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Influence of sowing dates and cutting management on productivity and profitability of dual purpose barley (*Hordeum vulgare* L.) in Indo-Gangetic Plains of India

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Abstract

A study was carried out during winter season of 2015-16 and 2016-17 to find out optimum time of sowing and suitable cutting management for higher growth, productivity and economics of dual purpose barley (*Hordeum vulgare* L.). Growth attributes i.e. plant height and dry matter of October 15 sown crop were highest when fodder cut was taken at 50 days after sowing (DAS). Significantly higher productivity (fodder, grain and biological yields) of barley was observed in early sowing (October 15). Control and cut at 50 DAS treatments produced statistically similar grain and biological yields and it can be delayed up to 60 DAS to get more production of green fodder (40.5 to 41.8%) than at 50 DAS but at the cost of 20.6-22.7% reduction in grain yield. Crop sown on October 15 with fodder cut at 60 DAS + 25% additional N application (15 kg N ha^{-1}) after fodder cut resulted in significantly higher net return (Rs 82,863) vis-a-vis benefit cost ratio (2.88).

Keywords: Barley, benefit cost ratio, cutting management, net return, productivity

1. Introduction

Barley (*Hordeum vulgare* L.) plays a key role in the integrated crop-livestock production systems. It is a stable food, feed and fodder source for sustaining smallholder farmers' income. Furthermore, barley is among the most salt-tolerant cereals and replaces wheat in many arid areas (Johnson and Flower, 1992). Today, barley accounts for 15% of world coarse grains in use. Traditionally, it is considered as a poor man's crop and in India it is favoured because of its low input requirement and better adaptability to harsh environments, like drought, salinity/ alkalinity and marginal lands. In the recent years it has been observed that in the drier parts of northern plains there is an acute shortage of green fodder in the months of November to January. Since berseem (*Trifolium* spp) and oat are not available due to water shortage, in such areas, barley can be utilized as green fodder with very limited irrigation or rainfall in these areas. In drier parts of northern plains (Rajasthan, Madhya Pradesh, southern Haryana, South west Punjab and western U.P.) during November to January, farmers can grow barley in place of other forage crops because of its dual utilization and less water requirement (Verma *et al.,* 2007). In these regions, animal husbandry occupies an important role and there is a big gap between demand and supply of forage. Since both the green forage and grain can be utilized for animal fodder/ feed purposes, the crop can be advantageous over oats, because of its dual utilization, faster early growth as well as less water requirement. Barley possesses regeneration capacity like other cereals after taking it as fodder before jointing stage. The regeneration ability of barley can be put to use by taking one cutting during the active vegetative growth stage and then leaving the regenerated crop for grain production (Mishra and Kumar, 2002). Therefore, it is reasonable to assume that one cutting for green forage at active growth stage will reduce the lodging chances in barley. It will also help in mitigating the fodder shortage. So, barley can provide important nutrition to the livestock through its green fodder and grains harvested from regenerated crop. The experiments were conducted to optimise the date of sowing and stage of cutting with nitrogen management for forage and grain yield.

2. Materials and methods

A field experiment was conducted at the research farm of the Department of Agronomy, Punjab Agricultural University, Ludhiana during the rabi seasons of 2015-16 and 2016-17. The experimental site is situated at 30°54/N latitude and 75°48/E longitude at a height of 247 meters above the mean sea level. The site is characterized by subtropical and semi-arid type of climate. The soil at experimental site was a loamy sand in texture, normal in reaction (pH 7.3) and had electrical conductivity 0.21 ds/m. It was low in available nitrogen (186.0 kg ha^{-1}), high in available phosphorus (29.9 kg ha^{-1}) and medium in available potassium (147.5 kg ha^{-1}). The cropping system followed was sunhemp (*Crotalaria juncea* L.)–barley as sunhemp being a legume crop contributes to soil health.

The experiment comprised 15 treatment combinations having three sowing dates (October 15, October 30 and November 15) in main plot and five different cutting management {control, cut at 50 days after sowing (DAS), cut at 60 DAS, cut at 50 DAS + 25% additional nitrogen after cut (15 kg N ha^{-1}) and cut at 60 DAS + 25% additional nitrogen after cut (15 kg N ha^{-1})} as sub plot treatment was laid out in split plot design with four replications were taken.. Barley variety PL 807 was sown at 5 cm depth using seed a rate of 87.5 kg $ha^{-1}$with a seed drill at row spacings of 22.5 cm on specified dates. A uniform basal dose of nitrogen (62.5 kg N ha^{-1}), phosphorous (30 kg $P_2O_5ha^{-1}$) and potassium (15 kg K_2O ha^{-1}) were applied at the time of sowing in the form of urea (46% N), single super phosphate (16% P_2O5) and muriate of potash (60% k_2O), respectively. Under cutting management, crop was harvested from specified net plots for fodder purpose leaving the stumps of 5 cm for further regeneration at 50 and 60 DAS. An additional dose of nitrogen (15 kg N ha^{-1}) and irrigation was applied immediately after each fodder cut only in cutting plots of barley. Green fodder yield from net plot was weighed and converted into kg ha^{-1}.

