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EARLY PLANTING DATE CAN COMPENSATE THE REDUCTION IN WHEAT YIELD DUE TO FODDER CUTTING IN DUAL PURPOSE WHEAT

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Despite the great potential of dual purpose wheat, limited exploitations have so far made due to decrease in final grain yield owing the removal of early crop assimilates as fodder. A better planting time decision; however, can compensate this reduction through considerable accumulation of assimilates for both fodder and grain. The influence of planting time to compensate this reduction is yet unknown. We studied the effect of planting time in dual purpose wheat context over two years (2009-10 and 2010-11) at DI Khan, Pakistan, using wheat cv. Zam-04 sown on four planting dates in dual purpose vs. grain only treatments. Significant influence of planting dates and cutting was revealed on physiological attributes and yield potential. Although both cutting and late sowing negatively influenced grain yield and yield related traits. The early sowing resulted in a higher yield undercut than the late sown crop without cut, with an increased leaf area index (20%), leaf area duration (20%), crop growth rate (16%), number of productive tillers (12%), number of grains spike^{-1} (25%), 1000-grain weight (2%) and grain yield (24%). The early sowing in a dual purpose wheat system compensated the overall yield reduction by fetching high incomes than grain only wheat system.
Keywords: Sowing date, crop growth, yield potential, wheat as fodder

INTRODUCTION

Population explosion and urbanization has been resulted in scarcity of arable lands, reducing the availability of land for fodder/forage production due to allocation of most of this arable land to food, fiber or other cash crops (Arif *et al.,* 2006a). In order to overcome this issue, interest has recently been shown in "dual purpose" cultivation of cereal crops in the regions where winter is mild.

In dual purpose (DP) cereal production, a cut is made in early winter to take the fodder and then the crop is left to grow for grain, compared to the grain-only (GO) cropping system in which no cut is made. When these cereal crops are managed properly as dual purpose crop, these provide excellent grazing and high-quality silage or hay. Similarly, such dual purpose cereal production has been suggested to be economically feasible when considering the fodder and grain produced per land area (Arif *et al.,* 2006a). This encouraged the adoption of the strategy at experimental level by several researchers, particularly for wheat crop (Epplin *et al.,* 2000). Among several other cereals, wheat (*Triticum aestivum* L.) is considered as the most promising candidate as dual purpose cereal.

Wheat is the leading food grain crop of Pakistan and occupies a central position in the formulation of agricultural policies. It contributed 14.4 percent to the value added in agriculture and 3.1 percent to GDP. Livestock sector has its due importance in Pakistan. About 30-35 million rural populations is directly or indirectly engaged in livestock rearing. Economic feasibility has been confirmed for wheat as fodder alone or in a "dual purpose" approach (Epplin *et al.,* 2000; Arif *et al.,* 2006a). Even the introduced winter wheat germplasm has been tested for their disease resistance status for their suitability as dual purpose varieties (Ali *et al.,* 2009a). The fodder produced from wheat has been suggested to be palatable and its crude protein level and digestibility is considered comparable to that of alfalfa (Hossain *et al.,* 2003). Wheat pasture is a valuable source of high quality forage; it is high in protein, energy and minerals, and low in fiber. Beside grain, wheat straw constitutes an integral part of the daily ration for livestock. To reduce competition between area devoted to grain and forage crops and make sure the availability of forage during winter, there is a need to shift from grain-only (GO) to dual-purpose (DP) wheat system of forage plus grain production.

A pre-requisite of the system is to select the appropriate planting time, the most important management decision for any dual-purpose crop, as late sowing could result in low yield and thus low benefit cost ratio (Akpandey, 2005; Singh *et al.,* 2005). A strategy needs to be devised to provide the abundance of sunshine in most of the winter to provide enough degree days to accomplish photosynthesis for accumulation of assimilates into vegetative parts before the cut and to the grain after cut. Thus, for a high winter dry matter production followed by good grain recovery, early sowing would be required. However, the most efficient “early date” needs to be identified to let appropriate time to the summer crop, before wheat. In Pakistan, spring wheat is planted as grain crop in winter from early October to early November as in most of the Indian sub-continent and warm winter regions of all Middle East (Ali *et al.,* 2009a). Late planting would result in reduction in yield (Hussain *et al.,* 2012). However, to the best of our knowledge, little effort has been made to evaluate the influence of planting time on the physiological attributes and yield potential of wheat under the “dual purpose” cultivation. The present study was thus designed to assess the role of planting time on physiological attributes and yield potential of wheat under the agro-ecological conditions of D.I. Khan, Pakistan.

