Bangladesh J. Agri. 2024, 49(1): 10-18 *DOI: https://doi.org/10.3329/bjagri.v49i1.74027*

EFFECTS OF SOWING DATE AND CUTTING MANAGEMENT ON THE GRAIN AND FODDER YIELD OF BARLEY

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Abstract

Cereal crops need to be grown for dual purpose to overcome continuous food and feed shortage. Sowing date and cutting management are important to obtain the balanced fodder and grain simultaneously. To address the issue, field experiment was conducted at the agronomy field of Sher-e-Bangla Agricultural University (SAU), Dhaka to find out the effect of optimum sowing date and cutting management on the plant growth, green fodder and grain yield of barley. Five sowing times viz., 30 October, 15 November, 30 November, 15 December and 30 December and four cutting management *viz*., uncut and cutting at Zadoks growth stages, ZGS 19, ZGS29 and ZGS31 were used. Results of the present study revealed that early sowing time, 30 October gave significantly higher plant height, dry matter accumulation, effective tiller, fertile spikelet, spike length, 1000-grain weight, grain yield, straw yield, biological yield and green fodder yield under both uncut (control) and cut conditions. Cutting of barley for green fodder had reduced significantly all growth parameters, yield attributes and yield compared to uncut barley. Among cutting schedules, minimum and maximum reduction in growth parameters, yield attributes and yield were recorded with cutting of fodder at ZGS19 (vegetative growth stage) and ZGS31 (stem elongation stage), respectively compared to uncut. However, cutting of barley for fodder purpose at ZGS29 (tillering stage) was found in a balance between green fodder and grain yield simultaneously. Therefore, the study suggested that early sowing (30 October) can compensate the reduction in barley yield due to cutting for fodder purpose and cutting at maximum tillering stage (ZGS29) can balance having optimum grain and green fodder simultaneously.

Keywords: Barley, Biological yield, Growth parameters, Fodder yield

Introduction

Barley (*Hordeum vulgare* L.) is the world first ranked grain crop in terms of cultivated area, production and productivity. In many countries like USA, New Zealand and Australia, the crop is cultivated for both grain purpose and fodder production. However, in Bangladesh, this crop is cultivated only for grain purpose and the practice for grain and fodder not yet exploited. The production area and productivity of barley in Bangladesh is 0.45 M ha, 1.38 M t and 3.04 t ha^{-1}, respectively (BBS, 2023). Barley is a good source of high-quality forage, containing high amount of nutrients, protein and

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energy when other fodder plant species are low in quantity and quality (Kumar *et al*., 2017; Singh *et al*., 2017).

Time of seed sowing is one of the essential agronomic practices affecting both fodder and grain productivity in barley. Early and optimum seed sowing time has extended growth duration, which subsequently provides an opportunity to accumulate more dry matter as compared to late seed sowing, and henceforward demonstrated in higher grain, biological yield and harvest index. Previous studies suggested that early seed sowing helps increase both grain and fodder yield in dual-purpose system (Alam *et al*., 2005; Sharma, 2007). On the other hand, late seed sowing reduces the time of growth and development phases, which consequently decreases photosynthetic assimilates and source-sink relationship (Alam *et al*., 2007). In addition, late seed sowing may be exposed plants to heat stress during the grain filling stage and hence harmfully affect yield contributing traits, grain yield and biological yield. The adverse impacts of late sowing were significant in dual-purpose system and negatively affected fodder and crude protein Previous research findings suggested that plant growth, biomass, yield traits, and grain yield were higher under early sowing than later sowing (Hameed *et al*., 2003; Singh *et al*., 2019; Mani *et al*., 2009). Deleterious effect of late sowing was reported barley growth, biomass and grain yield and its components (Royo *et al*., 1997; Singh *et al*., 2013; Fayed *et al*., 2015; Farooq *et al*., 2016, Tahir *et al*., 2019). Similarly, fodder and crude protein yields inclined to be progressively declined due to delaying of seed sowing from 25 October to 14 November or 4 December (Moustafa *et al*., 2021). Early seed sowing in late October revealed the highest forage yield and crude protein content related with late sowing date of early December. Singh *et al*. (2013) and Choudhary and Chaplot (2015) reported that seed sowing at the end of October or commencement of November lead to higher nitrogen accumulation and protein content in green fodder, grain and straw compare to late sowing of barley. Moreover, Salama (2019) stated that cutting barley at early growth stages (45 and 55 days after sowing, DAS) increased the fodder yield and crude protein content compared to late cutting at 65 DAS.

