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Research Paper

Evaluation of tall wheat (*Triticum aestivum*) for dual purpose under various cutting and nitrogen-management practices

MEENAKSHI SANGWAN[1], JAGDEV SINGH[2] AND V.S. HOODA[3]

Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana 125 004

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) seasons of 2015–16 and 2016–17 at Hisar, Haryana, to evaluate tall wheat (*Triticum aestivum* L.) for dual purpose under cutting and nitrogen management practices. Treatments comprising 18 different combinations of cutting and nitrogen management included uncut with 2 N doses, viz. 60 and 75 kg/ha (T_1 and T_2)-both applied half at sowing + half at 1st irrigation, cut at 5 cm stubble height with 2 N doses (60 and 75 kg/ha) each scheduled with four different combinations of scheduling, viz. sowing$_{1/2}$ + 1st irrigation$_{1/2}$, sowing$_{1/2}$ + after cut$_{1/2}$, sowing$_{1/3}$ + after cut$_{2/3}$ and sowing$_{1/3}$ + 1st irrigation$_{1/3}$ + after cut$_{1/3}$ (T_3 to T_{10}), cut at 10 cm stubble height with 2 N doses (60 and 75 kg/ha) each scheduled with 4 different combinations of scheduling, viz. sowing$_{1/2}$ + 1st irrigation$_{1/2}$, sowing$_{1/2}$ + after cut$_{1/2}$, sowing$_{1/3}$ + after cut$_{2/3}$ and sowing$_{1/3}$ + 1st irrigation$_{1/3}$ + after cut$_{1/3}$ (T_{11} to T_{18}). The treatment with cut at 55 days after sowing (DAS) at 5 cm stubble height with 75 kg N/ha applied at sowing$_{1/2}$ + 1st irrigation$_{1/2}$ resulted in the highest green fodder yield during both the years. Among cutting and nitrogen-management treatments, the highest leaf-area index and plant height were observed under the treatment 75 kg N/ha applied at sowing$_{1/3}$ + after cut$_{2/3}$ with cut at 55 days after sowing at 10 cm stubble height owing to the complementary effect of nitrogen fertilizer and growth of wheat that might have resulted in increased vegetative growth of wheat and hence LAI and plant height. In cut plots, heading delayed by 1 week as compared to no-cut treatments. Among cutting and nitrogen-management treatments, the highest effective tillers, grain yield, net returns and benefit: cost ratio were observed under the treatment 75 kg N/ha applied at sowing$_{1/3}$ + after cut$_{2/3}$ with cut at 55 days after sowing at 10 cm stubble height followed by 75 kg N/ha applied at sowing$_{1/3}$ + after cut$_{2/3}$ with cut at 55 days after sowing at 5 cm stubble height and 60 kg N/ha applied at sowing$_{1/3}$ + after cut$_{2/3}$ with cut at 55 days after sowing 10 cm stubble height and both were statistically at par with each other and higher than rest of the treatments.

Key words : Cutting management, Dual purpose, N dose, N scheduling, Stubble height, Tall wheat

Dual-purpose (DP) crop means getting fodder as well as grain from the same crop. It can serve 2 major objectives: (a) winter season fodder crop for livestock and (b) used as a grain crop. In tall wheat ('C 306') lodging problem is very common due to its less responsiveness to high inputs (fertilizer and irrigation) which results in reduction of production of tall wheat. Tall wheat productivity can be enhanced by cutting management. Del Duca *et al.* (2006) reported that, grazing can reduce the plant height which prevent lodging in tall cultivars and increase the number of fertile tillers. Moreover, India is deficit in green fodder by about 35.6% as per Ministry of Agriculture and Farmers Welfare, New Delhi. Winter wheat can provide high-quality forage at a time of the year when fodder is not available in early winter months. Wheat can be grown as a dual-purpose crop where it provides both grain and forage from the same patch of land (Shuja *et al.,* 2010). Dual-purpose wheat provides quality forage for cattle during the winter season, when other fodder sources for livestock are low in quantity and quality (Krenzer, 2000). Thus, the use of wheat as a dual-purpose crop is aimed at reducing competition between area devoted to grain and forage crops. The income stability of this system should be higher because both livestock and wheat commodities are available for market (Redmon *et al.*, 1995). In India, cultivation of wheat for dual purpose is not very common. Thus, dual

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[1]**Corresponding author's Email**: meenakshisangwan1991@gmail.com

[1]District Extension Specialist (Agronomy), Krishi Vigyan Kenra, Rohtak; [2]Professor, [3]Assistant Scientist, Department of Agronomy, CCSHAU, Hisar, Haryana 125 004

purpose production system of tall wheat could be one of the methods to solve existing problem.