MATERIALS AND METHODS

The experiment was carried out at D.I. Khan (31° 49 N: 70° 55 E and Elevation of 165 m) during wheat cropping seasons of 2009-10 and 2010-11. The experimental site had mild winter during the course of experiment as revealed by the metrological data of the test site i.e., the minimum December and January temperature of 4°C and the maximum April temperature of 35.5°C over both years (Table 1). The soil of the experimental site was silt clay having pH 8.82 and <1% organic matter. The experiment was laid out in a randomized complete block (factorial) design with split plot arrangement using four planting dates viz. 10th October, 25th October, 10th November and 25th November as factor-A in the main plot and cutting (grain-only; GO vs. dual purpose; DP) as factor-B in the sub-plots. The net plot size was 1.8 m x 5 m having 6 rows in each plot, 5 m long and 30 cm apart. Fertilizer was applied @ 150-120-90 NPK kg ha^{-1} in the form of urea, di-ammonium phosphate and sulpahte of potash, respectively. Half of nitrogen and all phosphorous and potash were applied at the time of sowing while remaining nitrogen was applied with first irrigation. The experimental field was prepared by one deep ploughing and then with cultivator followed by rotavator and planking to ensure a fine seedbed. The field was prepared in such a way as to destroy weeds etc. The stubbles of previous crop were incorporated into the soil to add organic matter. The recommended well adapted, long duration, high yielding tall wheat variety Zam-04 was sown as a test crop. The crop was sown with a man-driven hand drill. Irrigation was applied at crown root initiation, tillering, jointing, boot, flowering and grain development stages. Broad and narrow leaf weeds were controlled by applying herbicides Buctril Super (bromoxynil+MCPA) and Puma Super (fenoxaprop-p-ethyl) @ 750 ml each for efficient management.

A cut for dual purpose grain (DP) was given to half of the treatments 60 days after sowing (DAS) just before the appearance of first hollow stem to compare with rest of no-cut grain-only (GO) treatments. Fresh and dry fodder yield (kg ha^{-1}) was calculated for the cutting treatment. The weight of fresh forage was recorded with the help of an electronic balance and then was converted into kg (ha^{-1}). Dry forage yield was calculated by sun drying the fresh forage for 72 hours, weighed with the help of an electronic balance and then converted into yield (kg ha^{-1}).

Data pertaining to physiological and growth parameters were recorded for leaf area indices (LAI), leaf area duration (LAD) and crop growth rate at 112 days after sowing. For LAI, five plants from each subplot were uprooted, counted their number of leaves, measured their lengths and widths using a scale and multiplied with correction factor (0.75) and number of plants (m^{-2}) using the formula:

$$LAI = \text{Total area of green leaves } (m^2) / \text{ Ground area occupied } (m^2)$$

The total area of green leaves was calculated as:

LA = Leaf length × leaf width × correction factor (0.75) ×

Table 1. Average monthly and seasonal weather data at the Agricultural Research Institute, Dera Ismail Khan, during 2009-2010 and 2010-2011.

Month	2009-10				2010-11			
	Maximum temperature (°C)	Minimum temperature (°C)	Relative Humidity (%)	Rainfall (mm)	Maximum temperature (°C)	Minimum temperature (°C)	Relative Humidity (%)	Rainfall (mm)
October	33	16	70	13	34	19	69	…
November	25	10	68	--	27	9	63	…
December	22	5	72	--	21	3	64	…
January	16	5	82	9.2	17	3	69	2.5
February	22	8	67	1.1	21	7	67	29
March	30	15	63	2.2	28	11	66	5.5
April	37	19	60	--	34	16	55	11.5

Source: Arid Zone Agriculture Research Institute (PARC), KPK, D. I. Khan number of leaves plant^{-1} × number of plants m^{-2}

Leaf area duration (expressed in weeks) was obtained by integrating leaf area index over crop growth period, using the formula:

$$LAD = LAI \times M$$

where LAD = Leaf area duration, LAI = Leaf area index and M = Number of weeks in the crop growth period. Crop growth rate was determined using the formula:

$$\text{Crop growth rate (g day}^{-1}\text{ m}^{-2}) = W_2\text{-}W_1/T_2\text{-}T_1$$

where W_2 = final weight, W_1 = initial weight, T_2 and T_1 are the time interval in days.

In case of yield related parameters, data were recorded on number of tillers (m^{-2}), number of grains spike^{-1}, 1000-grain weight (g), grain yield (kg ha^{-1}) and biological yield (kg ha^{-1}). Grains spike^{-1} data were determined by counting grains in ten randomly selected spikes in each subplot, threshed and average was worked out accordingly. 1000-grains weight was recorded by taking samples of 1000 grains from each subplot and weighed by using sensitive electronic balance. Data regarding both grain yield and biological yield were recorded by harvesting four central rows in each subplot. For biological yield the plants were fully dried and tied into bundles. The bundles were weighed with a spring balance and then converted into kg ha^{-1}. For grain yield, the plants of each treatment were threshed separately; the grains were weighed and converted into kg ha^{-1}. Harvest index (HI) was calculated as:

$$HI = (\text{Grain yield} / \text{Biological Yield}) \times 100$$

***Statistical analyses*:** The data were compiled in MS Excel and mean tables were drawn. The statistical analyses were carried out using analysis of variance technique (Steel *et al.,* 1997). Least significant difference (LSD) test was used to check the significance of difference among the treatment means.

