dates, cultivars, cutting and year. All interactions were found non significant (Table 2). More lodging (2.7) was recorded during 2nd year than 1st year of the study (2.0). Lodging was increased (2.9) when sowing was done in mid of November compared to 30th October (2.3) and 15th October (1.9). Greater lodging score (2.6) was observed in Saleem-2000 and Bathoor-2007 followed by FS-99 and Uqab-2000 (2.3). Wheat cultivars Siran-2008 and Ghaznavi-98 had reduced lodging score (2.2). Imposition of cutting largely reduced lodging (2.0) than no-cut plots (2.7).

Spike length (cm): Perusal of the data revealed that sowing dates, cultivars and cutting did not significantly influence spike length of wheat. The year as source of variance was remained significant. All interactions except D x V was found non significant (Table 2). Spike length was more (11.64 cm) during 2010-11 than 2009-10 (10.69). Significant D x V interaction revealed that all cultivars except Saleem-2000 and Ghaznavi-98 had longer spikes under mid October compared to Ghaznavi-98 with longer spikes under later sowing in mid November (Fig. 1d).

Spike weight (g): Planting dates, cutting and year had considerable influence on spike weight while there was no significant variation in spike weight among the wheat cultivars. None of the interaction was found significant for spike weight. Heavier spikes (3.52 g) were recorded during 2nd year than 1st year (3.31 g). Greater spike weight (3.70 g) was recorded in mid October followed by 30th October (3.51 g). Planting on 14th November had lower spike weight (3.03 g). Imposition of cutting had reduced spike weight as compared to no-cut.

Grains weight spike^{-1}: Grains weight spike^{-1} was considerably affected by sowing dates, year and cutting while cultivars did not vary among each others for grains weight spike^{-1}. All interactions were remained non significant (Table 2). More number of grains weight spike^{-1} (1.81 g) was recorded during 2nd year of the study than 1st year (1.69 g). Sowing of wheat till mid and 30th October had heavier grains weight spike^{-1}, while lesser grains weight spike^{-1} (1.56 g) was recorded in mid November. Imposition of cutting significantly reduced grains weight spike^{-1} (1.69 g) than no-cut treatment (1.81 g).

Discussion

Planting dates significantly influenced leaf area tiller^{-1}, whereas leaf area index was not affected under varying planting time. Leaf area tiller^{-1} was higher for planting done on 30th October and 14th November, whereas lower leaf area tiller^{-1} was produced by early planting in mid-October. However, Prabhakar *et al*. (2002) reported leaf area index reduced under later sowing as compared to early sowing. Leaf area index is important for direct comparison with the forage yield as greater the LAI higher will be the fodder yield and vice versa. The probable reason for greater leaf area obtained from earlier planting could be due to the favorable environmental factors for improved plant growth. The present findings are in line with Saleem *et al*. (1996); Raghuwanshi *et al*. (2001) and Nasim *et al*. (2010) who evaluated considerable differences among various cultivars for leaf area index. Number of nodes is controlled largely by the genetic character of a cultivar, though it may also be affected by the growing conditions (Shahzad *et al*., 2002). Early sowing might have provided better environmental conditions that resulted in more number of nodes.

