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Growth and yield performance of dual purpose wheat as influenced by sowing time and cutting schedule

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Abstract
A field experiment was conducted at Research area of CCSHAU, Hisar during *rabi* 2016-17 in split plot design having four sowing times in main plots and five cutting schedules in sub plots with three replications to find out the effect of growth and yield of dual purpose wheat. Among sowing times, 3rd week of October sowing was found most suitable for both uncut as well as dual purpose wheat. Among cutting schedules, higher rate of reduction was recorded with delay in cutting of fodder from 45 DAS upto75 DAS. For dual purpose, tall wheat (C306) sown during 3rd week of October and harvested at 55 DAS for fodder purpose was found most suitable having green fodder yield (14,313 kg ha^{-1} additional over uncut), grain yield (3,710 kg ha^{-1}, with a reduction of 9.3 percent over uncut), straw yield (7,820 kg ha^{-1} with a reduction of 19.7 % over uncut).

Keywords: Sowing time, cutting schedule, dual purpose, wheat, growth and yield

Introduction
Wheat (*Triticum aestivum* L.) being world first ranked cereal crop with cultivated area (223.8 m ha), production (733.1 m t) and with productivity of (3280 kg ha^{-1}) is the base of the agricultural economy. India is the second largest producer of wheat next to China in the world. The area, production and productivity of wheat in India is 30.7 m ha, 97.4 m t and 3172 kg ha^{-1}, respectively, while area, production and productivity of wheat in Haryana state is 2.54 m ha, 11.4 m t and 4407 kg ha^{-1}, respectively (AICRP on Wheat and Barley, Director's Report 2016-17). There is remarkable pressure of livestock for fodder as the arable land for forage production is becoming limited and fallow land available for grazing are declining and Cereal crops can be used as feed for livestock (Lukuyu *et al*., 2011) [9]. Cereals are grown predominantly as grain crops in most of the sub-tropical countries of the world and their use for dual purpose *i.e.* production of grain and livestock forage is limited. To mitigate the continued shortage of green fodder for animal consumption and grains for human, the conventional cereal crops need to be grown for dual purpose under irrigated farming system (Naveed, 2013; Dove and Kirkegaard, 2014; Jarial, 2014) [10, 2, 7]. India due to the alarming increasing rate in population is facing food and feed shortages. To overcome food and feed shortage, there is an urgent need to increase the yield of wheat by bringing more area under cultivation or increasing yield per unit area. Among cereals, wheat has potential to produce more grain yield along with substantially higher green fodder and also for enhancing net income, dual purpose wheat requires high level of management and a balance should be there between both the components (fodder and grain). So, schedules of cutting as well as sowing time both are important to realize the optimum yield of green fodder and grains from dual purpose wheat. But little information on this aspect is available in respect to tall wheat (C 306). Keeping these points in view, the present investigation was taken up to find out optimum sowing time and cutting schedule to realize the best growth and yield performance of dual purpose wheat.

Materials and Methods
The experiment was conducted at Agronomy Research Area of CCS Haryana Agricultural University, Hisar, which is situated in the sub-tropical region at 29° 10' N latitude and 75° 46' E longitude with an elevation of 215.2 meter above mean sea level in Haryana state of India,

during *Rabi* season of 2016-17. The experiment was comprised of four sowing times (3rd week of October, 4th week of October, 1st week of November and 2nd week of November) as main plot treatments and five cutting schedules (Uncut, cutting at 45 DAS, cutting at 55 DAS, cutting at 65 DAS and cutting at 75 DAS) as sub plot treatments. Experiment was laid out in split plot design with three replications. The soil of experiment sites in general was sandy loam. The nitrogen, phosphorus and potassium of soil were 133 kg ha^{-1}, 18 kg ha^{-1} and 245 kg ha^{-1}, respectively. The organic carbon ranged from 0.45 – 0.52 percent with pH of 7.73 and mean electrical conductivity (EC) of 0.23 dSm^{-1}. Each plot size was 4 m x 5 m and seeds were sown in rows 20 cm apart. The experimental field was prepared by two ploughing with cultivator and finally planking to ensure a fine seedbed. Tall wheat variety C306 was sown by following recommended package and practices of CCS HAU with seed drill machine.

