International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(1): 2063-2068

Received: 11-11-2018
Accepted: 15-12-2018

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Yield and nutrient uptake of barley (*Hordeum vulgare* L.) as influenced by time of sowing and cutting management

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Abstract
The field experiment was conducted during *rabi* season of 2015-16 and 2016-17 at Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana to study the effect of sowing time and different cutting management practices on yield and nutrients (N, P & K) uptake in barley (*Hordeum vulgare* L.). Crop sown on October 15 gave significantly higher grain yield with significantly higher fodder yield. One fodder cut of barley taken at 50 days after sowing (DAS) without any significantly yield reduction and it can be delayed up to 60 DAS to get more production of green fodder (40.5 to 41.8%) than that at 50 DAS but at the cost of 20.6-22.7% reduction in grain yield. Application of additional dose of 15 kg N ha^{-1} after fodder cut at 60 DAS increased the grain yield in all three sowing dates. But grain yield in all three sowing dates decreased with application of additional dose of 15 kg N ha^{-1} after fodder cut at 50 DAS. November 15 sowing gave higher nitrogen and potassium content in grain and straw, whereas October 15 recorded higher content of phosphorus in grain. Significantly higher nitrogen, phosphorus and potassium uptake was recorded in October 15 sowing.

Keywords: Barley, cutting management, grain yield, green fodder, nutrient uptake

1. Introduction

Barley (*Hordeum vulgare* L.) is an important winter season crop grown under Indian conditions. In India, it is primarily grown for human consumption, while most of it is used as cattle feed in USA and Europe. Barley has considerable potential to provide fodder during lean periods and low temperatures due to its fast growth. It is a source of early nutritious fodder to overcome the winter feed problem. Today, barley accounts for 15% of world coarse grains in use. Whole barley grain contains important vitamins and high levels of minerals like calcium, magnesium, phosphorus, potassium, vitamin A, vitamin E and niacin. Each 100 g of barley grain comprises 10.6 g protein, 2.1 g fat, 64 g carbohydrate, 50 mg calcium, 6 mg iron, 0.31 mg vitamin B_2 and 50 µg folate (Vaughan *et al.* 2006) [16]. Consumption of barley reduces the cholesterol level in liver by inhibiting the rate of limiting hepatic enzyme, beta hydroxyl beta methyl glutaryl CoA reductase. It also stimulates fatty acids synthesis in liver.

In world, about 70% of barley is used for animal feed, 20% for malting and 5% for direct food use. Its straw is also used for making hay and silage. This crop was grown on 589.4 thousand hectares and recorded a production of 1437.5 thousand tonnes with an average yield of 24.39 q ha^{-1} in India, during 2015-16 (Anonymous, 2017) [1]. Sowing time affects crop performance by altering weather conditions prevailing during crop growth especially germination and maturity period, thus, causing variation in duration of various phenophases, consequently, crop duration. Early sowing always produces higher yield than late sowing. Variation in weather conditions among and within seasons is one of the most important constraints affecting yield potential (Murungu and Madanzi, 2010) [10]. In addition to agriculture, livestock plays an important role in strengthening rural economy of northern regions. 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 *rabi* season. To improve the productivity of animals availability of adequate quantity of nutritive fodder is prerequisite. The productivity of milch animals in India is very low as compared to developed countries, primarily due to less availability of nutritive feed and fodder to animals (Patel *et al.* 2011) [11]. The estimated requirement of green and dry fodder in the country is 1,400 and 950 million tonnes, respectively, against the corresponding availability of 250 and 440 million tonnes (Chotiya and Singh, 2005) [3].

To maintain good health and potential of animals in terms of milk, meat and wool, feeding of good-quality fodder is highly important (Bhilare and Joshi, 2007) [2].
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) [9]. 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. Under Punjab conditions, green fodder availability is only 28.4 kg/animal against a requirement of 40.0 kg/animal. So, barley can serve as alternative for augmenting the green forage demand in the arid and semi-arid areas of northern plains under limited irrigations along with satisfactory levels of grain yield from the regenerated crop, which can be utilized as feed for cattle or for human consumption.

