Dual purpose barley as affected by date of sowing, varieties and stage of harvesting-A review

Magan Singh*, Avinash Chauhan, Rakesh Kumar, Deepa Joshi, Pooja Gupta Soni and V.K. Meena

Forage research and management Centre,
ICAR-National Dairy Research Institute, Karnal-132001 Haryana, India.
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ABSTRACT

Barley is primarily a cereal grain crop grown in *rabi* season and widely used for food, fodder and in beer industry. Dual purpose barley provides quality fodder as well as grain. Cutting at early stage at about 50-55 days after sowing, provides good quality of fodder particularly in lean period (mid December to mid January) for feeding to the animals. After harvesting for fodder, the regenerated crop left for grain production without sacrificing the grain yield with similar management as grain crop. For dual purpose barley need to evaluate the cultivars, optimum sowing time and stage of harvesting is a critical issue for production of good quality fodder as well as grain. Hence in this review article it has been emphasized for production of quality fodder and grain as influenced by date of sowing, dual barley variety used as suitable cultivars, and appropriate stage of harvesting which had been revealed and cited by different scientists, workers and co-workers.

Key words: Date of sowing, Dual barley, fodder quality and economics of barley, Growth, Green fodder yield, Grain yield, Stage of harvesting, Varieties.

Barley (*Hordeum vulgare* L.) is a *rabi* cereal crop which is cultivated mainly for grain production. It can also be grown as a dual purpose crop for providing good quality fodder as well as grains. In 2009-10, the total area for barley cultivation was 0.78 million hectares, while the production was estimated at 1.50 million tonnes, yield per ha 1.92 metric tonnes and feed and residues 0.15 million tonnes in India. Barley is used as a grain crop for human consumption and animal feed in India. In recent years, due to increasing scarcity of green fodder in the arid and semi-arid region, it has been observed that barley can be utilized as an alternative source of green fodder which is mainly grown in the drier parts of the northern plains (Rajasthan, Southern Haryana, South-West Punjab and Western U.P.).

In irrigated areas, barley can be harvested one cut at early stage (50-55 DAS) to provide green fodder during scarcity period of fodder supply from mid December to mid January. With the development of high yielding dual barley varieties, it can serve as an alternative for green fodder demand and satisfactory level of grain yield from regenerated crop. The regenerated crop can provide the grains and that can be utilized for animal fodder/feed purposes. It responds well to date of sowing, varieties and stage of harvesting which varies from location to location. The crop has the advantage of the lesser water requirement as compared to oats. However, not much agronomic research work has been conducted on barley as a dual purpose crop in the country. A systematic review on literature available on the effect of agronomic factors on growth, yield and fodder quality of dual purpose barley has been cited on the basis of findings and views of active investigators, theoreticians and practitioners are discussed on different aspects to study the fodder and grain production from barley as a dual crop under the following headings:

1. Effect of date of sowing

   Date of sowing is one of the important factors for higher production as it determines the optimum time of sowing of the crop. An optimum time of sowing enhances the efficiency of barley by exploiting growth factors in an effective manner. As dual purpose barley plant provides green fodder during lean period, the right time of sowing for availability of green fodder for longer time should be optimally utilized and therefore, the effects of various dates of sowing on dual purpose barley are quite remarkable.

   The staggered sowing is a common practice to obtain high quality green fodder for longer duration. Optimum date of sowing is necessary for maximum possible yield of good quality green fodder because availability of highest nutritive stage for longer duration is desired. However for this, it is essential to follow proper date of sowing to utilize the optimum time of sowing efficiently.

   a) Effect of date of sowing on growth: Gill *et al.*, (1977) reported that the highest yields were obtained by sowing from mid October to early November. Prasad and Mukerji (1988) also reported November 15 as optimum sowing date