All the other agronomic practices were applied uniformly to each plot. Chemical herbicides, Metsulfuron @ 8.0 gm/Acre with 200-250 liter water at 30 days after sowing were sprayed for the control of broad leaved weeds and narrow leaved weeds were controlled with Isoproturon (50% wp) @ 800 g/acre with 250 liter water at 37 days after sowing. Data pertaining to growth parameters (plant height and dry matter accumulation) were recorded at 30 days after cutting, anthesis and maturity, while leaf area index (LAI) at anthesis was recorded. Canopy temperature depression (CTD) were recorded at anthesis by using hand-hold infrared thermometer (Tela temp AG42) in each plot and find the difference between the ambient air temperature (Ta) and the canopy temperature (Tc) (CTD=Ta-Tc). In case of yield and yield attributes, data were recorded on number of tillers (m^{-2}), number of grains $spike^{-1}$, spike length (cm), number of spikelets per spike, 1000-grain weight (g), green forage yield after cut (kg ha^{-1}), biological yield (kg ha^{-1}) grain yield (kg ha^{-1}) and straw yield (kg ha^{-1}).

Results and Discussion

Growth Parameters

Data given in table 1 revealed that irrespective of cutting schedules delay in sowing of wheat from 3rd week of October up to 2nd week of November had reduced plant height and dry matter accumulation significantly at all the growth stages. This was might be attributed to maximum period available to early sown crop in comparison to delayed sown crop for vegetative growth of the crop, resulting in taller plants. These results are supported by Shafiq (2004) [12] and Gupta *et al*. (2002) [4] who reported that early sowing enhanced plant height over late sowing. Rahman *et al*. (2004) [11] also concluded that early planting favorably influenced dry weights of leaves and total dry matter accumulation. Cutting of wheat at different times had reduced the plant height significantly compared to uncut wheat at all the growth stages. At maturity, maximum (144.8 cm) and minimum (117.2 cm) plant height was recorded with uncut wheat and wheat cutted for fodder at 75 DAS, respectively (Table 1).The reason might be decapitation of wheat causing termination of growth and the new growth of shoot could not attain the same plant height as that of uncut treatment on account of slow growth under different planting time. Khalil *et al*. (2011) [11] found that plant height was significantly affected by cutting. Cutting of wheat at different times had reduced the dry matter accumulation of plant significantly compared to uncut wheat throughout growth period. It might be due to the favorable environmental conditions at sowing and no decapitation stress which resulted in taller and healthier plant. Maximum (479.8 g/mrl) and minimum (293.2 g/mrl) dry matter at maturity was recorded with uncut wheat and wheat cutted at 75 DAS, respectively (Table 1).

It is evident from Table 1 that delay in sowing of wheat from 3rd week of October to 2nd week of November reduced leaf area index significantly at anthesis irrespective of the cutting schedules. Wheat sown during 3rd week of October and 2nd week of November were recorded with maximum (1.69) and minimum (1.37) LAI, respectively. The reason of higher LAI obtained in earlier sown plots is availability of more time for maturity and also was attributed to the optimum availability of crop production factors that enhanced the growth of plants and the opposite was true for late planting. These results are in line with those of Shivani *et al*. (2003) [14], who also found leaf area index to be more in early sown wheat cultivars as compared to late sown crop. Among the cutting schedules cutting of wheat for fodder purpose at different times resulted in reduction of LAI significantly over uncut wheat. Irrespective of sowing times, uncut wheat sown was recorded the maximum LAI (1.87), while wheat cutted at 75 DAS reported with minimum (1.22) LAI. This was due to increase in biomass in uncut as compared to cut treatments. Among sowing times, the delayed sown wheat (2ndweek of November) had shown significantly lowest CTD (-1.9 ˚C) compared to 3rd week of October sown wheat (-3.3 ˚C). Among the cutting times, delay in cutting of wheat for fodder from 45 to 75 DAS had shown significant reduction in CTD. Significantly higher (33.2 ˚C) and lower (29.6 ˚C) canopy temperature were recorded with 2nd week of November and 3rd week of October sown crop. Among cutting schedules, wheat fodder cutting at 75 DAS and uncut wheat were recorded with significantly higher (33.1˚C) and lower (28.7 ˚C) canopy temperature, respectively.