One of the most important processes in dual-purpose wheat system is to optimize cutting-management practices for fodder. Often farmers and researchers have apprehensions that cutting wheat for green fodder will not regenerate or the practice may result in heavy yield penalty in grain production. However, cutting may reduce grain yield in wheat, due to leaf-area limitations and tiller senescence during reproduction phase if crop is not managed properly. Thus, normal vegetative growth is required after cutting to produce reasonable yield which is possible only if adequate nutrition is provided to the crop well in time after cutting. To achieve better regeneration of the crop, stubble height is very important, but the information on this aspect is not available in respect to tall wheat. The nitrogen fertilization is the most limiting factor in the production of grain and forage production of dual purpose wheat (Zagonel *et al.,* 2002). It is an established fact that, nitrogen application favours vegetative plant growth as it is essentially required for cell development and cell enlargement. Nitrogen dose and its time of application is very crucial for attaining the normal growth of wheat after cutting. The studies on this aspect are very scanty. Thus, there is need to investigate proper cutting and nitrogen-management practices for dual-purpose wheat to get quality fodder for animals as well as to achieve good grain yield. Hence present experiment was carried out on these aspects.

MATERIALS AND METHODS

The field experiment was carried out during the winter (*rabi*) seasons of 2015–16 and 2016–17 at Research area of Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar (India). The meteorological data recorded at meteorological observatory of the University indicated that rainfall received during the crop season was 33.4 mm and 47.2 mm in the crop season of wheat during 2015–16 and 2016–17, respectively. The crop experienced mean weekly maximum temperatures ranged between 15.3 and 36.6°C and 16.9 and 38.4°C during 2015–16 and 2016–17, respectively, whereas the mean weekly minimum temperature ranged from 3.5 to 18.8°C and 3.2 to 17.3°C during 2015–16 and 2016–17 respectively. The soil was loamy sand (62.5% sand, 22.2% silt and 15.3% clay). The top 0–15 cm layer of the soil profile slightly alkaline in *p*H (7.9) was low in organic carbon (0.35%) and available nitrogen (132 kg/ha), medium in available phosphorus (17 kg/ha) and high in available potassium (370 kg/ha). The experiment was conducted in randomized block design with 3 replications and 18 treatments as: viz. no cut with 60 kg N/ha applied half at sowing + half at first irrigation (T_1), no cut with 75 kg N/ha applied half at sowing + half at first irrigation (T_2), cut at 5 cm stubble height with 2 N doses 60 and 75 kg/ha, each scheduled with 4 different ways i.e half at sowing + half at first irrigation, half at sowing + half after cut, one-third at sowing + two-thirds after cut and one-third at sowing + one-third at first irrigation + one-third after cut (T_3 to T_{10}), cut at 10 cm stubble height with two N doses 60 and 75 kg/ha, each scheduled with four different ways i.e 1/2 at sowing + half at first irrigation, half at sowing + half after cut, one-third at sowing + two-third after cut and one-third at sowing + one-third at first irrigation + one-third after cut (T_{11} to T_{18}). Tall wheat variety 'C-306' was sown on 28 October and 30 October during 2015–16 and 2016–17, respectively, in a plot size of 6.5 m × 4.5 m by using 100 kg/ha seed. During both the years, the crop was fertilized with recommended dose of phosphorus fertilizer (30 kg P_2O_5/ha) and drilled at the time of sowing of wheat in the form of single superphosphate during both the years. Wheat crop was fertilized with 2 different rates of nitrogen fertilizer, one was the recommended dose, i.e. 60 kg N/ha for tall wheat and another was 75 kg N/ha which was 25% enhanced dose of recommended one. Nitrogen was applied in the form of urea and scheduling was according to the treatments, but broadly there were 3 splits, viz. at sowing, first irrigation and after harvesting of wheat for fodder (55 DAS). Irrigation was applied as per the requirements in the crop during both the years. The crop was harvested 55 days after its sowing at 2 different stubble heights, i.e. 5 and 10 cm, for green fodder. Plant height was recorded from 3 permanently tagged plants in each plot with the help of meter scale and average value was calculated. The leaf area of the plants was measured using leaf area meter and was used for calculating leaf area index (LAI) as per standard method.