***Economic analyses*:** Economic analysis was conducted to assess the economic feasibility of dual purpose wheat cultivation planted on different sowing dates. Total expenses of wheat production were included as land rent, seedbed preparation, seed and sowing, fertilizers, irrigation and harvesting of crop. Gross income was estimated according the current common market prices of green fodder, wheat grain and straw in the country. Moreover, net income was worked out by deducting the total expenses by gross income while benefit:cost ratio (BCR) was recorded as:

$$\text{Benefit cost ratio} = (\text{Total income} / \text{Total expenditure}) \times 100$$

RESULTS

Leaf area index (LAI) after cut at 112 DAS was significantly affected by cutting treatments and planting dates during both years (Table 2). Substantially, higher LAI was recorded in no-cut treatment as compared to cut treatment during both the years. Moreover, significantly higher LAI was recorded for the crop sown on October, 25 followed by October, 10

Table 2. Leaf area index, leaf area duration and crop growth rate (g m^{-2}day^{-1}) and crop growth rate of wheat as affected by planting dates and cutting treatments during the years 2009-10 and 2010-11.

Parameters	Planting date	2009-10 No cut	2009-10 Cut	2009-10 Means	2010-11 No cut	2010-11 Cut	2010-11 Means
Leaf area index after cut	10-Oct	3.74	3.29	3.51 b	4.14	3.74	3.94 a
	25-Oct	4.41	3.61	4.01 a	4.16	4.01	4.08 a
	10-Nov	3.03	2.85	2.94 c	3.25	2.52	2.88 b
	25-Nov	2.85	2.85	2.85 c	2.99	2.75	2.87 b
	Means	3.51 a	3.15 b	-	3.63 a	3.25 b	-
Leaf area duration after cut	10-Oct	59.8	52.7	56.2 b	66.3	59.8	63.0 a
	25-Oct	70.6	57.7	64.1 a	66.5	64.2	65.4 a
	10-Nov	48.6	45.6	47.1 c	52	40.4	46.2 b
	25-Nov	45.6	45.6	45.6 c	47.8	43.9	45.9 b
	Means	56.7 a	50.4 b		58.1 a	52.1 b	
Crop growth rate (g m^{-2}day^{-1})	10-Oct	13.29	12.26	12.78 a	12.49	11.04	11.77 ab
	25-Oct	14.01	12.76	13.39 a	13.51	11.12	12.32 a
	10-Nov	12	11.54	11.78 b	11.7	10.25	10.98 b
	25-Nov	10.07	9.22	9.64 c	10.02	9.16	9.59 c
	Means	12.34 a	11.45 b		11.93 a	10.39 b	
LSD values							
		Cut	**Planting**	**Interaction**	**Cut**	**Planting**	**Interaction**
Leaf area index		0.260	0.367	NS	0.177	0.250	NS
Leaf area duration		4.162	5.885	NS	2.842	4.019	NS
Crop growth rate		0.616	0.871	NS	0.682	0.965	NS

Means followed by different letter(s) in a column are significant at 5% level of probability.

while minimum LAI was recorded for the crop sown on November, 25 during both years (Table 2).

Similarly cutting treatments and planting dates significantly affected LAD during both the years (Table 2). High LAD was recorded for no-cut treatment as compared to cut treatment during both years. Similarly, high LAD was recorded for planting on 25th October followed by planting on 10th October while minimum LAD was recorded for the delayed planting on 10 or 25th November during both years (Table 2).

Crop growth rate (CGR) was significantly affected by cutting treatments and planting dates over the two growing seasons (Table 2). The maximum CGR was obtained in no-cut plots as compared to cut plots during both years. Maximum and statistically at par CGR was recorded for early planting dates while minimum CGR was recorded for late sown plots. The interaction between cutting and planting dates was not significant (Table 2).

Cutting treatments had non-significant effect on number of productive tillers during the year 2009-10 but had significant effect on tillers during 2010-11 (Table 3). Planting dates significantly affected the number of productive tillers during both years. During the year 2010-11, significantly higher number of productive tillers was recorded in no-cut plots as compared to cut plots. During both years, statistically higher number of productive tillers was recorded in plots sown on 25th October followed by 10th November while minimum number of productive tillers was noted in 25th November sowing.

In case of number of grains spike^{-1} there were non-significant differences in cut and no-cut treatments during both years (Table 3). However, number of grains spike^{-1} was significantly affected by planting dates during both years. Number of grains spike^{-1} decreased with successive delay in planting. The maximum grains spike^{-1} were recorded in plots sown on 10th October followed by sowing on 25th October, while the minimum grains spike^{-1} were recorded in 25th November sowing. Similar trend of decreased number of grains spike^{-1} with successive delay in planting date was recorded in 2010-11.