2. Materials and Methods

A field experiment was conducted at the Research Farm of the Department of Agronomy, Punjab Agricultural University, Ludhiana during two consecutive barley growing seasons (2015–16 and 2016–17). The experimental site is situated at 30º54/N latitude and 75º48/E longitude at a height of 247 m above the mean sea level. The site is characterized by subtropical and semi-arid type of climate with average annual rainfall of 755 mm, 75–80% of which is received in July–September. The soil at experimental site was a loamy sand (Typic Ustipsament), 7.3 pH, 0.36% organic C content, 186.0 kg ha^{-1} available N content, 29.9 kg ha^{-1} available P content, 147.5 kg ha^{-1} available K content, 2.77 mg kg^{-1} available Zn content, 9.39 mg kg^{-1} available Fe content, 8.2 mg kg^{-1} available Mn content and 0.46 mg kg^{-1} available Cu content. The bulk density was 1.6 Mg m^{-3} in the 0-1m soil profile.
The experiment was laid out in a split-plot design with 15 treatments (3 × 5), replicated three times. The main factor comprised three sowing dates (15, 30 October; and 15 November) and the sub-factor comprised five cutting management [un-cut, cut at 50 days after sowing (DAS), cut at 60 DAS; cut at 50 DAS + additional 15 kg N ha^{-1} after cut (N_{15}) and cut at 60 DAS + additional 15 kg N ha^{-1} after cut (N_{15})]. The size of the subplots was 3.6 by 6.0 m. Field was prepared by cultivating twice using a disc harrow followed by leveling with a wooden board. A heavy pre-sowing irrigation (10 cm) was applied to ensure adequate moisture in the soil profile at the time of planting. When the field attained proper moisture condition, a fine seedbed was prepared by giving two ploughings with cultivator each followed by planking. Before sowing, seed was treated with Raxil @ 1.5 g kg^{-1} to control covered smut, loose smut and stripe disease. Barley variety PL 807 was sown at 5 cm depth with single row cotton drill spaced 22.5 cm apart by a uniform seed rate of 87.5 kg ha^{-1} on specified dates. A uniform basal dose of nitrogen (62.5 kg N ha^{-1}), phosphorous (30 kg P_2O_5 ha^{-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_2O_5), 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. 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 was cut at height of 5 cm from the ground after 50 and 60 days after sowing as per treatments. Green fodder yield from net plot was weighed and converted into kg/ha. 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. Plant samples collected at harvest were first dried in hot air oven at 60 °C for 24 hours and then the dried samples were grounded. Nitrogen (%) in samples was determined by using Kjeldahl's Distillation method. To calculate the uptake by crop, the percent nitrogen content in plant (grain and straw) was multiplied with total plant biomass. The phosphorus content in plant (grain and straw) was determined by using Vanado-Molybdo-Phosphoric Yellow Colour method in nitric acid (Jackson, 1967) [6]. Intensity of developed colour was measured by Spectronic-20 Colorimeter at wavelength of 470 nm using blue filter. Percent contents of phosphorus in grain and straw were multiplied by total biomass to calculate phosphorus uptake by the crop. The aliquot (digested material of grain and straw) samples that were used for phosphorus determination were used for the determination of potassium content in grain and straw. The potassium content was estimated using Lange's Flame Photometer (Jackson, 1967) [6]. The nitrogen, phosphorus and potassium uptake in plant (grain and straw) was calculated by multiplying the respective percent contents with total plant biomass (grain and straw yield).

2.1 Statistical analyses

The experiment were performed in continue two years. Least significant difference test was used to determine the significance of differences among treatments at 95% confident level using Proc GLM procedure of SAS version 9.4 (SAS, 2017) [13].

3. Results and Discussion

3.1 Yield of barley

October 15 sowing resulted in maximum production of fodder, biomass and grain yields, which was significantly higher than October 30 and November 15 sowing during 1st and 2nd year, respectively (Table 1). 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 was obtained under October 15 sowing might be due to fact that favorable environmental conditions at all phenological stages led to higher plant height and dry matter. 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) [5] reported that green fodder yields were positively correlated with plant height. Similar results were obtained by Khan *et al.* (2015) [7] and Ram *et al.* (2010).
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 cut at 50 DAS to 60 DAS, grain yield reduction might be due to reduced period for vegetative and reproductive growth. After delayed forage harvest, due to which 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 reduction of grain yield in cutting crop for fodder at 60 DAS. Reduction in the grain yield of fodder cut at 50 DAS + N_{15} treatment was attributed to more lodging of crop. When crop was cut for fodder at 60 DAS also under impose to stress and took more number of days for regeneration due to less temperature conditions. Fodder cut at 60 DAS produced in 40.7 and 46.1% higher green fodder yield than the fodder cut at 50 DAS. It might be due to more dry matter production and higher plant height.