Days to heading were recorded by counting the days from sowing to the date when 100% plants completed heading in each subplot. From each plot 5 random spikes were taken out at the time of harvesting and spike length of each spike was measured from base to tip. The mean length was worked out and expressed in cm. These 5 spikes were threshed separately, grains were counted and average number of grains was calculated as number of grains/spike. A meter scale was used to count total number of tillers and effective tillers (productive earheads) per meter row length in each plot at the time of maturity. The aboveground harvested crop biomass from each plot was tied in bundles, tagged, sun-dried and then weighed to have total biological yield. The crop was threshed treatment-wise with the help of the mini thresher and grain yield was recorded. Harvest index (HI) is the percentage of grain in total produce and calculated as:

$$\text{H.I (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Benefit: cost ratio was also calculated

All experimental data for various growth, yield and yield-attributing characters were analyzed using software SPSS version 7.5. The significant difference among treatments was tested with help of 'F' (variance) test and by calculating CD at 5% level of significance.

RESULTS AND DISCUSSION

Plant height and leaf area index

The maximum plant height and leaf-area index (LAI) at 25 and 55 days after sowing (DAS) were obtained under cut at 10 cm stubble height with 75 kg N/ha applied at $\text{sowing}_{1/2}$ + 1st $\text{irrigation}_{1/2}$ which was statistically at par with cut at 5 cm stubble height with 75 kg N/ha applied at $\text{sowing}_{1/2}$ + 1st $\text{irrigation}_{1/2}$ and no cut with 75 kg N/ha applied at $\text{sowing}_{1/2}$ + 1st $\text{irrigation}_{1/2}$ (Table 1). At 25 and 55 DAS, significantly more plant height and LAI were observed under those treatments where complete dose of N fertilizer was applied before cutting of wheat for fodder, this might be owing to more nitrogen availability which results in taller plants and more crop growth.

At 85 and 115 DAS, significantly more plant height and LAI were observed under no cut with 75 kg N/ha applied at $\text{sowing}_{1/2}$ + 1st $\text{irrigation}_{1/2}$. This might be owing to non-cutting of wheat for fodder, as the cutting imposed stress causing termination of growth and the new growth of shoot could not attain the same plant height. Similarly, Khalil *et al*. (2011) also reported that tallest plants were observed where no cut was done as compared to crop cutting plots. Among the cutting-management treatments, the highest plant height and LAI were observed under cut $_{55\text{ DAS}}$ at 10 cm stubble height with 75 kg N/ha applied at $\text{sowing}_{1/3}$ + after $\text{cut}_{2/3}$ (Table 1). This might be owing to more availability of nitrogen for growth, as under these treatments, 67 % of recommended N fertilizer was applied after cutting of wheat for regeneration of crop and might be owing to more stubble height, as stubble height plays crucial role in regeneration of wheat after cutting. In the present study, 2 different stubble height, i.e. 5 and 10

Table 1. Effect of cutting and nitrogen-management practices on growth parameters of dual-purpose wheat (pooled data of 2 years)

