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Research Paper

Effect of nitrogen fertilization on agro-physiological and quality parameters of dual-purpose wheat (*Triticum aestivum*)

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

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

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ABSTRACT

An experiment was conducted during the winter (*rabi*) season of 2015–16 and 2016–17 at the Chaudhary Charan Singh Haryana Agricultural University, Hisar, to study the impact of different nitrogen level and scheduling on crop performance, canopy temperature depression; nitrogen (N) content, N uptake and protein content of dual-purpose wheat (*Triticum aestivum* L.). The results revealed that, cutting of wheat at 55 days after sowing with 10-cm-stubble height did not show canopy temperature depression and yield reduction. The maximum fresh forage yield (4,303 kg/ha) was reported either when full dose or 66.6% of the recommended dose of nitrogen (RDN) was applied before cutting, but the maximum crop-growth rate (19.8 g/m^2/day), grain yield (3331 kg/ha) and benefit : cost ratio (1.99:1) were observed in treatment receiving 33.3% of the RDN before the cut and 66.6% after the cut. Highest nitrogen uptake (63.30 kg/ha), nitrogen content (1.9%) and protein content (11.14%) were observed when 75 kg N/ha was applied and which was scheduled 1/3rd at sowing and 2/3rd after the cut. Split application and after cut N application was effective in increasing wheat grain yield and grain protein content.

Key words: Crop-growth rate, Cutting management, Dual-purpose wheat, N scheduling, N uptake, Protein content, RGR

In India, where agriculture and animal husbandry are complimentary to each other and livestock rearing is integral part of rural economy, food security is directly linked with fodder availability. Thus, there is greater need to find an alternative production system as compared to wheat (*Triticum aestivum* L.) grain monoculture. 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). Wheat optimize cutting-management practices is one of the most important processes in dual-purpose for fodder. As 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. This is possible if good regeneration of the crop is achieved with adequate nutrition is provided to the crop well in time after cutting. The nitrogen fertilization is the most limiting factor in grain and forage production in dual-purpose wheat. It is an established fact that nitrogen application favours vegetative growth, as it is essential for cell development and cell enlargement. Roberts (2009) concluded that, for exploitation of the higher yield potential of traditional, high-yielding as well as dual-purpose varieties, increased N application is very important part of nutrition management. On the other hand, scheduling of N is also an important aspect in nitrogen uptake and protein content. The positive effects may be attributed mainly to the N rate effect, since the N fertilizer-use efficiency can be enhanced by split N application under appropriate environmental condition, which results in higher plant N uptake (Ercoli *et al*., 2013). In dual-purpose wheat, the quantity of nitrogen and its time of application is very crucial for attaining the normal growth of the regenerated vegetative material after cutting. Iqbal *et al.,* (2012) found an increase in plant height due to N fertilization. Abedi *et al.,* (2011) reported that, not only increasing the N fertilization rate but also scheduling of N had a beneficial effect on grain yield and its quality.

Application of N is also essential for protein production in plants, which is the direct or indirect source of protein for animal and human nutrition. But, the information on these aspects is very meagre and contradictory. In order to minimize the losses caused due to crop cutting for fodder,

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

[1]District Extension Specialist (Agronomy), Chaudhary Charan Singh Haryana Agricultural University, Krishi Vigyan Kendra, Rohtak, Haryana 124 001; [2]Assistant Scientist, [3]Ex-Professor and Head, Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana 125 004

the higher dose of N than recommendation and split application of nitrogen may play a significant role. Thus, the present experiment was conducted to study the effect of different doses of nitrogen and its scheduling on dual-purpose wheat.