3.2 Nitrogen content and uptake

Nitrogen (N) is an essential element for plant growth which is required in large amount as compared to major elements. Data on nitrogen content in barley grain have been presented in Table 2. Sowing date had significant effect on nitrogen content of barley grain during both the years of study. Nitrogen content in grain was significantly increased with delay in crop sowing. Crop sown on November 15 recorded higher content of nitrogen in grain which was statistically at par with October 30 sowing but significantly higher than October 15 sowing. Late sowing had higher content of nitrogen in grain because of more availability of nitrogen and less biomass production (Table 1), resulted in lower dilution of available nitrogen in dry matter and higher the nitrogen content in grain under late sown conditions. November 15 sowing recorded 7.4 and 2.6 percent higher nitrogen content in grain during 1st year, 6.7 and 3.6 percent during 2nd year, as compared to October 15 and October 30 sowing, respectively. Highest values of nitrogen content in grain was recorded in fodder cut at 50 DAS + N_{15}, which was statistically at par with cut at 60 DAS + N_{15}, but significantly higher than un-cut, cut at 50 DAS and cut at 60 DAS. It might be due to increased availability of nitrogen with application of 15 kg N ha^{-1} after fodder cut resulted in higher uptake of nitrogen by plant and translocation to grains. Similar finding have also reported by Singh and Uttam (1993) [14].

Nitrogen uptake depends upon nitrogen content and dry matter produced by the crop. Nitrogen uptake in grain among sowing dates was found to be significant during both the years of study. The significantly higher nitrogen uptake in grain was recorded in October 15 sowing as compared to October 30 and November 15. Because of higher grain yield (Table 1) under October 15 sowing higher nitrogen uptake in grain was recorded. Singh (2005) [3] reported higher nitrogen uptake in grain by barley crop sown in optimum sowing window than late sown barley in Ludhiana (Punjab). Among cutting management, highest values of nitrogen uptake in grain were recorded in un-cut which was statistically at par with the fodder cut at 50 DAS, but significantly higher than cut at 60 DAS, cut at 50 DAS + N_{15} and cut at 60 DAS + N_{15}. Lowest value of nitrogen uptake in grain was recorded in fodder cut at 60 DAS crop which might be due to lower grain yield (Table 1) under this treatment. Fodder cut at 50 DAS recorded significantly higher nitrogen uptake in grain than cut at 60 DAS. Results also confirmed the findings by Lal (2015) [8], Singh *et al.* (1997) [15] and Singh and Uttam (1993) [14].

Nitrogen content in straw was significantly increased with delay in crop sowing. November 15 sowing recorded higher content of nitrogen in straw which was statistically at par with October 30 sowing but significantly higher than October 15. Late sowing had higher content of nitrogen in straw because of more availability of nitrogen and less biomass production (Table 1), resulted in lower dilution of available nitrogen in dry matter and higher the nitrogen content in straw under late sown conditions. November 15 sown crop resulted in 7.3 and 3.6 percent higher nitrogen content in straw during 1st year, 5.0 and 1.7 percent during 2nd year, as compared to October 15 and October 30 sowing, respectively. Highest values of nitrogen content in straw was recorded in fodder cut at 50 DAS + N_{15} which was statistically at par with cut at 60 DAS + N_{15} but significantly higher than un-cut, cut at 50 DAS and cut at 60 DAS. It might be due to increased availability of nitrogen by additional application of nitrogen after fodder cut resulted in higher uptake of nitrogen by plant. Nitrogen uptake in straw with respect to sowing date was found to be non-significant during 2nd year of study. Significantly higher values of nitrogen uptake in straw were recorded in October 15 sowing as compared to October 30 and November 15 sowing during 1st year of study. Similar results were reported by Singh (2005) [3]. Among cutting management, higher values of nitrogen uptake in straw was recorded in fodder cut at 50 DAS + N_{15} which was statistically at par with un-cut, cut at 50 DAS, but significantly higher than cut at 60 DAS and cut at 60 DAS + N_{15}. Lowest value of nitrogen uptake in straw was recorded in fodder cut at 60 DAS crop during both the years of study. Fodder cut at 50 DAS recorded significantly higher nitrogen uptake in straw than cut at 60 DAS. Similar results were obtained by Lal (2015) [8], Singh *et al.* (1997) [15], Sood and Sharma (1996) and Singh and Uttam (1993) [14].