Ten random plant samples plants were selected from each plot, excluding the border row, for taking observation on plant height at 120 DAS. Representative at 120 DAS from 25 cm-row length in penultimate rows were oven dried to record dry weight. The biological and grain yield was recorded as total weight and weight of threshed grains obtained from net plot area of each experimental unit, respectively and expressed as kg ha^{-1}. Economics of barley was calculated by using prevailing prices for inputs and produce of the crop. Net return was the returns after deducting the cost of cultivation from gross return. Benefit cost ratio (BCR) was calculated by dividing the net returns with the cost of cultivation. The data generated from the experiment were analyzed by using standard analysis of variance procedures and mean comparisons were performed based on least significant differences test at 0.05 probability.

3. Results and discussion

3.1 Growth attributes: The growth attributes, viz. plant height and dry matter accumulation at 120 days after sowing (DAS) were significantly affected due to sowing date and cutting management. The interaction effects of sowing date and cutting management on plant height are presented in Table 1. The plant height of October 15 sown crop was significantly higher than November 15 sown crop when fodder cut was taken at 50 DAS and cut at 50 DAS + N15, but it was statistically similar with October 30 sown crop. Taller plant in early sowing crop might be due to high temperature conditions prevailed in the early season. In October 15 sown crop, fodder cut at 50 DAS and cut at 50 DAS + N15 attained statistically similar plant height with control. Application of additional N (15 kg N ha^{-1}) after fodder cut at 50 and 60 DAS increased the plant height in all three sowing dates. Under control treatment, October 15 sowing crop attained significantly higher plant height than November 15 sowing but it was statistically at par with October 30. Forage harvest of barley might have slowed down the rate of internode elongation and caused reduction in the supply of assimilates from the leaves to roots. Kumar *et al.* (1999) reported that plant height was significantly higher when the wheat crop was raised with no cut as compared to the crop where one cut was imposed for taking additional forage yield.

There was significant interaction between sowing date and cutting management practices for the dry matter

Table 1. Interaction effects of sowing date and cutting management on plant height (cm) of barley at 120 DAS (Pooled analysis).

Sowing date	Cutting management				
	Control	50 DAS	60 DAS	50 DAS + N_{15}	60 DAS + N_{15}
Oct. 15	96.2	92.1	85.5	92.8	87.8
Oct. 30	94.2	87.2	76.0	88.6	81.1
Nov. 15	89.4	80.8	69.3	82.8	72.3
	LSD (P=0.05): 5.6				

N_{15}= 25% additional nitrogen after cut (15 kg N ha^{-1})

accumulation at 120 DAS (Table 2). October 15 sown crop accumulated significantly higher dry matter than October 30 and November 15 sown crop when fodder cut was taken at 50 DAS. In October 15 and October 30 sown crop, fodder cut at 50 DAS and cut at 50 DAS +

N_{15} accumulated statistically similar dry matter as control treatment. Dry matter accumulation of crop increased by additional N application i.e. 15 kg N ha^{-1}, when fodder cut was taken at 60 DAS and decreased when fodder cut at 50 DAS in all three sowing dates which might be due to higher crop lodging in fodder cut at 50 DAS crop. Acreche and Slafer (2011) and Berry and Spink (2012) reported that grain yield of wheat was reduced due to higher crop lodging.

3.2 Productivity of barley: October 15 sowing resulted in significantly higher production of fodder, biomass and grain yields, compared to October 30 and November 15 sowing (Table 3). October 15 sowing recorded 11.8 and 34.1% during 1st year and 9.0 and 30.2% during 2nd year, higher grain yield than October 30 and November 15 sowing, respectively. Significantly higher grain yield under October 15 sowing might be due to fact that favourable environmental conditions at all phenological stages led to higher plant height and dry matter (Tables 1 and 2). This might be also due to total duration of crop which was 139.9 and 141.8 days under November 15 sowing was increased to 166.8 and 168.1 days under October 15. November 15 recorded lowest biological yield might be attributed to the low temperature conditions prevailing during initial stages of plant growth, responsible for reduced the vegetative growth by affecting its various metabolic processes. Dhumale and Mishra (1979) reported that green fodder yields were positively correlated with plant height. Similar results were obtained by Khan *et al.* (2015) and Ram *et al.* (2010).

Table 2. Interaction effects of sowing date and cutting management on dry matter accumulation (q/ha) at 120 DAS of barley (Pooled).