MATERIALS AND METHODS

The study was carried out during the winter (*rabi*) season of 2015–16 and 2016–17 at Research farm of Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The meteorological data were recorded at meteorological observatory of the University. Rainfall during the crop season was 33.4 mm and 47.2 mm during 2015–16 and 2016–17, respectively (Fig. 1). The experimental soil was loamy sand (62.5% sand, 22.2% silt and 15.3% clay) in texture, slightly alkaline in *p*H (7.9), 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 a randomized block design (RBD), with 3 replications and 18 treatments, viz. no cut with 60 kg N/ha applied half at sowing + half at the first irrigation (T_1), no cut with 75 kg N/ha applied at half at sowing + half at the 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 the first irrigation, half at sowing + half after cut, one-third at sowing + two-thirds after cut and one-third at sowing + one-third at the first irrigation + one-third after cut (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 ways, i.e half at sowing + half at the first irrigation, half at sowing + half after cut, one-third at sowing + two-thirds after cut and one-third at sowing + one-third at the first irrigation + one-third after cut (T_{11} to T_{18}). Tall wheat variety 'C306' was sown with a seed rate of 100 kg/ha on 28 and 30 October during the season 2015–16 and 2016–17, respectively, in a plot size of 6.5 m × 4.5 m rate. The 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. Irrigation was applied as per the crop requirements during both the years. Wheat crop was harvested for fodder 55 days after sowing at 2 different stubble heights (SH) of 5 cm and 10 cm for green fodder.

Crop-growth rate (CGR) is expressed as gram of dry matter produced per day.

$$\text{CGR} = \frac{W_2 - W_1}{t_2 - t_1} \text{ g/m}^2\text{/day}$$

where W_1 and W_2 are dry weights of plant at time t_1 and t_2 respectively.

Relative growth rate (RGR)was calculated as:

$$\text{RGR} = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1} \text{ g/g/day}$$

where W_1 and W_2 are dry weights of plant at time t_1 and t_2, respectively. Log_e is natural logarithm.

Canopy temperature depression (CTD) is used as a crop water stress indicator and measured with the help of Infra Red Thermometer (IRT) at heading stage during afternoon when plant water was maximized. The above-ground 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 plot-wise with the help of the mini thresher grain yield was recorded.

The samples of wheat grain and straw were collected at harvesting, dried in sun and then in oven. Plant samples were ground in a Wiley Mill and passed through 32-mesh size. Grain samples were ground in small grinding mill. The grain and straw samples were used for estimation of nitrogen content with the help of colorimetric (Nessler's reagent) method (Lindner, 1944) The nitrogen uptake was calculated by multiplying the per cent N content with their respective biomass yields by using the formula:

$$\text{N uptake by crop (kg/ha)} = \frac{\text{Per cent N content} \times \text{crop yield (kg/ha)}}{100}$$

Grain protein (%) was determined from the per cent N determined in the grain by colorimetric (Nessler's reagent) method (Lindner, 1944) as:

Grain protein content = N% × 5.83

All experimental data for various parameters were analysed using software SPSS version 7.5. The significance difference among treatments was tested with help of 'F' (variance) test and means were separated at $P<0.05$ and adjusted with Fisher's Protected Least Significant Difference (LSD) test.

RESULTS AND DISCUSSION

Canopy temperature depression (CTD) data at heading stage showed that crop did not face any stress after cutting. This might be due to congenial crop, weather and soil conditions (Fig. 1).

During initial 30 days period after cutting, lower crop-growth rate (CGR) and relative growth rate (RGR) were observed this might be due to decapitation effect in cut plots. After cutting low rate of CGR and RGR were observed under treatments, where nitrogen fertilizer was not applied after cutting of wheat. Among different cutting and nitrogen management treatments, 75 kg N/ha applied 33.3% N at sowing + 66.6 % N after cut at 55 days after sowing (DAS) at 10-cm-stubble height (SH) showed higher CGR and RGR for 56–85 and 86–115 DAS as compared to all other treatments and for 116 DAS–harvesting, there was no significant difference among different treatments

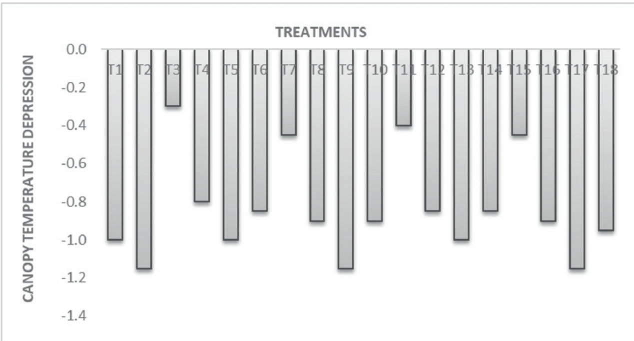

Fig. 1. Effect of different cutting and nitrogen management practices on canopy temperature depression of dual-purpose wheat (pooled data of 2 years)

(Fig. 2). The highest CGR and RGR were recorded under the treatments where two-thirds of nitrogen was applied after cut followed by half and one-third, both were statistically similar, but significantly higher than the treatments where complete fertilizer was applied up to the first irrigation. The results confirm the findings of Naveed *et al.,* (2013) that, the maximum crop-growth rate was obtained in treatment receiving 75% recommended dose of nitrogen after cut.