As internodes length is mainly controlled by the genetic potential of a genotype, yet it may be influenced by the environmental factors (Shahzad *et al*., 2002). The longer nodes in early sowing may be due to the optimal temperature and solar radiation which resulted in the prolific growth of the crop consequently increased the internodes length. The shorter internodes length in cutting plots might reduce stature of plants in cut plots compared to no-cut plots. The reduction in internode length could be due to the cutting stress, which might have terminated the growth of crop for certain time therefore the cut treatment shoot could not attained the same height because of shorting of growth period. The other reason could be the removal of stem that leads to termination of growth and the new growth of shoot could not reach to the same height of no-cut plot. Stature of crop influence yield of crops in many ways and this may have direct and synergetic effect on biological yield. However the stature of crop is controlled mainly due to inherited potential of a cultivar and can also be varied by the environmental factors (Shahzad *et al*., 2007). Early sowing might provide better growing conditions as optimal temperature and solar radiation that might provide taller plants. The results are similar with finding of Shahzad *et al*. (2002) who reported taller plants under early sowing of wheat. Likewise, short stature plants in delayed sowing could be due to the decline in the growing period compared to early sowing. Wheat being determinate plant (Hatam, 1994), stops vegetative growth in terms of plant height and produces spikes after fulfilling photoperiodic need of the crop, that might shorten height in later planting (Inamullah *et al*., 2007). Likewise, Ahmed *et al*. (1997) exhibited decline in plant height with delay in sowing. Differences in plant height of wheat cultivars could be explained by their genetic trait. Ahmad (1991) also found considerable difference in plant height of various wheat genotypes. Similarly, Shahzad *et al*. (2002) and Irfaq *et al*. (2005) also reported significant decrease in plant stature of various wheat cultivars due to delay in sowing. The reduction in the plant height might be due to imposition of cutting stress, which resulted in termination of growth for some periods of time and thus the cut plots shoot may not attain the same plant height due to shorting of growth duration. Khalil *et al*. (2011) found that plant height was reduced largely due to cutting. The results are in line with Noy-Meir & Briske (2002) who reported higher plant height in no-cut plots than cut plots.

Interestingly, cutting reduced lodging score than no-cut that might help in increasing final yield as lodging is consider as one of the major constraints in reduction of wheat yield. Kelman & Dove (2009) also found short stature plants under grazed crops that had considerably reduced the susceptibility of crop to lodging. The slight reduction in the height of crop at maturity in cutting treatment had decreased lodging of wheat (Berry *et al*., 2003; Sylvester-Bradley & Riffkin, 2008).

Spike length is one the important traits that relate directly to the number of grains spike^{-1} and finally to yield of crop (Shahzad *et al*., 2007). Several factors influence spike traits such as genotypes, sowing times and environmental conditions. The spike length may reduce due to delay in sowing where maturity was hastened at later growth stages and thus shortening growth periods (Slafer & Whitechurch, 2001) which might shorten spike length. Slafer & Rawson (1994) reported that there is a significant interaction between temperature and photoperiod for plant traits that varied among cultivars. Similarly, Ahmed *et al*. (1994) reported that delay in sowing reduced spike length in all cultivars. Bisht *et al*. (2008) also reported non significant differences among cultivars for spike length. Less number of grains spike^{-1} in late sowing was due to less production of photosynthates due to shorter growing period. The reduction in spike weight in later sowing may be due to sensitivity of the wheat to photoperiod and temperature (Slafer & Whitechurch, 2001).

Spikes traits generally is the most important determinants of grain yield (Shah & Akmal, 2002). No significant differences in number of grains spike^{-1} among the cultivars can be attributed to their alike genetic potential. The results are not line with those reported by Haider (2004) who found differences in number of grains spike^{-1} among various cultivars. Likewise, the results are not accordance with those of Aslam *et al*. (2003), Khaliq *et al*. (2004) and Shahzad *et al*. (2007) who also reported significant differences in spikes traits among wheat cultivars. Cutting substantially reduced grains weight spike^{-1} and spike weight with imposition of cutting**.** The reduction in the aforesaid trait might be due to stress imposed by cutting during the stem elongation stage, which had removed fresh fodder and the nutrients which were at once accumulated. These results are not in line with Noy-Meir & Briske (2002) who found no difference in number of grains weight spike^{-1} from control plots than grazed plots. Similarly, the results are also contrary to Khalil *et al*. (2011) who found no difference in grains weight spike^{-1} due to cutting. The results are in line with Bisht *et al*. (2008) who found reduced grain weight spike^{-1} in cut plots than no-cut plots.

Conclusion

It is concluded that early sowing either in mid October or end of October had produced more number of nodes tiller^{-1}, long stature plants, heavier spikes and reduced lodging than later sowing in mid November. Cutting had considerably reduced lodging, leaf area, leaf area index, internodes length, plant height and spike weight in all wheat cultivars. Wheat cultivar Uqab-2004 and Siran-2008 produced longer internodes, higher leaf area index and number of nodes tiller^{-1}. Fakhre sarhad-99 had no considerable reduction in the leaf area index due to imposition of cutting.

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