*Corresponding author’s e-mail: magansingh07@gmail.com*
due to taller plants, more shoots and leaves. Delayed germination and slow growth due to low temperature at the time of sowing under delayed condition. Sood et al. (1992) from Palampur reported that earlier sowing recorded higher plant height and tillers per metre row length in oats compared to delayed sowing. Farid et al. (1993) reported that the possible causes of decreased plant height in later sowing might be due to decrease in temperature as well as day length which shorten the vegetative growth period. Working under Haryana conditions, Singh et al. (1997) recorded significantly higher plant height (91.6 cm) and number of tillers/meter row length (132.5) in oats sown on 6th November compared to plant heights of 87.5 and 81.2 cm and tillers per meter row length (129.1 and 118.2) when sown on 22nd October and 21st November, respectively. Razzazque and Rafiquzzaman (2006) reported that the plant height was significantly influenced by different date of sowing and the tallest plant (85.86cm) was obtained from 20 November sowing which was statistically different from other sowing dates. The shortest plant (74.67cm) was obtained from 20 December sowing. Alam et al. (2007) reported significant reduction in plant height due to delay in sowing. Mani et al. (2009) reported that sowing dates significantly influence the yield and yield attributes of barley. The number of tillers per plant and number of spikes per plant were significantly higher in 30th November sown crop as compared to other dates of sowing. Number of spikelets per spike and grains per spike were significantly higher under 30th November sown crop, whereas these were lower in 30th October sown crop. Rashid et al. (2010) reported that sowing date had significantly affected the plant height of barley. Early sowing produced significantly taller plants of 86.63 cm compared with 71.92 cm at late sowing. Rashid et al. (2010) reported that number of tillers per plant was found non significant with sowing date.

b) Effect of date of sowing on yield and yield attributes of barley grains and its fodder: Randhawa et al. (1977) reported that late sowing of wheat and barley might expose the crop to higher temperature after and during heading resulting in reduced number of ears per square meter and number grains/ear. Agrawal and Arora (1980) reported that yield of late planting crop suffered mostly due to drastic reduction in ear number. Highest 1000-grain weight was recorded in November 15 sowing which was significantly higher than December 15 but statistically at par with October 15 in 2008-09 but in 2009-10, it was significantly higher than October 15 and December 15 sowing. Abdel-Raouf et al. (1983) reported that the sowing times significantly influenced straw dry matter and total dry matter in barley. They show that highest dry matter yield was obtained in 5th November sowing followed by 17th November, 29th November and 11th December. Singh et al. (1989) found that grain yield of barley decreased at delayed sowing. Sobati and Dezfuli (1998) reported that the highest grain yield was obtained from var. Raihaneh sown on 22 October. var. Binam showed good yield stability and relatively high yield, particularly from unfavourable sowing dates. With more favorable sowing dates (6 and 22 October), grain weight was positively correlated with linear grain filling rate, storage and translocation of reserves. LAI, LAR, RGR, CGR and LAD of each cultivar were higher from the second sowing date than the earliest date. The “ratio of post anthesis growth to maximum total DM” showed a high correlation with the harvest index. Raihaneh had the greatest resistance to lodging, harvest index, storage and translocation of assimilates, and linear grain filling rate. It is suggested that at favourable sowing dates, V'allhaj and Binam had source limitation or disturbed translocation and Raihaneh had sink limitation. Begum et al. (1999) reported that the 30 November sowing produced the length of spike (6.65cm) followed by that in 20 November and 10 December (6.33cm) The differential behaviour or length of spike due to different sowing date might be explained by the fact that sowing during higher temperature, the plant could not get congenial environment for growth and development affecting development of spike. Abdullah et al. (2000) reported that the planting date at 1st Nov. was significantly higher than the other planting dates in forage, grain yield and straw production. Kavak (2004) also reported that from November 10 to November 25 the grain yield was similar but in later dates i.e. December 10, December 25, January 9, January 24 and February 8 the grain yield was significantly reduced which was due to reduction in yield attributes. Alam et al. (2005) working in Bangladesh reported that barley was sown on 5th, 17th and 29th November and 11th December and it was observed that barley sown on 5th November produced significantly higher dry matter yield than other sowing dates. 17th November sowing was significant superior to 29th November sowing and 29th November sowing was superior to 11th December sowing in terms of dry matter yield per plant. A study on the effect of different sowing dates and row spacing’s on the yield of oats conducted in Madhya Pradesh by Shaikh et al. (2004) revealed that 15th November sowing produced higher fresh and dry fodder yield in oats compared to other sowing dates. Razzazque and Rafiquzzaman (2006) reported that no significant difference was observed among the sowing time for spike length. The 30 November sowing produced the length of spike (6.65cm) followed by that in 20 November and 10 December (6.33cm). Razzazque and Rafiquzzaman (2006) found that spikes/m2 was significantly affected by sowing time superior number of spikes/m2 was found when crop was sown on 30 November (209.3) and 20 November (204.8) and lowest in 20 December (191.53). Mani et al. (2006) reported that delay in sowing date of barley beyond November 10 resulted in a significant decrease in grain yield. The data collected on phenology revealed that October 15 sown crop took...
maximum days to 75 per cent earing and maturity which was significantly higher than November 15 and December 15 except for 2009-10 in which October 15 and November 15 were statistically on par with each other for days taken to 75 per cent earing. Sharma(2007) reported that sowing time significantly influenced green fodder yield of barley. Maximum yield was received from crop sown on 15 October and adopting third cut management i.e. first cut at 75 days after sowing and second cut at 45 days after. Fodder yield in different sowing time and cutting management treatments ranged between 19.09 and 31.92 tonnes/ha.