Cutting treatments and planting dates significantly affected 1000-grain weight during both the years of research. Data revealed that no-cut treatment resulted in the maximum grain weight as compared to cut treatment during both years (Table 3). Higher and statistically at par grain weight was recorded for 10th October and 25th October sowing followed by 10th November sowing in both years. The interaction of planting date and cutting treatments revealed significant differences during the year 2009-10. The data indicated heavier grains in no-cut plots sown on 10th October and 25th October.

Scrutiny of the effect of planting date on the fresh and dry forage yield obtained from the plots with cutting treatment revealed significant effect during both the years of research.

Table 3. Number of productive tillers (m^{-2}), grains spike^{-1} and 1000-grain weight (g) of wheat as affected by planting dates and cutting treatments during the years 2009-10 and 2010-11.

Parameter	Planting date	2009-10 No cut	2009-10 Cut	2009-10 Means	2010-11 No cut	2010-11 Cut	2010-11 Means
Number of productive tillers m^{-2}	10-Oct	214.2	223.5	218.9 c	220.8 de	228.0 cd	224.4 b
	25-Oct	257.0	254.7	255.9 a	253.3 a	244.3 b	248.8 a
	10-Nov	227.0	226.5	226.8 b	229.8 c	216.0 e	222.9 b
	25-Nov	205.5	204.0	204.8 d	199.0 f	196.8 f	197.9 c
	Means	225.9	227.1		225.6 a	221.2 b	
Number of grains spike^{-1}	10-Oct	64.5	64.2	64.3 a	62.4	61.2	61.8 a
	25-Oct	58.4	55.3	56.9 b	59	57.1	58.0 b
	10-Nov	55.9	52.3	54.1 bc	50.3	49.4	49.9 c
	25-Nov	53.5	51.6	52.6 c	46.8	47	46.9 d
	Means	58.1	55.8		54.6 ^{NS}	53.7	
1000-grain weight (g)	10-Oct	42.18 ab	38.55 cd	40.37 a	42.54	40.57	41.56 a
	25-Oct	42.89 a	38.49 cd	40.69 a	42.68	41.07	41.88 a
	10-Nov	37.05 d	37.92 d	37.48 b	40.87	39.17	40.02 b
	25-Nov	40.49 bc	38.58 cd	39.53 a	40.81	39.12	39.97 b
	Means	40.65 a	38.38 b		41.73 a	39.98 b	
LSD values							
		Cut	**Planting**	**Interaction**	**Cut**	**Planting**	**Interaction**
Productive tillers (m^{-2})		NS	7.667	NS	3.996	5.651	7.991
Grains spike^{-1}		NS	3.687	NS	NS	1.562	NS
1000-grain weight (g)		1.225	1.560	2.218	0.384	0.543	NS

Means followed by different letter(s) in a column are significant at 5% level of probability.

Table 4. Biological yield (kg ha^{-1}) , grain yield (kg ha^{-1}) and harvest index (%) of wheat as affected by planting dates and cutting treatments during the years 2009-10 and 2010-11.

Parameters	Planting date	2009-10 No cut	2009-10 Cut	2009-10 Means	2010-11 No cut	2010-11 Cut	2010-11 Means
Biological yield (kg ha^{-1})	10-Oct	12337	11537	11937	12009	11010	11510 b
	25-Oct	13130	10437	11783	13177	12097	12640 a
	10-Nov	12450	11062	11756	12303	11008	11660 b
	25-Nov	11982	11212	11597	10929	9379	10150 c
	Means	12475 a	11062 b		12104 a	10873 b	
Grain yield (kg ha^{-1})	10-Oct	5009	4831	4920 a	4815	4711	4763 b
	25-Oct	5086	4970	5028 a	5028	4837	4933 a
	10-Nov	4281	4051	4167 b	4452	4359	4406 c
	25-Nov	3748	3827	3788 c	3976	3925	3951 d
	Means	4531	4420		4568 a	4458 b	
Harvest index (%)	10-Oct	40	43	42 a	40	43	41 a
	25-Oct	39	48	43 a	38	40	39 b
	10-Nov	34	37	36 b	36	40	38 b
	25-Nov	32	34	33 b	36	42	39 b
	Means	36 b	40 a		38 b	41 a	

LSD values

	2009-10 Cut	2009-10 Planting	2009-10 Interaction	2010-11 Cut	2010-11 Planting	2010-11 Interaction
Biological yield	682.06	NS	NS	309.4	437.6	NS
Grain yield	NS	164.6	NS	106.64	150.8	NS
Harvest index	2.3	3.2	4.6	1.4	2.0	2.8

Means followed by different letter(s) in a column are significant at 5% level of probability

Higher and statistically at par fresh and dry fodder yield was obtained for 10th October and 25th October sowing, followed by 10th November, while the minimum fresh and dry fodder yield of wheat was obtained for 25th November planting (Fig. 1).