Sowing date	Cutting management				
	Control	50 DAS	60 DAS	50 DAS + N_{15}	60 DAS + N_{15}
Oct. 15	115.5	119.2	94.0	108.3	103.5
Oct. 30	107.4	106.6	83.3	98.3	92.2
Nov. 15	106.5	85.4	72.9	83.2	76.0
LSD (P=0.05): 8.5					

N_{15}= 25% additional nitrogen after cut (15 kg N ha^{-1})

Control and cut at 50 DAS treatments were statistically similar among each other with respect to biological and grain yields, but these were significantly higher than other cutting treatments. There was an increase of 22.8 and 23.3% in grain yield when fodder cut was taken at 50 DAS than cut was taken at 60 DAS during 1st and 2nd year of study, respectively. Higher grain and biological yields of early cutting (i.e. at 50 DAS) treatment might be due to better growth with longer period than cutting at 60 DAS. Further delay in cutting from 50 DAS to 60 DAS, grain yield reduction might be due to reduced period for vegetative and reproductive growth. Delayed forage harvest, significantly reduced the leaf area of crop due to which reduction in the photosynthesis efficiency and supply of photosynthates from source (leaves) to sink (grains) was restricted, which ultimately reduced the grain yield in cutting crop for fodder at 60 DAS. Reduction in the grain yield of fodder cut at 50 DAS + N15 treatment was attributed to more lodging of crop. When crop was cut

Table 3. Effect of sowing date and cutting management on productivity of barley

Treatment	Fodder yield (kg ha^{-1})			Biological yield (kg ha^{-1})			Grain yield (kg ha^{-1})		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Sowing date									
Oct.15	17393	18151	17772	12681	11915	12298	4254	3874	4064
Oct.30	14280	15772	15026	11504	11074	11289	3747	3515	3631
Nov. 15	13583	14805	14194	10244	10011	10127	2795	2697	2746
LSD (P=0.05)	803	619	605	452	600	342	253	207	137
Cutting management									
Control	-	-	-	12178	11773	11976	4028	3827	3928
50 DAS	12567	13198	12983	12048	11413	11730	3927	3648	3787
60 DAS	17684	19290	18452	10638	10229	10434	3204	2956	3080
50 DAS + N_{15}	12429	13036	12733	11343	10876	11110	3301	3053	3177
60 DAS + N_{15}	17662	19250	18489	11173	10708	10940	3532	3328	3430
LSD (P=0.05)	436	445	339	623	590	402	210	210	150

N_{15}= 25% additional nitrogen after cut (15 kg N ha^{-1})

for fodder at 60 DAS also imposed stress and took more number of days for regeneration due to less temperature conditions. Fodder cut at 60 DAS produced 40.7 and 46.1% higher green fodder yield than the fodder cut at 50 DAS

3.3 Economics: Interaction effect of sowing date and cutting management with respect to net return found to be significant (Table 4). Fodder cut at 60 DAS + N15 observed the highest net return from the crop sown on October 15 which was statistically similar with cut at 60 DAS, but significantly higher than all other treatments. Net returns of control crop was significantly lower than cut at 50 DAS, cut at 60 DAS, cut at 50 DAS + N15 and cut at 60 DAS + N15 sown in October 15 and October 30. The net returns of fodder cut at 50 DAS and cut at 60 DAS were statistically similar.

Table 4. Interaction effects of sowing date and cutting management on net return (Rs/ha) of barley (Pooled analysis).

Sowing date	Cutting management				
	Control	50 DAS	60 DAS	50 DAS + N_{15}	60 DAS + N_{15}
Oct. 15	49,677	74,007	77,205	66,268	82,863
Oct. 30	45,777	64,935	60,301	57,040	66,912
Nov.15	38,057	48,112	51,313	38,322	53,200
	LSD (P=0.05): 6,614				

N_{15}= 25% additional nitrogen after cut (15 kg N ha^{-1})

Interaction effect of sowing date and cutting management with respect to benefit cost ratio found to be significant (Table 5). A perusal of data revealed that delayed sowing time reduced the benefit cost ratio in all cutting treatments. Fodder cut at 60 DAS + N15 recorded the highest benefit cost ratio from the crop sown on October 15 which was statistically at par with cut at 60 DAS, but significantly higher than all other treatments.

Thus it is concluded that barley crop sown on October 15 gave significantly higher that barley grain yield as well as fodder yield. One fodder cut of barley (variety PL 807) taken at 50 DAS without any significantly yield reduction and it can be delayed up to 60 DAS to get more production of green fodder than that at 50 DAS but at the cost of 20.6-22.7% reduction in grain yield. Crop sown on October 15 with fodder cut at 60 DAS + N15 observed significantly higher net returns and benefit cost ratio.

Table 5. Interaction effects of sowing date and cutting management on benefit cost ratio of barley (Pooled analysis).

Sowing date	Cutting management				
	Control	50 DAS	60 DAS	50 DAS + N_{15}	60 DAS + N_{15}
Oct. 15	2.21	2.59	2.70	2.30	2.88
Oct. 30	2.05	2.28	2.12	1.99	2.33
Nov. 15	1.71	1.78	1.82	1.34	1.86
	LSD (P=0.05): 0.27				

N_{15}= 25% additional nitrogen after cut (15 kg N ha^{-1})

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