Total nitrogen uptake among sowing dates was found to be significant during both the years of study. Significantly higher values of total nitrogen uptake were recorded in October 15 sowing as compared to October 30 and November 15. October 15 sowing resulted in 6.8 and 4.6 percent higher total nitrogen uptake as compared to October 30 and 24.8 and 16.9 percent as compared to November 15 during 1st and 2nd year of study, respectively. Because of higher biological yield (Table 1) in October 15 sowing led to higher nitrogen uptake. Among cutting management, higher values of total nitrogen uptake were recorded in un-cut which were statistically at par with the cut at 50 DAS but significantly higher than cut at 60 DAS, cut at 50 DAS + N_{15} and cut at 60 DAS + N_{15}. Lowest value of total nitrogen uptake was recorded in fodder cut at 60 DAS crop during both the years of study. It might be due to lower biomass production (Table 4) under cut at 60 DAS treatment. Fodder cut at 50 DAS recorded significantly higher total nitrogen uptake than cut at 60 DAS might be due to higher grain yield and straw yield in cut at 50 DAS. Similar results were obtained by Lal (2015) [8], Singh *et al.* (1997) [15] and Singh and Uttam (1993) [14].

3.3 Phosphorus content and uptake

The data on phosphorus content and uptake by barley grain and straw have been presented in Table 3. Sowing date had significant effect on phosphorus content of barley grain during both the years of study. Crop sown on October 15 recorded higher content of phosphorus in grain which was statistically at par with November 15 sowing but significantly higher than October 30. Cutting management had no significant effect on phosphorus content of barley grain during both the years of study. Phosphorus is slowly taken by the crop, so early sown crop have more time to absorb higher phosphorus from soil. The highest phosphorus uptake in grain was recorded in October 15 sown crop which was significantly higher than October 30 and November 15. October 15 sowing recorded higher phosphorus uptake might be due to higher grain yield (Table 1). The higher phosphorus uptake in grain was recorded in un-cut crop recorded which was statistically at par with cut at 50 DAS but significantly higher than cut at 60 DAS, cut at 50 DAS + N_{15} and cut at 60 DAS + N_{15}. Fodder cut at 50 DAS recorded significantly higher phosphorus uptake in grain than cut at 60 DAS might be due to higher grain yield (Table 1) in cut at 50 DAS treatment. Lowest value of phosphorus uptake in grain was recorded in fodder cut at 60 DAS crop during both the years of study. It might be due to lower grain yield (Table 1) under cut at 60 DAS treatment. Similar results were reported by Lal (2015) [8] and Singh *et al.* (1997) [15].

Sowing date and cutting management had no effect on phosphorus content of barley straw during both the years of study. Phosphorus uptake in straw among sowing dates was found to be significant during both the years of study. The highest phosphorus uptake in straw was recorded in October 15 sown crop which was significantly higher than October 30 and November. October 15 sowing recorded higher phosphorus uptake in straw might be due to higher straw yield (Table 1). The higher values of phosphorus uptake in straw was recorded in fodder cut at 50 DAS + N_{15} which was statistically at par with un-cut but significantly higher than cut at 50 DAS, cut at 60 DAS and cut at 60 DAS + N_{15}. Lowest value of phosphorus uptake in straw was recorded in fodder cut at 60 DAS crop during both the years of study. It might be due to lower straw yield (Table 1) under cut at 60 DAS treatment. Similar results were reported by Lal (2015) [8], Singh *et al.* (1997) [15] and Sood and Sharma (1996).

Total phosphorus uptake among sowing dates was found to be significant during both the years of study. Highest total phosphorus uptake was recorded in October 15 sown crop which was significantly higher than October 30 and November 15. October 15 sowing resulted in 19.8 and 15.5% higher total phosphorus uptake as compared to October 30, whereas, 26.6 and 25.9% as compared to November 15 during 1st and 2nd year of study, respectively. October 15 sowing recorded higher phosphorus uptake might be due to higher grain yield and biomass production (Table 1). The higher total phosphorus uptake was recorded in un-cut crop recorded which was statistically at par with fodder cut at 50 DAS, but significantly higher than cut at 60 DAS, cut at 50 DAS + N_{15} and cut at 60 DAS + N_{15}. Fodder cut at 50 DAS recorded significantly higher total phosphorus uptake than cut at 60 DAS which might be due to higher biological yield (Table 1) under cut at 50 DAS treatment. Lowest value of total phosphorus uptake was recorded in fodder cut at 60 DAS crop during both the years of study. It might be due to lower grain yield and biomass production (Table 1) under cut at 60 DAS. Similar results were also reported by Lal (2015) [8], Singh *et al.* (1997) [15] and Sood and Sharma (1996).