Cutting treatment	Dose of N (kg/ha)	Time of application	Plant height (cm) 25 DAS	55 DAS	85 DAS	115 DAS	At harvest	Leaf area index 25 DAS	55 DAS	85 DAS	115 DAS	Days to heading
No cut for fodder	60	$\text{Sowing}_{1/2}$ + 1st $\text{irrigation}_{1/2}$	18.8	41.7	83.9	119.9	139.7	0.77	2.68	3.83	4.09	98.0
No cut for fodder	75	$\text{Sowing}_{1/2}$ + 1st $\text{irrigation}_{1/2}$	20.2	45.7	85.3	121.4	141.6	0.81	2.84	3.94	4.21	98.0
$\text{Cut}_{55\text{ DAS}}$ at 5 cm SH	60	$\text{Sowing}_{1/2}$ + 1st $\text{irrigation}_{1/2}$	18.9	42.8	63.8	92.2	105.9	0.78	2.66	0.91	2.98	103.0
$\text{Cut}_{55\text{ DAS}}$ at 5 cm SH	60	$\text{Sowing}_{1/2}$ + after $\text{cut}_{1/2}$	18.8	37.0	68.1	98.5	111.2	0.77	2.44	1.03	3.42	105.0
$\text{Cut}_{55\text{ DAS}}$ at 5 cm SH	60	$\text{Sowing}_{1/3}$ + after $\text{cut}_{2/3}$	17.1	34.5	70.8	103.2	116.5	0.67	2.36	1.16	3.72	106.0
$\text{Cut}_{55\text{ DAS}}$ at 5 cm SH	60	$\text{Sowing}_{1/3}$ + 1st $\text{irrigation}_{1/3}$ + after $\text{cut}_{1/3}$	17.1	39.2	68.5	98.4	111.3	0.68	2.36	1.02	3.42	105.0
$\text{Cut}_{55\text{ DAS}}$ at 5 cm SH	75	$\text{Sowing}_{1/2}$ + 1st $\text{irrigation}_{1/2}$	20.0	46.3	65.4	94.9	109.6	0.82	2.84	0.98	3.08	103.0
$\text{Cut}_{55\text{ DAS}}$ at 5 cm SH	75	$\text{Sowing}_{1/2}$ + after $\text{cut}_{1/2}$	20.2	38.8	71.0	102.1	115.5	0.81	2.61	1.12	3.53	105.0
$\text{Cut}_{55\text{ DAS}}$ at 5 cm SH	75	$\text{Sowing}_{1/3}$ + after $\text{cut}_{2/3}$	17.6	36.4	73.9	107.3	120.9	0.69	2.51	1.25	3.90	106.0
$\text{Cut}_{55\text{ DAS}}$ at 5 cm SH	75	$\text{Sowing}_{1/3}$ + 1st $\text{irrigation}_{1/3}$ + after $\text{cut}_{1/3}$	17.9	41.2	71.1	102.3	115.5	0.69	2.51	1.09	3.52	105.0
$\text{Cut}_{55\text{ DAS}}$ at 10 cm SH	60	$\text{Sowing}_{1/2}$ + 1st $\text{irrigation}_{1/2}$	19.1	42.5	66.9	96.9	112.1	0.77	2.68	0.98	3.13	104.3
$\text{Cut}_{55\text{ DAS}}$ at 10 cm SH	60	$\text{Sowing}_{1/2}$ + after $\text{cut}_{1/2}$	18.8	37.1	71.7	103.4	116.7	0.78	2.45	1.12	3.52	105.0
$\text{Cut}_{55\text{ DAS}}$ at 10 cm SH	60	$\text{Sowing}_{1/3}$ + after $\text{cut}_{2/3}$	17.2	34.7	75.3	108.1	122.1	0.68	2.39	1.26	3.91	106.0
$\text{Cut}_{55\text{ DAS}}$ at 10 cm SH	60	$\text{Sowing}_{1/3}$ + 1st $\text{irrigation}_{1/3}$ + after $\text{cut}_{1/3}$	17.0	39.4	71.9	103.3	116.7	0.67	2.38	1.10	3.51	105.0
$\text{Cut}_{55\text{ DAS}}$ at 10 cm SH	75	$\text{Sowing}_{1/2}$ + 1st $\text{irrigation}_{1/2}$	20.1	46.6	68.7	99.5	114.9	0.81	2.85	1.02	3.19	103.0
$\text{Cut}_{55\text{ DAS}}$ at 10 cm SH	75	$\text{Sowing}_{1/2}$ + after $\text{cut}_{1/2}$	20.1	39.2	74.4	107.2	120.3	0.83	2.62	1.19	3.62	105.0
$\text{Cut}_{55\text{ DAS}}$ at 10 cm SH	75	$\text{Sowing}_{1/3}$ + after $\text{cut}_{2/3}$	18.1	36.6	77.6	112.2	126.3	0.70	2.51	1.33	4.00	106.0
$\text{Cut}_{55\text{ DAS}}$ at 10 cm SH	75	$\text{Sowing}_{1/3}$ + 1st $\text{irrigation}_{1/3}$ + after $\text{cut}_{1/3}$	17.8	41.6	74.4	107.1	120.5	0.69	2.52	1.18	3.62	105.0
SEm±			0.5	0.8	1.0	1.5	1.8	0.03	0.05	0.02	0.03	1.4
CD (P=0.05)			1.55	2.35	3.05	4.45	5.2	0.08	0.14	0.05	0.08	4.15