c) Effect of date of sowing on quality of barley fodder: Sood et al. (1992) reported that delay in sowing of oats from 31st October to 30th December significantly decreased the crude protein content. However, crude protein contents recorded in 31st October and 15th November sowings were similar. Shin et al. (1992) reported that 20th September sowing of oats resulted in higher crude protein concentration on dry matter basis compared to 31 st August and 10th September sowings. Noworolnik (2013) reported that the delayed sowing date caused decrease of number of ears per unit area and grain yield and increase of protein content in grain, but did not result in significant changes in number of grains per ear, 1000 grain weight and grain filling. Basza, Xanadu, Suwen and KWS 010f cultivars with higher tillering ability, can be considered to be cultivars more tolerant to delayed sowing date.

2. Effect of varieties: Selection of a suitable variety for any specific area is one of the most important factors to achieve highest production because different varieties have different qualities and perform in a different way in diverse conditions. Climatic conditions of any area affect performance of any variety both in positive or negative direction. One variety performs very well in one situation but fails to repeat its performance in any other area. A variety has specific response character for specific situation like irrigation, temperature, humidity, soil condition etc. for its growth and yield. We should grow the variety in an area which responds perfectly well to the specific condition.

(i) Effect of varieties on growth of barley: Ghasemi et al. (2004) combined analysis of variance for green fodder indicated significant differences among the cultivars (P<0.01). The highest green fodder (21.01tha⁻¹) was obtained from barley cultivar LB. Three triticale cultivars 4116, 4108 and Mus“S”/Beta“S” produced 17.24, 15.79 and 14.1 tha⁻¹ green fodder, respectively. The differences among the cultivars were not significant. Barley cultivar Dasht had the lowest green fodder. Combined analysis of variance for agronomic characters showed significant difference among the cultivars for grain yield, plant height, spike length, number of kernels per spike and 1000 kw (P<0.01). The highest and lowest grain yield belonged to triticale cultivar 4116 and barley cultivar Dasht, respectively. Alam et al. (2007) reported that among the cultivars, BB 1 produced the tallest plant followed by Karan 351, Karan 163 and Karan 19. Ryan et al. (2009), in an experiment on barley stated as expected, the main factors N and variety were significantly affected either on the yield parameters, but The interactions were less consistent. Kapoor et al. (2010) reported that RD-2715 was superior in terms of plant height compare to RD-2552 and the variety RD-2552 was higher in leaf: stem ratio as compare to variety RD-2035. Singh et al. (2012) reported that green fodder yield was obtained from variety ‘RD 2035, yielded (17.4 t/ha) significantly higher than variety ‘RD 2552’ (16.5 t/ha). The grain yield of RD 2035 (4502 kg/ha) was significantly higher than RS 2552. The 9.9% higher yield in RD 2035 was because of 12.2% higher number of grains per earhead. Musavi et al. (2012) reported that cultivar had significant influence on peduncle length, ear length, lodging percentage and seed yield. The highest of plant height and ear length achieved in Binam cultivar but the highest of peduncle length and flag leaf length related to Nosrat cultivar.