Yield and yield attributes

Sowing times and cutting schedules had affected significantly all the yield attributes of wheat (Table 2). Delay in sowing of wheat from 3rd week of October up to 2nd week of November had reduced significantly effective tillers/mrl (148.2 to 103.2), spike length (9.7 to 8.9 cm), spikelets/spike (17.7 to 16.4), grains per spike (51.7 to 40.0) and test weight (45.3 to 42.1g), the reason might be the maximum period of vegetative growth recorded in early sown crop which was 162 days upto maturity in 3rd week of October sown as compared to 149 days in 2nd week of November sown crop, which enabled the crop to obtain and utilize maximum resources and produce higher number of yield attributes. On the other hand maximum number of grains $spike^{-1}$ obtained in earlier sown crop was possibly due to longer growing season and more transfer of photosynthesis from source (leaf) to sink (grain), which resulted in better development of grain accompanied by grain filling. The findings are in close conformity with those of Haq and Khan (2002) [5] and Shah and Akmal (2002) [13]. Spink *et al*. (2000) [16] observed that delayed sowing shortened the duration of each development phase ultimately reducing grain filling period and lowering the grain weight.

Irrespective of sowing times, cutting of wheat for fodder purpose at different times had reduced significantly all the yield attributes compared to uncut wheat. The reason for lower number of effective tillers in cut treatments was probably due to failure of some tillers to regenerate after cutting and vice-versa and the reason of minimum spike length obtained in cut treatment was probably due to drain on

photosynthates occurred as a result of regeneration because of cutting thereby reducing translocation of assimilates towards spike formation. But in case of obtaining low grain weight in cut treatments might be due to removal of photosynthetic organs by clipping which negatively affected source sink relationship. These findings are supported by Shuja *et al*. (2010) [15].

Delay in sowing of wheat from 3rd week of October to 2nd week of November significantly reducedgreen fodder yield of dual purpose wheat (Table 2). The reason is availability of optimum conditions of temperature, light and nutrients to earlier sown plots which resulted in higher fresh forage production, while late sown plots were unable to carry out photosynthesis efficiently under low temperature and light conditions. These results are in line with Arzadun *et al*. (2006) [1] and Gaylon *et al*. (2004) [3] who concluded that forage yield reduced in later planting date. Irrespective of the sowing time, the delay in cutting of wheat for fodder lead to increasing fodder yield. The delay in cutting from 45 to 75 DAS resulted in (380%) increasing fodder yield over 45 DAS cutting. This was due to increase in biomass in late cutting as compared to early cut wheat.

Delay in sowing from 3rd week of October to 2nd week of November had significantly reduced biological yield, grain and straw yield. The significantly higher biological yield, grain yield and straw yield (11,056 kg ha^{-1}, 3,862 kg ha^{-1} and 7,194 kg ha^{-1}, respectively) were recorded in 3rd week of October sown crop, while significantly lower biological, grain and straw yield (8,066 kg ha^{-1}, 3,166 kg ha^{-1} and 4,900 kg ha^{-1}, respectively) were recorded in 2nd week of November sown crop. The reason of maximum biological yield obtained was probably the optimum growth factors (temperature and time) available to crop, which resulted in enhanced crop growth, leaf area index and productive tillers as compared to late sown crop. These results are in line with Rahman *et al*. (2004) [11], who concluded that early planting favorably influenced plant height, dry weights of leaves and total dry matter. Among the cutting schedules early cutting (45 DAS) was recorded with significantly higher biological yield (11,200 kg ha^{-1}), grain yield (4,005 kg ha^{-1}) and straw yield (7,195 kg ha^{-1}), while late cutting (75DAS) resulted with minimum biological yield (6,283 kg ha^{-1}), grain yield (2,618 kg ha^{-1}) and straw yield (3,665 kg ha^{-1}) and the reasons of significant reduction of yield in cut plots compared to uncut wheat was possibly due to removal of photosynthetic tissues that resulted in lower crop growth rate, grain weight and number of productive tillers and the reverse was true for uncut treatment.

Conclusion

Sowing times and cutting schedules had significantly affected growth parameters (plant height, dry matter accumulation and leaf area index), yield attributes and yield of tall wheat (C 306). Among sowing times, 3rd week October was recorded with significantly higher plant height (136.4 cm), dry matter accumulation (429.5g/mrl), LAI (1.69), CTD (-3.3˚C), effective tiller/mrl (148.2), spikelets/spike (17.7), spike length (9.7 cm), grains/spike (51.7), test weight (45.3 g), biological yield (11056 kg/ha), grain yield (3862 kg/ha) and green fodder yield (20725 kg/ha). Cutting of wheat for green fodder purpose had reduced significantly all growth parameters, yield attributes and yield compared to uncut wheat. Among cutting schedules, minimum and maximum reduction in growth parameters, yield attributes and yield were recorded with cutting of fodder at 45 DAS and 75 DAS, respectively compared to uncut. Delay in cutting of wheat for fodder purpose from 45 upto 75DAS was recorded with percent reduction range of 3.8-19.1 (plant height), 5.6-38.9 (dry matter accumulation), 5.3-34.7 (LAI), 8.6-42.8 (CTD), 14.7-46.4 (effective tiller/mrl),5.4-15.3 (spikelets/spike), 4.0-12.1 (Spike length), 5.1-25.7 (grains/spike),2.6-12.1 (test weight), 6.6-47.6 (biological yield) and 2.1-36.0 (grain yield) compared to uncut wheat, but an additional green fodder yield of 5625-29233 kg/ha was obtained when we delay the fodder cutting time from 45 to 75 DAS. On the basis of overall growth and yield performance, wheat (C306) sown during 3rd week of October and harvest at 55 DAS for green fodder was found most suitable having grain yield (3710 kg/ha with a percent reduction of 9.3 over uncut) and additional green fodder yield of 14313kg/ha over uncut.