The cutting treatments had significant effect on biological yield (kg ha^{-1}) during both the year (Table 4), while planting date had non-significant effect during the year 2009-10 and had significant effect during 2010-11. Considering the mean affect, both cutting treatment and late planting resulted in a low biological yield. Statistically higher biological yield (kg ha^{-1}) was recorded in crop sown on 25th October, while the minimum biological yield (kg ha^{-1}) was noted for the crop sown on 25th November sowing (Table 4).

Planting dates significantly affected grain yield during both the years while cutting treatments had significant effect on grain yield only during 2010-2011 (Table 4). Higher grain yield was obtained in no-cut treatment as compared to lower grain yield in cut plots. Likewise, higher and statistically at par grain yield was recorded in 10th October and 25th October sown plots respectively, followed by 10th November planting date while the minimum grain yield was recorded in 25th November planting during both the years. The interaction of cutting vs. non-cutting treatments and planting dates was found non-significant.

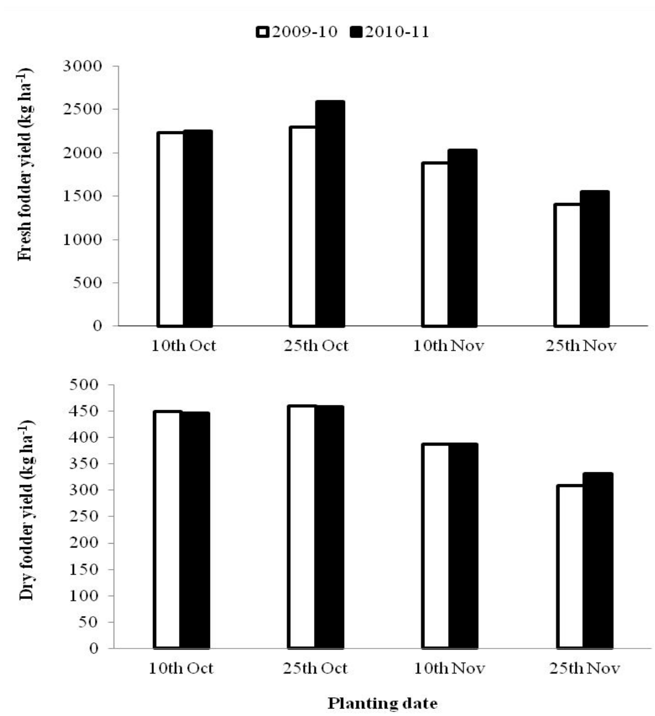

Figure 1. Fresh and dry forage yield (kg ha^{-1}) as affected by planting dates in dual-purpose wheat during the years 2009-10 and 2010-11.

The harvest index (HI) was significantly affected by the cutting treatment, planting date and their interaction during both the year (Table 4). Late planting resulted in reduced harvest index, while the cutting resulted in increased harvest index. During both the years, the maximum harvest index was recorded in crop sown on 10th October with cutting, while the minimum for the crop sown on 25th November sowing without cutting treatment (Table 4).

***Economic analyses using benefit cost ratio (BCR)*:** The economic analyses in terms of benefit cost ratio (BCR) showed that higher net returns were obtained in dual-purpose wheat as compared to grain-only wheat under different planting dates (Table 5). During the first crop season (2009-2010), the maximum net returns and BCR (Rs.85749/- and 2.62, respectively) were obtained in cut plots sown on October-25, while minimum net returns and BCR (Rs.44745/- and 1.87, respectively) were recorded in no-cut plots sown on November-25. During the second crop season (2010-11), the maximum net returns and BCR (Rs.77278/- and 2.31, respectively) were obtained in cut plots sown on October-25, while the minimum net returns and BCR (Rs.44163/- and 1.77, respectively) were recorded in no-cut plots sown on November-25.

***Comparison of early-sown-cut treatment with late-sown-uncut treatment*:** A final perusal of the data was made to compare early-sown-cut treatment with the late-sown-un-cut treatment for the studied parameters (Table 6). It was revealed that an early-sown crop with cut resulted in an

Table 5. Benefit cost ratio as affected by planting dates and cutting treatments during the year 2009-2010 and 2010-11.