(ii) Effect of varieties on Yield and yield attributes of barley grains and its fodder: Abdel Raouf et al. (1983) reported that the variability in the number of grains/ear in different varieties. The biological and grain yield were significantly influenced by the varieties. Highest biological and grain yield were recorded in PL 807 which were statistically at par with BH 902 but significantly higher than RD 2552 and RD 2035 in both the years of studies. Singh and Dixit (1995) reported that superior numbers of grains/space was recorded with BSH-2 sown on 20 November (42.6) and 30 November (41.43). Chun et al. (2000) reported that varietal differences for ear density. The variety PL 807 recorded highest grains/ear which was significantly higher than BH 902 and RD 2552 but statistically at par with RD 2035 variety. Kharub et al. (2007) reported that the multi-locational experiments taken up to identify varieties for dual purpose barley resulted that two released varieties of feed barley (RD2035 and RD2552) can be used as dual purpose barley with good yield of the green forage (between 200 to 250 q/ha-1) and the grain yield (24 to 32 q/ha-1) from regenerated crop in North Western plain Zone (Table 2). Another variety RD 2715 has been released as dual purpose barley for Central zone, which gave on an average 160 q/ha-1 of fodder and 27.0 q/ha-1 grain yield. Sharma (2009) reported that differences among barley varieties for green fodder yield were found statistically significant. Variety RD-2715 recorded maximum green fodder yield of 229.20 q/ha, which was statistically at par with RD-2552. The lowest fodder production was attained with PL-751 (191.20 q/ha). However, seed yield was maximum in variety RD-2035 (46.20 q/ha) and straw yield in RD-2552 (68 q/ha) in regenerated crop. Kaur et al. (2009) variety RD 2552 produced significantly higher number of effective tillers (526.6) and 1000-grain weight (39.93 g) than PL 426 but
was at par with PL 172 during first year. However, during second year variety RD 2552 produced significantly higher number of effective tillers (370.8) and 1000-grain weight (44.37 g) than PL 426 and PL 172. The varieties RD 2552 (39.2 q ha\(^{-1}\)) and PL 172 (37.7 q ha\(^{-1}\)) were statistically at par but gave significantly higher grain yield than PL 426 (30.2 q ha\(^{-1}\)) during first year. During second year RD 2552 variety (56.4 q ha\(^{-1}\)) gave significantly higher grain yield than the other two varieties. Kaur et al. (2013) reported that PL 172 variety produced significantly higher dry fodder yield (19.4 q/ha) than the other two varieties of barley i.e. PL 426 (16.8 q/ha) and RD 2552 (16.8 q/ha) which were statistically at par with each other. Hundal et al. (2014) reported that the effect of genotype of barley, on the fodder and grain yield revealed that dual purpose variety (RD-2035) gave higher (P<0.01) fodder and lower (P<0.01) grain yield as compared to grain (RD2552) variety. The straw production was higher (P<0.01) in RD-2552 as compared to RD-2035. Kaur et al. (2009) have also reported almost similar fodder, grain and straw yield from RD-2552 variety of barley.

(iii) Effect of varieties on quality parameters of barley fodder: Kaur et al. (2013) reported that RD 2552 had significantly higher content of crude protein (25.4%), mineral matter (11.0%) and dry matter digestibility (79.67%) and significantly lower ether extract (2.56%). All the three varieties did not differ significantly for crude protein and nitrogen free extract. PL 172 variety produced significantly higher yield of crude protein (2.1 q/ha), ether extract (0.52 q/ha), nitrogen free extract (10.31 q/ha) and dry matter digestibility (14.92 q/ha). For crude fibre and mineral matter yield differences were non-significant for all the three varieties. Hundal et al. (2014) reported that the effect of genotype of barley, on the chemical composition of barley fodder revealed that grain variety (RD-2552) had higher (P<0.05) total ash, CP and hemicelluloses content as compared to dual purpose variety (RD-2035), but reverse (P<0.01) trend was observed with respect to OM, ADF and cellulose contents.

3. Effect of stage of harvesting
Stage of harvesting is one of the most important factors which determine the higher production level with higher nutritive value, as the nutritive value of green fodder is highest at fifty percent flowering stage and decreases after flowering stage in most of the crops. In dual purpose barley crop, stage of harvesting also determine the regenerative potential of the crop, as the regeneration capacity is adversely affected by the higher stage of harvesting for green fodder. That’s why it’s important to determine the right stage of harvesting to obtain the highest green fodder as well as grain yield from the crop.

1. Effect of stage of harvesting on growth of barley: Prasad and Mukerji (1988) found reduction in number of tillers with delay in cutting after 60 days. Bhatti et al. (1992) found that the maximum leaf area was recorded at early milk and early dough stage, whereas the minimum at 4-leaf and tillering stages. Sood et al. (1992) reported that increase in plant height with delay in first cutting and cutting management had no significant effect on number of tillers per metre row length.