Among all the cutting and nitrogen management treatments, cut at 55 DAS at 5-cm-stubble height with 75 kg N/ha applied 50% at sowing + 50% at time irrigation resulted in the highest fodder yield (3,975 kg/ha) which was significantly higher one other treatments (Table 1). This was obvious because harvesting near the ground level (5-cm-stubble height) with N (75 kg/ha) application before cut resulted in more green fodder yield. Significantly higher biological yield in no-cut treatment was observed which might be owing to increased plant height, leaf area and CGR which ultimately increased the total biomass of plant and hence biological yield. The reduction in biological yield in cutting treatments might be due to the fact that, cutting imposed stress causing termination of growth and reduction in leaf-area index (LAI). Significantly higher biological yield was observed with 75 kg/ha N as compared to 60 kg/ha N. But, treatments with cutting at 5-cm-stubble height (SH) with 75 kg/ha N was at par with 10-cm-stubble height (SH) with 60 kg/ha N for biological and grain yields during both the years. This might be owing to the fact that cutting stress under 5-cm-stubble height (SH) was balanced by enhanced application of nitrogen. Our results contradict the findings of Singhal *et al*. (2008) who reported that application of increased N levels did not affect the yield significantly. During both the years, no-cut treatments resulted in significantly lower grain yield than cut plots. This 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. Lower grain yield was reported under the treatments where nitrogen fertilizer was not applied after cutting of wheat for fodder. Among cutting-and nitrogen-management treatments significantly higher biological yield, grain yield and benefit: cost (B:C) ratio were observed under the treatment where 75 kg N/ha was applied 33.3% N at sowing + 66.6% N after cut (10-cm-stubble height) at 55 DAS (Table 1). This might be due to the fact that, 67% of recommended nitrogen was applied after cutting for fodder. Similarly, Abedi *et al*. (2011) reported that not only increasing the N fertilization rate but also scheduling of N had a beneficial effect on grain yield and its quality. But, the results of present study on wheat grain yield are contradictory to the findings of Birsin (2005), who observed the effects of removing flag leaf on yield parameters of wheat and found reduction in grains/spike, grain weight/spike and 1000-grain weight occurred as a result of removal of flag leaf.

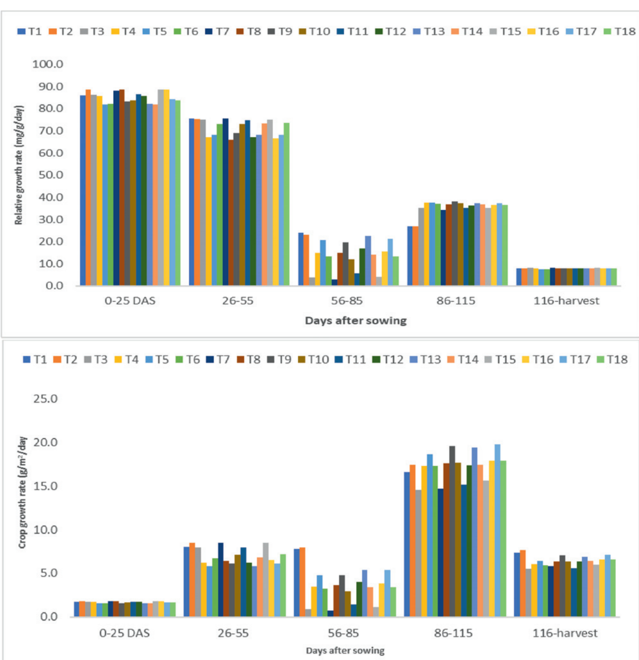

Fig. 2. Effect of different cutting-and nitrogen management practices on relative growth rate and crop-growth rate of dual-purpose wheat (pooled data of 2 years)