SH, Stubble height; NS, non-significant; $\text{Cut}_{55\text{ DAS}}$, cutting of wheat for fodder at 55 days after sowing cm were taken and 10 cm stubble height was significantly better than 5 cm stubble height. Similar results were reported by Singhal *et al.* (2008), who found that wheat crop, irrespective of the variety, can be grown with stubble height 10 cm for fodder purpose, without affecting the growth parameters and grain yield of crop. More plant height and LAI were observed under the treatments where 75 kg N/ha was applied as compared to 60 kg N/ha but both were statistically at par with each other. This might be due to owing to the complementary effect of N fertilizer and growth of wheat that might have resulted in increased vegetative growth of wheat and hence plant height and LAI. These results corroborate with the findings of Iqbal *et al*. (2012), who reported that increase in plant height was due to increase in N fertilization. Amanullah *et al*. (2007) and Naveed *et al.* (2013) also reported that, more leaf-area index was obtained in plots that received 75% recommended dose of nitrogen after cut.

However, in the present investigation the plant heights recorded under cut at 10 cm stubble height with 60 kg/ha N and cut at 5 cm stubble height with 75 kg/ha N were found significantly at par with each other. This might be due to decapitation stress of less stubble height could be balanced with higher dose of N, which greatly helps the plant to expose its potential to grow vigorously.

Days to heading

Two years pooled data on heading showed that, heading delayed by 1 week in cut plots (106 days) as compared to no-cut treatment (98 days) (Table 1). The delay in heading in cut treatments might be due to harvesting of wheat for fodder causing temporary termination of growth for a short period that increased the vegetative growth period and also scheduling of N after cutting resulted in increased vegetative growth and LAI of decapitated crop and caused more photosynthetic activity. Yau *et al*. (1989) also found delay in days to heading in wheat after cutting and grazing. But Munsif *et al.* (2015) reported that, harvesting green fodder 70 days after sowing did not prolong physiological maturity more than 3 days with no significant reduction in yield indicating that wheat can be used as dual purpose for valuable additional fodder.

Yield-attributing characters, yields and economics

Wheat was harvested for fodder 55 days after sowing which resulted in production of fodder as well as more grain yield as compared to no-cut treatment, this might be owing to optimum time (55 DAS) of wheat harvesting for fodder, so that crop will regenerate very fast to produce normal vegetative growth and grain yield similar to uncut crop. Our result confirm the findings of Kamboj (2011), who reported that wheat crop regenerates very fast when cut 55–60 days after sowing as reflected by dynamic NDVI measurements taken with Green Seeker sensor. Among all the cutting and nitrogen-management treatments, cut $_{55\ DAS}$ at 5 cm stubble height with 75 kg N/ha applied at sowing$_{1/2}$ + 1st irrigation$_{1/2}$ resulted in highest fodder yield which was statistically higher than all other treatments (Table 2).

Number of effective tillers was significantly higher under cut treatments than un-cut (Table 2). This might be due to lodging of tall wheat was arrested in cut plots. Similarly, Harrison *et al.* (2008) also reported that, grazing can reduce the plant height which prevents lodging in tall cultivars, extends the vegetative period and increases the number of fertile tillers and grain yield. Among the different cutting and nitrogen-management treatments, cut $_{55\ DAS}$ at 10 cm stubble height with 75 kg N/ha applied at sowing$_{1/3}$ + after cut$_{2/3}$ produced more number of effective tillers which was statistically at par with 75 kg N/ha applied at sowing$_{1/3}$ + after cut$_{2/3}$ with cut$_{55\ DAS}$ at 5 cm stubble height and 60 kg N/ha applied at sowing$_{1/3}$ + after cut$_{2/3}$ with cut$_{55\ DAS}$ at 10 cm stubble height but significantly higher than all the other treatments. The results corroborate with the findings that enhanced dose of nitrogen led to an increased number of productive tillers (Hussain *et al.,* 2006; Ali *et al*., 2010). Spike length and number of grains/spike did not vary significantly under various cutting and nitrogen-management treatments (Table 2).