II. Effect of stage of harvesting on yield and yield attributes of barley grains and fodder: Abdullah et al. (2000) reported that cutting for forage at age of 65 days was superior (5.17 tons/h) to cutting at the age of 50 days (2.1 tons/h). Utilization of vegetative growth for forage at the age of 65 days has resulted in a reduced grain yield ranging from 12 and 59 % in the first and the third planting dates respectively. Whereas the reduction in straw yield was greater ranging from 35 to 58% in the first and the third planting dates respectively. Kharub et al. (2007) reported that at 55 days stage, the reduction in grain yield over cut at 40 days was around 25 per cent but significant gain in forage yield was observed. Similarly increase in forage yield was not enough to compensate the yield reduction at 70 days cut over cut at 55 days. Pal and Kumar (2009) observed highest grain yield in no cut crop. Jain and Nagar (2010) reported that barley crop cut at 45 days after sowing yielded highest grain yield (28.7q/ha). It was numerically low (3.75%) in no cut crop and reduced significantly by 20.1% in 55 days cut crop. Kaur et al. (2013) reported that forage cut at 60 DAS produced significantly higher dry fodder yield (24.2 q/ha) than the forage cut at 45 DAS (11.1 q/ha) and this gave 119 per cent higher dry fodder than the forage cut at 45 DAS.

III. Effect of stage of harvesting on quality parameters of barley fodder: Midha(1994) at Hisar concluded that different cutting management found to influence quality of fodder. Each delay in fodder cutting from 50 DAS to 80 DAS found to decrease protein content of fodder significantly and increase in ADF and NDF content while there was no effect on Ether Extract content. He further explained that protein content with delay in cutting decreased because of higher fodder yield which led to dilution of photosynthates. Unlike protein content, ADF and NDF content increased because of increase in fibre content of plant with increasing age. However, the total production of crude protein, Ether extract, ADF and NDF increased with each delay in cutting because of increase in fodder yields. Hussain et al. (1995) reported that oats harvested at booting stage and barley at 100% flowering stage gave the maximum green-fodder yields (79.45 and 63.10 t/ha respectively). In both oat and barley crops, the highest DM yields (15.54 and 13.75 t/ha respectively) were recorded at the early dough stage. In both the crops crude protein contents decreased with the advancement in crop maturity. The maximum crude protein content (14.93 and 14.37% in oats and barley respectively) was observed when the crops were cut repeatedly at the 4-
leaf stage, whereas the minimum was at early dough stage in both the crops. Oats and barley harvested at the booting stage gave reasonable green-fodder yield (mean 67.32 t/ha), DM yield (11.66 t/ha) and fodder quality (crude protein 10.33%). Boss and Carlson (2001) showed earlier cutting of barley appeared to be of higher forage quality than late cutting. Kaur et al. (2013) reported that forage cut at 45 DAS had significantly higher content of crude protein (13.3%), ether extract (2.87%), mineral matter (12.0%) and dry matter digestibility (79.94%) but forage cut at 60 DAS had significantly higher content of crude fibre (26.5%) and nitrogen free extract (52.86%) than forage cut at 45 DAS. Forage cut at 60 DAS had produced significantly higher yield of crude protein (24.2 q/ha), crude fibre (2.1 q/ha), ether extract (6.4 q/ha), mineral matter (0.62 q/ha), nitrogen free extract (2.31 q/ha) and digestible dry matter (0.62 q/ha) than forage cut at 45 DAS.

4. Economics of dual purpose barley production: Mutti (1995) reported crop sown on November 6 in combination with one cut for fodder and then grain from the regenerated crop gave the highest average net returns to the tune of Rs 9297 per hectare. Sharma et al. (2001) reported that oats fodder cut at 65 DAS and at 50 percent flowering gave 30.65 and 21.62 percent higher net returns over oats cut at 85 DAS and 50% flowering and only one cut at 50% flowering, respectively. Chakrawarty and Kushwaha (2007) reported highest grain yield of variety RD 2552 among three varieties i.e. RD 2552, K 560 and DL 88. They also reported that 27 November sowing date resulted in considerable reduction in net return by Rs. 1615/ha and cost: benefit ratio compared to normal sowing at November 7. Sharma (2009) reported that the gross returns received from green fodder, grain and straw yields were maximum in RD-2715 (64270/ha) followed by RD-2035 (Rs 62640/ha). Therefore, a variety RD-2715 and RD-2035 were found suitable and seems to be promising for the cultivation as dual purpose crop.

CONCLUSION

It is found that optimum sowing time for dual purpose barley was mid of October to mid of November. Delayed sowing decreased in fodder as well as in yield attributing characters and grain yield and quality of fodder. It was noticed that at one cutting (50-55 DAS) a suitable stage of harvesting for green forage as well as grain crop obtained from regenerated dual purpose barley crop. Date of sowing and stage of harvesting being non-monetary inputs by simple management in alteration of sowing time and stage of harvesting on region basis this will be advantageous to the growers. The existing improved dual barley variety can serve the purpose in specified environment as alternative for the green forage demand without sacrificing the grain yield in the arid and semi-arid region of the country.

REFERENCES