In present experiment, among cutting- and nitrogen management treatments more nitrogen content and increased uptake of nitrogen by both grain as well as straw were observed under the treatment 75 kg N/ha applied–33.3% N at sowing + 66.3% at after cut-with 10-cm-stubble height (SH) at 55 DAS. This treatment was significantly higher than all the other treatments and followed by 75 kg N/ha applied 33.3% N at sowing + 66.6% N after cut-with cut 5 cm at 55 DAS and 60 kg N/ha applied, 33.3% N at sowing + 66.6% N after cut, with 10 cm at 55 DAS and both were statistically at par with each other and

Table 1. Effect of different cutting- and nitrogen management practices on yield, economics and quality of dual-purpose wheat (pooled data of years)

Cutting treatment	Dose of N (kg/ha)	Time of application	Fodder yield (kg/ha)	Biological yield (kg/ha)	Grain yield (kg/ha)	Benefit: cost (B:C) ratio	Protein content in grain (%)	N content in grain (%)	N content in straw (%)	N uptake by grain (kg/ha)	N uptake by straw (kg/ha)
No cut for fodder	60	$Sowing_{1/2}$ + 1st $irrigation_{1/2}$	-	9,919	2,660	1.68	10.67	1.83	0.37	48.55	26.50
No cut for fodder	75	$Sowing_{1/2}$ + 1st $irrigation_{1/2}$	-	10,718	2,849	1.80	11.08	1.90	0.40	54.15	31.50
$Cut_{55\ DAS}$ at 5 cm SH	60	$Sowing_{1/2}$ + 1st $irrigation_{1/2}$	3,975	6,584	2,011	1.40	9.62	1.65	0.26	33.10	11.90
$Cut_{55\ DAS}$ at 5 cm SH	60	$Sowing_{1/2}$ + after $cut_{1/2}$	3,434	7,573	2,412	1.57	10.73	1.84	0.37	44.25	18.80
$Cut_{55\ DAS}$ at 5 cm SH	60	$Sowing_{1/3}$ + after $cut_{2/3}$	3,204	8,289	2,699	1.69	10.34	1.86	0.38	50.25	21.25
$Cut_{55\ DAS}$ at 5 cm SH	60	$Sowing_{1/3}$ + 1st $irrigation_{1/3}$ + after $cut_{1/3}$	3,647	7,594	2,413	1.58	10.67	1.83	0.36	44.20	18.65
$Cut_{55\ DAS}$ at 5 cm SH	75	$Sowing_{1/2}$ + 1st $irrigation_{1/2}$	4,303	6,794	2,138	1.48	9.79	1.68	0.29	35.95	13.30
$Cut_{55\ DAS}$ at 5 cm SH	75	$Sowing_{1/2}$ + after $cut_{1/2}$	3,609	8,236	2,698	1.71	10.96	1.88	0.40	50.65	20.40
$Cut_{55\ DAS}$ at 5 cm SH	75	$Sowing_{1/3}$ + after $cut_{2/3}$	3,379	9,227	3,090	1.90	11.14	1.91	0.42	59.05	25.80
$Cut_{55\ DAS}$ at 5 cm SH	75	$Sowing_{1/3}$ + 1st $irrigation_{1/3}$ + after $cut_{1/3}$	3,830	8,194	2,685	1.72	10.99	1.87	0.39	50.10	21.00
$Cut_{55\ DAS}$ at 10 cm SH	60	$Sowing_{1/2}$ + 1st $irrigation_{1/2}$	3,359	6,910	2,168	1.44	9.68	1.66	0.27	36.00	12.80
$Cut_{55\ DAS}$ at 10 cm SH	60	$Sowing_{1/2}$ + after $cut_{1/2}$	2,902	8,216	2,690	1.66	10.73	1.84	0.37	49.35	20.45
$Cut_{55\ DAS}$ at 10 cm SH	60	$Sowing_{1/3}$ + after $cut_{2/3}$	2,708	9,232	3,073	1.85	10.90	1.87	0.40	57.45	24.35
$Cut_{55\ DAS}$ at 10 cm SH	60	$Sowing_{1/3}$ + 1st $irrigation_{1/3}$ + after $cut_{1/3}$	3,082	8,180	2,682	1.66	10.67	1.83	0.37	49.10	20.25
$Cut_{55\ DAS}$ at 10 cm SH	75	$Sowing_{1/2}$ + 1st $irrigation_{1/2}$	3,637	7,245	2,321	1.52	9.85	1.69	0.29	39.10	14.25
$Cut_{55\ DAS}$ at 10 cm SH	75	$Sowing_{1/2}$ + after $cut_{1/2}$	3,050	8,770	2,899	1.78	10.84	1.86	0.39	53.95	22.90
$Cut_{55\ DAS}$ at 10 cm SH	75	$Sowing_{1/3}$ + after $cut_{2/3}$	2,855	9,895	3,331	1.99	11.08	1.90	0.41	63.30	26.90
$Cut_{55\ DAS}$ at 10 cm SH	75	$Sowing_{1/3}$ + 1st $irrigation_{1/3}$ + after $cut_{1/3}$	3,237	8,740	2,903	1.78	10.84	1.86	0.39	54.00	22.45
SEm±			64	144	165		0.18	0.03	0.02	0.65	0.7
CD (P=0.05)			187	315	418	––	0.54	0.09	0.07	2.0	2.15