The reduction in grain yield under uncut plot might be due to lodging of tall wheat which resulted in decreased partitioning and decreased translocation of assimilates to sink. No-cut and cut treatments with 75 kg/ha N resulted in significantly higher grain yield as compared to 60 kg/ha N, during both years of experimentation (Table 2). In present study, significantly higher grain yield was obtained under cut at 10 cm stubble height than cut at 5 cm stubble height. This might be due to cutting of wheat higher above the ground level which would impose less stress on growth of crop owing to better regeneration ability of more succulent plant material. But treatments with 10 cm stubble height with 60 kg/ha N and 5 cm stubble height with 75 kg/ha N was at par with each other (Table 2). This might be owing to the fact that cutting stress under 5 cm stubble height was balanced by enhanced application of N. Lower grain yield was reported under those treatments where N fertilizer was not applied after wheat cutting for fodder despite of stubble height and dose of N. Among cutting and nitrogen-management treatments, the highest grain yield, harvest index and B:C ratio were observed under the treatment 75 kg N/ha applied at sowing$_{1/3}$ + after cut$_{2/3}$ with cut $_{55\ DAS}$ at 10 cm stubble height. This might be owing to the fact that 67% of recommended N was applied after cutting for fodder. Similarly, Abedi *et al*. (2011)

Table 2. Effect of different cutting and nitrogen-management practices on yield attributes, yield and economics of dual-purpose wheat (pooled data of 2 years)

Cutting treatment	Dose of N (kg/ha)	Time of application	Total tillers (No./m.r.l)	Effective tillers (No./m.r.l)	Grains/ spike	Fodder yield (t/ha)	Biological yield (t/ha)	Grain yield (t/ha)	Harvest index (%)	Benefit: cost ratio
No cut for fodder	60	Sowing$_{1/2}$ + 1st irrigation$_{1/2}$	80.8	72.9	55.3		9.92	2.66	26.8	1.68
No cut for fodder	75	Sowing$_{1/2}$ + 1st irrigation$_{1/2}$	82.8	74.3	58.2		10.72	2.85	26.6	1.80
Cut $_{55\ DAS}$ at 5 cm SH	60	Sowing$_{1/2}$ + 1st irrigation$_{1/2}$	80.8	68.9	54.0	3.98	6.58	2.01	30.5	1.40
Cut $_{55\ DAS}$ at 5 cm SH	60	Sowing$_{1/2}$ + after cut$_{1/2}$	80.1	72.9	54.9	3.43	7.57	2.41	31.8	1.57
Cut $_{55\ DAS}$ at 5 cm SH	60	Sowing$_{1/3}$ + after cut$_{2/3}$	79.3	75.5	57.7	3.20	8.29	2.70	32.6	1.69
Cut $_{55\ DAS}$ at 5 cm SH	60	Sowing$_{1/3}$ + 1st irrigation$_{1/3}$ + after cut$_{1/3}$	79.8	73.4	55.5	3.65	7.59	2.41	31.8	1.58
Cut $_{55\ DAS}$ at 5 cm SH	75	Sowing$_{1/2}$ + 1st irrigation$_{1/2}$	82.0	71.3	54.0	4.30	6.79	2.14	31.5	1.48
Cut $_{55\ DAS}$ at 5 cm SH	75	Sowing$_{1/2}$ + after cut$_{1/2}$	81.0	73.3	55.7	3.61	8.24	2.70	32.8	1.71
Cut $_{55\ DAS}$ at 5 cm SH	75	Sowing$_{1/3}$ + after cut$_{2/3}$	80.0	77.7	58.8	3.38	9.23	3.09	33.5	1.90
Cut $_{55\ DAS}$ at 5 cm SH	75	Sowing$_{1/3}$ + 1st irrigation$_{1/3}$ + after cut$_{1/3}$	80.6	74.4	56.4	3.83	8.19	2.68	32.8	1.72
Cut $_{55\ DAS}$ at 10 cm SH	60	Sowing$_{1/2}$ + 1st irrigation$_{1/2}$	82.1	70.9	54.2	3.36	6.91	2.17	31.4	1.44
Cut $_{55\ DAS}$ at 10 cm SH	60	Sowing$_{1/2}$ + after cut$_{1/2}$	80.6	73.7	56.0	2.90	8.22	2.69	32.7	1.66
Cut $_{55\ DAS}$ at 10 cm SH	60	Sowing$_{1/3}$ + after cut$_{2/3}$	80.0	78.0	59.2	2.71	9.23	3.07	33.3	1.85
Cut $_{55\ DAS}$ at 10 cm SH	60	Sowing$_{1/3}$ + 1st irrigation$_{1/3}$ + after cut$_{1/3}$	80.9	74.5	56.5	3.08	8.18	2.68	32.8	1.66
Cut $_{55\ DAS}$ at 10 cm SH	75	Sowing$_{1/2}$ + 1st irrigation$_{1/2}$	83.1	72.7	55.2	3.64	7.25	2.32	32.0	1.52
Cut $_{55\ DAS}$ at 10 cm SH	75	Sowing$_{1/2}$ + after cut$_{1/2}$	81.7	74.6	56.6	3.05	8.77	2.90	33.1	1.78
Cut $_{55\ DAS}$ at 10 cm SH	75	Sowing$_{1/3}$ + after cut$_{2/3}$	81.0	78.7	59.6	2.86	9.90	3.33	33.7	1.99
Cut $_{55\ DAS}$ at 10 cm SH	75	Sowing$_{1/3}$ + 1st irrigation$_{1/3}$ + after cut$_{1/3}$	82.0	75.2	56.9	3.24	8.74	2.91	33.2	1.78
SEm±			3.24	1.1	2.95	0.06	0.14	0.06	1.1	
CD (P=0.05)			NS	3.2	NS	0.19	0.42	0.18	3.2	-