Planting dates	Cost ha^{-1}			Income ha^{-1}				Net income ha^{-1}	BCR
2009-2010									
	Fixed	Variable	TOTAL	Grains	Fodder	Straw	TOTAL		
10th Oct. x no-cut	51204	0	51204	113198	0	15026	128225	77021	2.50
10th Oct. x cut	51204	1800	53004	109180	11165	14493	134838	81835	2.54
25th Oct. x no-cut	51204	0	51204	114943	0	15258	130201	78998	2.54
25th Oct. x cut	51204	1800	53004	112344	11495	14913	138752	85749	2.62
10th Nov. x no-cut	51204	0	51204	96773	0	12846	109619	58415	2.14
10th Nov. x cut	51204	1800	53004	91575	9420	12156	113151	60147	2.13
25th Nov. x no-cut	51204	0	51204	84704	0	11244	95948	44745	1.87
25th Nov. x cut	51204	1800	53004	86490	7015	11481	104986	51982	1.98
2010-2011									
Planting dates	**Cost ha^{-1}**			**Income ha^{-1}**				**Net income**	**BCR**
	Fixed	Variable	TOTAL	Grains	Fodder	Straw	TOTAL		
10th Oct. x no-cut	57238	0	57238	105930	0	16852	122782	65545	2.15
10th Oct. x cut	57238	1800	59038	103657	11260	16490	131408	72370	2.23
25th Oct. x no-cut	57238	0	57238	110620	0	17598	128219	70981	2.24
25th Oct. x cut	57238	1800	59038	106425	12960	16931	136316	77278	2.31
10th Nov. x no-cut	57238	0	57238	97959	0	15584	113543	56306	1.98
10th Nov. x cut	57238	1800	59038	95902	10155	15257	121314	62277	2.05
25th Nov. x no-cut	57238	0	57238	87483	0	13917	101400	44163	1.77
25th Nov. x cut	57238	1800	59038	86350	7755	13737	107842	48805	1.83

Rate of wheat seed = Rs.22.0 0 kg^{-1}; Rate of wheat straw = Rs. 350.00 per 100 kg grains
Rate of wheat fodder = Rs. 5.00 kg^{-1}; Cutting of wheat fodder = Rs. 1800.00 ha^{-1}

Table 6. Compensation of reduction in crop growth parameters and yield related traits due to cut by early sowing with cut.

	Early sowing with cut (10 October)	Late sowing without cut (25 November)	Percent increase/decrease
Leaf area index after cutting (112 days)	3.51	2.92	20% increase
Leaf area duration after cutting (112 days)	56.25	46.70	20% increase
Crop growth rate	11.65	10.04	16% increase
No. of productive tillers	225.70	202.20	12% increase
No. of grains spike^{-1}	62.70	50.15	25% increase
Thousand grain weight	39.56	40.65	02% decrease
Grain yield	4771.00	3862.00	24% increase

increased crop growth and yield potential when compared with late-sown crop without cut. This increase was varied for different traits viz. leaf area index (20%), leaf area duration (20%), crop growth rate (16%), number of productive tillers (12%), number of grains spike^{-1} (25%), 1000-grain weight (2%) and grain yield (24%).

DISCUSSION

The experimental results revealed that crop growth parameters and yield related traits decreased significantly due to delayed planting and the imposition of cutting. However, the early sowing alleviated the negative effects of cutting and compensated for the yield loss due to delayed planting or cutting.

Leaf area index is the functional leaf area of the crop canopy standing on the ground and a reference tool for crop growth. The earlier sowing resulted in a higher LAI. Whereas delay in sowing resulted in reduced leaf area, which could be due to the lack of optimum time for re-growth and accumulation of photosynthates and availability of crop production factors (Prabhakar *et al.,* 2002; Shivani *et al.,* 2003). The cutting resulted in a reduced LAI during both years. This could be due to cutting stress in cut treatment that resulted in the curtailment of leaf area and hence lower LAI. Similar results were noted for leaf area duration (LAD), which expresses the magnitude and persistence of leaf area or leafiness during the period of crop growth and is obtained by integrating leaf area index over the crop growth period. A higher LAD was obtained in earlier sowing compared to late sowing, which could probably be due to the optimum time and growth conditions.

Plant growth is the increase in dry weight overtime, mainly as a consequence of photosynthesis. A significantly higher crop growth rate (CGR) was obtained in no-cut treatment as compared to the minimum CGR in cut treatment. It could be due to cutting of already developed biomass 60 days after sowing and thus low leaf area and photosynthetic potential in cut plots. Clipping or cutting has been reported to induce decreases in dry weight and carbohydrate accumulation of Triticale (Royo *et al.,* 1999). Early sowing also resulted in a higher CGR than the late sowing during both years, which could be due to sufficient time for plant growth and development along with optimum availability of environmental resources and absence of stresses. However, planting dates × cutting interaction was not significant.

A similar effect was also noted for the biological yield where both cutting treatment and late planting resulted in a low biological yield. The reason of lower biological yield obtained in cut treatment might be due to imposition of cutting shock two month after sowing on wheat crop which resulted in removal of the already developed biomass and thus lower leaf area index and plant height and ultimately low biological yield. The reason for higher biological yield obtained in no-cut plots was the biomass which remained intact. The results obtained are in line with the findings of Arif *et al.* (2006a) who concluded that no-cut plots produced significantly more biological yield than cut plots. Shuja *et al.* (2010) also found significant reduction in biological yield of wheat due to forage clipping. Similarly, Noy-Meir and Briske (2002) reported reduced vegetative and reproductive biomass production with a single clipping of wheat.