SH, Stubble height; NS, non significant; $Cut_{55\ DAS}$, cutting of wheat for fodder at 55 days after sowing; $Sowing_{1/2}$, application of 50% N at the time of wheat sowing; 1_{st} $irrigation_{1/2}$, application of 50% N at first irrigation; after $cut_{1/2}$, application of 50% N after fodder cut; $sowing_{1/3}$, application of 33% N at the time of wheat sowing; After $cut_{2/3}$, application of 67 % N after fodder cut; 1_{st} $irrigation_{1/3}$, application of 33% N at first irrigation; After $cut_{1/3}$, application of 67 % N after fodder cut higher than rest of the treatments during both the years (Table 1). This might be owing to split application of nitrogen and scheduling of 67% of recommended nitrogen after cutting of wheat for fodder. Our results corroborates the findings of Gill *et al.* (1970), who reported that higher nitrogen dose and split application resulted in more nitrogen content (%) and uptake by wheat. Protein content in dual-purpose wheat grain did not differ significantly under the influence of both the nitrogen treatments, but numerically more protein content was reported under 75 kg/ha N than 60 kg/ha N during both the years (Table 1). Time of nitrogen fertilizer application significantly influenced the protein content in wheat grain under cutting management treatments. Significantly less protein content was observed under treatments where nitrogen fertilizer was not applied after cutting of wheat for fodder. This might be on account of direct relationship between nitrogen and protein content. Thus, after cut, application of nitrogen can drive a significant protein response. However, this effect may not only from increased N fertilization rate but also from split N application. Fisher *et al.* (1993) also reported that, split application of N was effective in increasing wheat grain yield and especially grain protein which was improved by the late application of N.

A positive relationship between nitrogen content and protein content in wheat grain (Fig. 3). The regression model explained about 99% of the variation in protein content due to nitrogen content and provided a good fit between the protein content and nitrogen content.

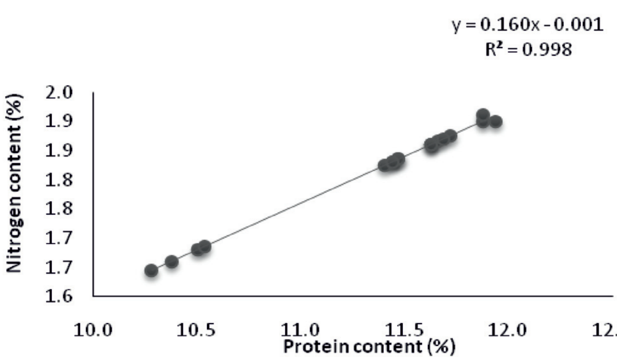

Fig. 3. Relationship between protein content and nitrogen uptake. The line represents a linear model fitted to the average data for both the years

Hence it was concluded that, scheduling of nitrogen fertilizer had remarkable influence in to improving protein content, nitrogen content and uptake in dual-purpose wheat grain and straw. Thus, tall wheat could be grown as dual-purpose crop with cut at 55 days after sowing at 10-cm-stubble height with application of 75 kg N/ha which was scheduled as 33% before cut and 67% after cut. For farmers, growing of tall wheat 'C 306' under dual-purpose system has potential to provide higher net returns than the grain only crop.

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