SH, Stubble height; NS, non-significant; Cut $_{55\ DAS}$, cutting of wheat for fodder at 55 days after sowing; m.r.l, meter row length

reported that not only increasing the N fertilization rate but also scheduling of N had a beneficial effect on grain yield and its quality.

No-cut treatment resulted in significantly higher biological and straw yields during both the years than to all the cutting treatments (Table 2). This might be owing to increased plant height and leaf area which ultimately increased total biomass of plant and hence biological and straw yields. Similarly, Khalil *et al*. (2011) observed more wheat forage dry matter and biological yield with increased N application. But, results of our study contradict to the findings of Singhal *et al*. (2008), who reported that application of increased N levels did not affect the yield significantly. Among cutting and nitrogen management treatments, the highest biological yield was observed under the treatment 75 kg N/ha applied at sowing$_{1/3}$ + after cut$_{2/3}$ with cut $_{55\ DAS}$ at 10 cm stubble height.

The maximum and minimum mean weekly temperature was congenial for growth and development of dual-purpose wheat crop during both the *rabi* seasons, while during 2016–17, mean weekly temperature was relatively 2–3°C higher than the first year during initial 7–8 weeks period of crop growth and had an adverse effect on growth which lead to reduction in yield of dual-purpose wheat crop.

Nitrogen uptake and protein content

Among the cutting and nitrogen-management treatments, increased N uptake and protein content were observed under the treatment 75 kg N/ha applied at sowing$_{1/3}$ + after cut$_{2/3}$ with cut $_{55\ DAS}$ at 10 cm stubble height which was statistically higher than all other treatments and followed by 75 kg N/ha applied at sowing$_{1/3}$ + after cut$_{2/3}$ with cut $_{55\ DAS}$ at 5 cm stubble height and 60 kg N/ha applied at sowing$_{1/3}$ + after cut$_{2/3}$ with cut $_{55\ DAS}$ at 10 cm stubble height and both were statistically at par with each (Fig. 1).

This study indicated that productivity of tall wheat 'C 306' under dual-purpose system was found to be more economical with respect to benefit: cost ratio than the grain only crop as lodging was arrested under cut treatments. Thus, tall wheat could be grown as dual-purpose crop with cut at 55 DAS at 10 cm stubble height with application of 75 kg N /ha which

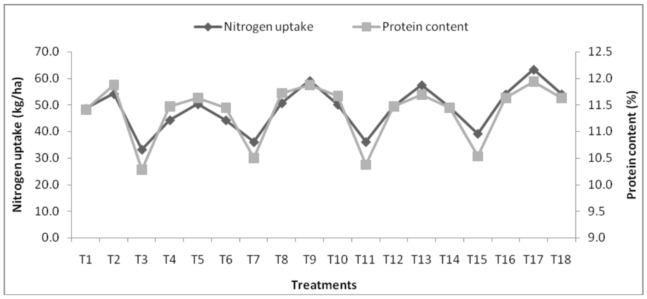

Fig. 1. Effect of different cutting and nitrogen-management practices on nitrogen uptake and protein content of dual-purpose wheat (T_1 to T_{18} treatments details are mentioned under Table 1).

was scheduled 33% before cut and 67% after cut.

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