3.4 Potassium content and uptake

Potassium is important component of barley straw. It strengthens the barley straw and helps in prevention of lodging. The data on potassium content of barley grain and straw have been presented in Table 4. Sowing date had significant effect on potassium content in grain during both the years of study. The higher content of potassium in grain was recorded in crop that sown on November 15 which was significantly higher than October 15 and October 30.

Cutting management had significant effect on potassium content in grain during both the years of study. Higher potassium content in grain was recorded in un-cut, which was significantly higher than cut at 50 DAS, cut at 60 DAS, cut at 50 DAS + N_{15} and cut at 60 DAS + N_{15}. The fodder cut at 50 DAS recorded higher potassium content in grain than cut at 60 DAS. The higher values of potassium uptake in straw were recorded in crop sown on October 15 which was significantly higher than October 30 and November 15. October 15 sowing recorded higher potassium uptake in grain might be due to higher grain yield (Table 1). The higher values of potassium uptake in grain was recorded in un-cut crop which was significantly higher than cut at 50 DAS, cut at 60 DAS, cut at 50 DAS + N_{15} and cut at 60 DAS + N_{15}. Fodder cut at 50 DAS recorded significantly higher potassium uptake in grain than cut at 60 DAS. Lowest value of potassium uptake in grain was recorded in fodder cut at 60 DAS crop during both the years of study. It might be due to lower grain yield (Table 1) in cut at 60 DAS treatment. The higher content of potassium in straw was recorded in crop that sown on November 15 which was significantly higher than October 15 and October 30 sowing. Higher potassium content in straw was recorded in un-cut, which was significantly higher than other treatments. The fodder cut at 50 DAS recorded higher potassium content in straw than cut at 60 DAS. Similar results were reported by Lal (2015) [8], Singh and Uttam (1993) [14] and Das and Sarxas (1988) [4]. The higher values of potassium uptake in straw were recorded in October 15 sown crop which was significantly higher than October 30 and November 15.

The higher values of potassium uptake in straw were recorded in un-cut crop which was significantly higher than other treatments. Fodder cut at 50 DAS recorded significantly higher potassium uptake in straw than cut at 60 DAS. Lowest value of potassium uptake in straw was recorded in fodder cut at 60 DAS crop during both the years of study. Similar results were reported by Lal (2015) [8], Singh *et al.* (1997) [15] and Sood and Sharma (1996). The higher values of total potassium uptake were recorded in crop sown on October 15 which was significantly higher than October 30 and November 15. October 15 sowing resulted in 9.4 and 7.8 percent higher total potassium uptake as compared to October 30, whereas, 14.3 and 11.8 percent as compared to November 15 during 1st and 2nd year of study, respectively. October 15 sowing recorded higher potassium uptake might be due to higher grain yield and biomass production (Table 1) under this sowing date.

Un-cut and cut at 50 DAS treatments for total potassium uptake was statistically at par with each other and significantly better than other treatments Fodder cut at 50 DAS recorded significantly higher total potassium uptake than cut at 60 DAS. Lowest value of total potassium uptake was recorded in fodder cut at 60 DAS crop during both the years of study. It might be due to lower grain yield and biomass production (Table 1) under cut at 60 DAS treatment. Similar results were also reported by Lal (2015) [8], Singh *et al.* (1997) [15] and Sood and Sharma (1996).

Table 1: Effect of sowing date and cutting management on fodder, biological and grain yields of barley N_{15}= 25% additional nitrogen after cut (15 kg N ha^{-1})

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									
October 15	17393	18151	17772	12681	11915	12298	4254	3874	4064
October 30	14280	15772	15026	11504	11074	11289	3747	3515	3631
November 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
Cut at 50 DAS	12567	13198	12983	12048	11413	11730	3927	3648	3787
Cut at 60 DAS	17684	19290	18452	10638	10229	10434	3204	2956	3080
Cut at 50 DAS + N_{15}	12429	13036	12733	11343	10876	11110	3301	3053	3177
Cut at 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

Table 2: Effect of sowing date and cutting management on nitrogen content and uptake in grain and straw of barley