Table 1: Effect of sowing time and cutting schedule on growth parameters of dual purpose wheat

Treatments		Plant height (cm)			Dry matter accumulation (g/mrl)			LAI at anthesis	CTD (Tc-Ta)	Canopy temperature (˚C)
		30 DAC	Anthesis	maturity	30 DAC	Anthesis	Maturity			
A) Sowing times	3rd week of October	55.7	124.6	136.4	49.7	278.1	429.5	1.69	-3.3	29.6
	4th week of October	48.9	123.7	135.0	43.5	259.9	410.3	1.61	-3.3	30.2
	1st week of November	43.9	119.4	132.1	39.6	245.1	394.7	1.48	-2.6	31.0
	2nd week of November	33.8	110.9	129.9	32.8	227.4	362.9	1.37	-1.9	33.2
	SEm±	0.5	0.5	0.5	0.4	1.0	0.7	0.01	0.1	0.1
	CD at 5%	1.9	1.8	1.8	1.4	3.5	2.6	0.02	0.5	0.3
B) Cutting schedules	Uncut	-	142.8	144.8	-	315.0	479.8	1.87	-3.5	28.70
	Cutting at 45 DAS	52.9	125.5	139.3	48.8	266.8	453.0	1.77	-3.2	29.08
	Cutting at 55 DAS	50.8	124.6	137.0	47.6	254.8	412.3	1.51	-3.0	31.20
	Cutting at 65 DAS	42.3	106.6	128.3	36.8	222.3	358.5	1.33	-2.2	32.90
	Cutting at 75 DAS	36.2	98.7	117.2	32.4	204.2	293.2	1.22	-2.0	33.10
	SEm±	0.6	0.6	0.5	0.5	1.0	0.9	0.01	0.2	0.1
	CD at 5%	1.9	1.8	1.4	1.5	2.8	2.6	0.01	0.6	0.3

Table 2: Effect of sowing time and cutting schedule on yield attributes and yields of dual purpose wheat

Treatments		Effective tiller (No/mrl)	Spikelet/spike	Spike length (cm)	Grain per spike	Test weight (g)	Biological yield (kg/ha)	Grain yield (kg/ha)	Straw yield (kg/ha)	Green fodder yield (kg/ha)
A) Sowing times:	3rd week of October	148.2	17.7	9.7	51.7	45.3	11,056	3,862	7,194	20,725
	4th week of October	134.7	17.2	9.5	50	44.2	10,082	3,642	6,460	19,398
	1st week of November	114	17.0	9.2	45.6	43.5	8,958	3,364	5,594	17,168
	2nd week of November	103.2	16.4	8.9	40	42.1	8,066	3,166	4,900	16,098
	SEm+	0.6	0.1	0.1	0.4	0.3	22.3	33.7	39.0	95.8
	CD at 5%	2.1	0.3	0.2	1.4	1.2	78.7	118.8	137.7	338
B) Cutting schedules	Uncut	164.4	18.5	9.9	53	46.3	11,988	4,093	7,895	0
	Cutting at 45 DAS	140.2	17.5	9.5	50.3	45.1	11,200	4,005	7,195	5,625
	Cutting at 55 DAS	128.4	17	9.3	47.8	44.5	10,023	3,710	6,338	14,313
	Cutting at 65 DAS	104	16.9	9.1	43.7	42	8,210	3,118	5,093	24,218
	Cutting at 75 DAS	88.1	15.7	8.7	39.4	40.7	6,283	2,618	3,665	29,233
	SEm+	0.7	0.1	0.1	0.3	0.3	43.4	43.3	60.5	68.9
	CD at 5%	2.1	0.2	0.2	0.8	0.9	125.5	125.2	175.2	202.3

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