The results of this study confirmed the previous findings that cutting and late sowing reduce (Lyon *et al.,* 2001; Rahman *et al.,* 2004). However, like physiological parameters reduction in yield parameters due to cutting was compensated by early sowing.

Imposition of cutting resulted in a significant reduction in grain yield, possibly due to insufficient time for re-growth after the removal of photosynthetic tissues through cutting. Many researchers have reported similar results that there was a decrease of 10 to 40% in grain yields from plots that were grazed or clipped before first hollow stem (Winter and Thompson, 1990; Winter and Musick, 1991).

Grain yield of dual-purpose wheat increased as planting date was delayed from the very early planting to the recommended planting date and then decreased with successive delay in sowing. The reason of maximum grain yield obtained in early to moderate sowing time was possibly due to longer growth period, maximum LAI, number of grains spike^{-1} and productive tillers while the reverse was true for late planted plots (Prabhakar *et al.,* 2002; Qamar *et al.,* 2004; Sharma *et al.,* 2006). Recently, Hussain *et al.* (2012) reported 58% yield reduction of wheat planted on 25th December @ 60 kg ha-1 for each day delay in wheat planting after 10th November. Consequently, while the delayed planting reduced the harvest index, the cutting increased harvest index, with the maximum HI noted for early sowing and cutting. The increased grain yield compared to due to biological yield explained the maximum HI for early sowing and cutting (Francia *et al.,* 2006).

Finally, the benefit cost ratio (BCR) showed that higher net returns were obtained in dual-purpose wheat as compared to grain-only wheat under different planting dates (Table 5). During both crop seasons 2009-10 and 2010-11, the maximum net returns and BCR were obtained in cut plots while the minimum was obtained for no-cut treatment. The reason of higher net returns and benefit cost ratio in cutting treatment might be the added income advantage of fodder. These results are supported by Arif *et al.* (2006a) who concluded that income of the cut plots was higher than no-cut plots. Similarly, early sowing resulted in high BCR endorsing the previous results of Singh *et al.* (2005) and Akpandey (2005) who recorded higher net income and benefit cost ratio from the early sown crop.

***Compensation of cut treatment through early sowing*:** While considering planting dates in the context of cutting, late planting resulted in lower grain yield. Epplin *et al.*

(2000) stated that the expected grain yield of dual-purpose wheat may be lower than the grain-only wheat not because of the effects of fall-winter grazing but as a result of the difference in planting date. This study confirmed that an early-sown-cut crop would perform better than the late-sown-un-cut treatment (Table 6). Thus an efficient management on the side of farmers would enable them to harvest both grain and fodder without any yield penalty. Future efforts should be made to assess the prospects of dual purpose crop under different nutrients management strategies (Arif *et al.,* 2006b; Jan *et al.,* 2007; Ali *et al.,* 2008). Finally, early sowing would result in a longer growing period thus necessitating the assessment of dual purpose crop for the status of previously reported important wheat diseases, like yellow rust (Ali *et al.,* 2009b; Ali *et al.,* 2014) and black point (Saqib *et al.,* 2008).

***Conclusion*:** Results of the present study revealed a significant reduction in crop growth and yield parameters due to late sowing and cutting treatment. It was concluded that early planting could favorably influence leaf area index, leaf area duration, crop growth rate, dry and fresh forage yield, grain yield and economics. Although the cutting resulted in lower growth and grain yield parameters, our result suggested that increase in these parameters due to early sowing could compensate the reduction due to cutting. The gain from forage yield will be a surplus and even further increase the utility of dual purpose cropping system, which was also evident from the higher net economic returns and benefit cost ratio reported for the cutting treatment coupled with early sowing.

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REFERENCES

Akpandey. 2005. Effect of agronomic practices on green fodder, grain yield and economics of dual-purpose wheat (*Triticum aestivum*). Ind. J. Agri. Sci. 75:27-29.

Ali, S., A.R. Khan, G. Mairaj, M. Arif, M. Fida and S. Bibi. 2008. Assessment of different crop nutrient management practices for yield improvement. Aust. J. Crop Sci. 2:150-157.

Ali, S., S.J.A. Shah, I.H. Khalil, H. Rahman, K. Maqbool and W. Ullah. 2009a. Partial resistance to yellow rust in introduced winter wheat germplasm at the north of Pakistan. Aust. J. Crop Sci. 3:37-43.

Ali, S., S.J.A. Shah, H. Rahman, M.S. Saqib, M. Ibrahim and M. Sajjad. 2009b. Variability in wheat yield under yellow rust pressure in Pakistan. Turk. J. Agri. and Forestr. 33:537-546.