Treatment	Nitrogen									
	Grain				Straw				Total uptake (kg ha^{-1})	
	Content (%)		Uptake (kg ha^{-1})		Content (%)		Uptake (kg ha^{-1})			
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Sowing date										
October 15	1.76	1.80	75.0	70.0	0.51	0.57	43.4	45.6	118.3	115.6
October 30	1.85	1.86	69.3	65.5	0.53	0.59	40.9	44.8	110.2	110.3
November 15	1.90	1.93	53.1	52.0	0.55	0.60	40.6	44.1	93.7	96.1
LSD (p=0.05)	0.05	0.07	5.6	3.7	0.02	0.02	2.2	NS	6.9	5.1
Cutting management										
Un-cut	1.83	1.86	73.5	71.2	0.53	0.59	42.9	46.4	116.4	117.6
Cut at 50 DAS	1.78	1.81	69.6	65.9	0.52	0.58	42.2	44.8	111.9	111.6
Cut at 60 DAS	1.69	1.71	53.9	50.1	0.50	0.57	37.4	41.1	91.3	90.7
Cut at 50 DAS + N_{15}	1.95	1.98	64.1	60.2	0.55	0.62	44.5	48.1	108.6	108.3
Cut at 60 DAS + N_{15}	1.93	1.97	67.8	65.4	0.54	0.60	41.2	43.9	109.0	109.3
LSD (P=0.05)	0.05	0.07	5.3	5.9	0.01	0.02	3.1	3.6	6.2	7.5

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

Table 3: Effect of sowing date and cutting management on phosphorous content and uptake in grain and straw of barley

Treatment	Phosphorous									
	Grain				Straw				Total uptake (kg ha^{-1})	
	Content (%)		Uptake (kg ha^{-1})		Content (%)		Uptake (kg ha^{-1})			
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Sowing date										
October 15	0.34	0.36	14.5	14.1	0.13	0.14	10.8	10.9	25.2	25.1
October 30	0.31	0.33	11.5	11.8	0.11	0.12	8.8	9.4	20.2	21.2
November 15	0.33	0.34	9.3	9.2	0.12	0.13	9.3	9.4	18.5	18.6
LSD (p=0.05)	0.01	0.02	1.2	1.3	NS	NS	0.3	1.2	1.0	2.3
Cutting management										
Un-cut	0.33	0.35	13.2	13.4	0.12	0.13	10.0	10.3	23.1	23.7
Cut at 50 DAS	0.32	0.34	12.5	12.5	0.12	0.13	9.7	9.9	22.2	22.5
Cut at 60 DAS	0.31	0.33	9.8	9.8	0.12	0.13	8.7	9.9	18.4	19.7
Cut at 50 DAS + N_{15}	0.34	0.36	11.2	11.1	0.13	0.13	10.2	10.5	21.4	21.6
Cut at 60 DAS + N_{15}	0.34	0.35	11.9	11.8	0.13	0.12	9.5	9.1	21.4	20.9
LSD (P=0.05)	NS	NS	1.0	1.1	NS	NS	0.4	0.5	1.4	1.6

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

Table 4: Effect of sowing date and cutting management on potassium content and uptake in grain and straw of barley

Treatment	Potassium									
	Grain				Straw				Total uptake (kg ha^{-1})	
	Content (%)		Uptake (kg ha^{-1})		Content (%)		Uptake (kg ha^{-1})			
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Sowing date										
October 15	0.55	0.53	23.4	20.3	0.92	0.85	77.3	68.4	100.7	88.7
October 30	0.55	0.51	20.7	18.0	0.91	0.85	70.5	63.8	91.2	81.8
November 15	0.57	0.55	16.1	14.8	0.94	0.87	70.2	63.4	86.3	78.2
LSD (p=0.05)	0.01	0.01	2.1	1.5	0.01	0.01	5.3	3.7	4.2	6.7
Cutting management										
Un-cut	0.59	0.55	23.7	21.1	0.95	0.88	77.5	70.3	101.2	91.4

Cut at 50 DAS	0.56	0.53	21.9	19.2	0.92	0.85	74.6	66.1	96.5	85.3
Cut at 60 DAS	0.54	0.52	17.3	15.4	0.91	0.84	67.6	60.8	84.9	76.2
Cut at 50 DAS + N_{15}	0.56	0.53	18.6	16.1	0.92	0.85	68.3	66.6	86.9	82.7
Cut at 60 DAS + N_{15}	0.55	0.52	17.4	17.4	0.91	0.85	69.6	62.6	87.0	80.0
LSD (P=0.05)	0.01	0.01	2.1	1.6	0.01	0.01	2.5	3.1	6.2	6.5

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

4. Conclusion

Thus it is concluded crop sown on October 15 gave significantly higher grain yield as well as fodder yield. One fodder cut of barley 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.

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