Ali, S., P. Gladieux, M. Leconte, A. Gautier, A.F. Justesen, M.S. Hovmoller, J. Enjalbert and C. de Vallavieille-Pope. 2014. Origin, migration routes and worldwide population genetic structure of the wheat yellow rust pathogen *Puccinia striiformis* f.sp. *tritici*. PLOS Path. 10, e1003903.

Arif, M., M.A. Khan, H. Akbar, M. Sajjad and S. Ali. 2006a. Prospects of wheat as a dual-purpose crop and its impact on weeds. Pak. J. Weed Sci. Res. 12:13-18.

Arif, M., S. Ali, A. Khan, T. Jan and H. Akbar. 2006b. Influence of farm yard manure application on various wheat cultivars. Sarh. J. Agric. 22:27-29.

Epplin, F.M., I. Hossain and E.J. Krenzer Jr. 2000. Winter wheat autumn-winter forage yield and grain yield response to planting date in dual-purpose system. Agric. Syst. 63:161-173.

Francia, E., N. Pecchioni., O. L. D. Nicosia , G. Paoletta , L. Taibi , V. Franco , M. Odoardi , A.M. Stanca and G. Delogu. 2006. Dual-purpose barley and oat in a Mediterranean environment. Fld. Crop. Res. 99:158-166.

Hossain, I., F.M. Epplin and E.J. Krenzer Jr. 2003. Planting date influence on dual-purpose winter wheat forage yield, grain yield, and test weight. Agron. J. 95:1179-1188.

Hussain, M., G. Shabir, M. Farooq, K. Jabran and S. Farooq. 2012. Developmental and phenological responses of wheat to sowing dates. Pak. J. Agri. Sci. 49:459-468.

Jan, T., M.T. Jan, M. Arif, H. Akbar and S. Ali. 2007. Response of wheat to source, type and time of nitrogen application. Sarh. J. Agric. 23:871-879.

Lyon, D.J., D.D. Baltensperger and M. Siles. 2001. Wheat grain and forage yields are affected by planting and harvest dates in the Central Great Plains. Crop Sci. 41:488-492.

Noy-Meir, I. and D.D. Briske. 2002. Response of wild wheat populations to grazing in Mediterranean grasslands: the relative influence of defoliation, competition, mulch and genotype. J. Appl. Ecol. 39:259-278.

Prabhakar, B.N., A.S. Halipyti and B.T. Pujari. 2002. Response of wheat genotypes to dates of sowing in north eastern dry zone. Karnataka J. Agri. Sci. 15:688-690.

Qamar, M., Shafiullah and S. Makeen. 2004. Genetic variability among wheat cultivars and effect of planting date on grain and straw yield under double cropping zone of Northern areas of Pakistan. Sarh. J. Agric. 20:99-102.

Rahman, M.S., M.A. Islam, M.S. Haque and M.A. Karim. 2004. Effects of planting date and gibberellic acid on the growth and yield of garlic (*Allium sativum* L.). Asian J. Plant Sci. 3:344-352.

Royo, C.J., Voltas and I. Romagosa. 1999. Remobilization of preanthesis assimilates to the grain for grain only and dual purpose (forage and grain) triticale. Agron. J. 91:312-316.

Saqib, M.S., S.J.A. Shah, F. Muhammad, W. Khan, M. Ibrahim and S. Ali. 2008. Genotypic variability for Alternaria alternata (fr.) keissler infection in bread wheat. Plant Patho. J. 7:34-39.

Sharma, N.P., K.V. Sumesh, D.L. Vaibhav and M.C. Ghildiyal. 2006. High temperature effect on grain growth in wheat cultivars: an evaluation of responses. J. Plant Physiol. 11:239-245.

Shivani, U.N., Verma, S. Kumar, S.K. Pal and R. Thakur. 2003. Growth analysis of wheat (*Triticum aestivum* L.) cultivars under different seeding dates and irrigation levels in Jharkhand. Ind. J. Agron. 48:282-286.

Shuja, M.N., Dure-Nayab, M. Ali, A. Iqbal and I.H. Khalil. 2010. Evaluating the response of wheat genotypes to forage clipping. Intl. J. Agric. Biol. 12:111-114.

Singh, I., V. Sardana and H.S. Sekhon. 2005. Influence of row spacing and seed rate on seed yield of lentil (*Lens culinaris* L.) under different sowing dates. Ind. J. Agron. 50:308-310.

Steel, R., J.H. Torrie and D. Dickey. 1997. Principles and Procedures of Statistics: A biometrical approach. McGraw Hillbook, New York.

Winter, S.R. and E.K. Thompson. 1990. Grazing winter wheat. I. Response of semidwarf cultivars to grain and grazed production systems. Agron. J. 82:33-37.

Winter, S.R. and J.T. Musick. 1991. Grazed wheat grain yield relationships. Agron. J. 83:130-135.