On the other hand, cutting height may reduce yield components and grain yield in barley due to the limitation of leaf area and tiller senescence during reproduction stage if barley is not managed appropriately (Waheddullah *et al*., 2018). The regular vegetative growth is obligatory after cutting to produce rational yield, so optimum seed sowing time and management of cutting schedule is essential to appreciate the optimum green fodder and grains yield of barley. Keeping concern about the above points, the present research was conducted to identify the optimum sowing time and cutting schedule of barley for dual purpose cropping system.

Materials and Methods

The study was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka during Rabi season (October 2021 to March 2022). The experiment was set as a Factorial Block Design (FBD), with three replications. Factor A and B represented five seed sowing date and four cutting management, respectively.

Barley was sown on five sowing dates *viz*., 30 October, 15 November, 30 November, 15 December and 30 December. The plant was given four cutting managements *viz*., no cut for fodder and left for seed only, cut at ZGS19 (maximum seedling growth stage) for fodder and left for seed, cut at ZGS29 (maximum tillering stage) for fodder and left for seed, cut at ZGS31 (stem elongation stage) for fodder and left for seed. The respective cut plots were given cut at 5 cm from a ground level by using sickle. Each of the experimental plots was 4.50 m² (3.00 m × 1.50 m) in size. The experimental plots were prepared by two ploughing and cross-ploughing with rotary plough and finally laddering to ensure a good condition of seed sowing. Seeds of Barley *var*. BARI Barley 9 were sown in row with spacing of 30 cm × 3 cm. The recommended dose of nitrogen (N), phosphorus (P) and potassium (K) 120:50:40 kg ha^{-1} was applied, respectively. Urea was applied in three equal splits i.e. as basal, 25 DAS (crown root initiation) and after 1st cut for fodder. TSP and MoP were applied at the time of final land preparation before seed sowing. All the other agronomic management, e.g. weeding, thinning and pest control were done uniformly to each experimental plot as per requirement. The first cut was done for fodder and the second cut for seed and straw. Data on plant height and dry matter accumulation were recorded of 30 days after cutting (DAC), anthesis and maturity stage of the crop. In case of yield contributing characters and yield, data were recorded on effective tillers per meter row length (mrl^{-1}), length of spike, fertile spikelet $spike^{-1}$, unfertile spikelet $spike^{-1}$, 1000-grain weight (g), green fodder yield (t ha^{-1}) after cut at 80% moisture content, grain yield (t ha^{-1}) at 14% moisture content and straw yield (t ha^{-1}) after sun dry, biological yield (t ha^{-1}) were measured.

Statistical analysis

All data were analyzed by using SPSS 20.0 for windows (SPSS Inc.). The significant differences among the treatment means were compared by Least Significant Difference (LSD) value at 1% level of significance. Different lower case letters in the figures were representing the significant differences among the treatments.

Results and Discussion

Effects of sowing date on plant height

Data presented in Table 1 stated that delay in seed sowing time of barley from 30 October to 30 December had reduced plant height significantly at 30 DAC, anthesis and maturity stage. Plant height ranged from 22.7 cm to 46.3 cm at 30 DAC, 33.5 cm to 80.6 cm at anthesis and 45.6 cm to 92.6 cm at maturity stage in sowing time from 30 October to 30 December (Table 1). Seed sowing at 30 October gave the maximum plant height 46.3 cm, 80.6 cm and 92.6 cm at 30 DAC, anthesis and maturity stage, respectively followed by seed sowing at 15 November where the plant height was 41.5 cm, 75.8 cm, and 88.3 cm at 30 DAC, anthesis and maturity stage, respectively. This may be contributed due to maximum period of time available to early sown crop in contrast to late sown crop for photosynthetic assimilation and translocation for vegetative growth of the barley, resulting in higher plant height. Similar findings was found by Bahadur and Chowdhury (2019) in barley and Waheddullah *et al*. (2018) in wheat, they reported that early seed sowing improved plant height over late seed sowing.

Effects of cutting schedules on plant height

Cutting of barley at different Zadoks growth stage (ZGS) had decreased the plant height meaningfully compared to uncut barley at all the three growth stages of plant (Table 1). Plant height ranged from 20.6 cm to 42.9 cm at 30 DAC, 32.8 cm to 78.3 cm at anthesis period and 45.5 cm to 90.2 cm at maturity stage when the plants were cutting at GS19 (maximum growth stage) to ZGS31 (stem elongation stage). Maximum plant height (67.5 cm, 87.2 cm and 98.3 cm at 30 DAC, anthesis and maturity stage, respectively) was found at uncut plant. The reason might be beheaded the barley plant height causing termination of growth and cutting imposed stress; therefore new shoot growth of plant could not reach the same plant height as that of uncut plant due to shorter growth duration. On the other hand, uncut plant was no disturbance in the vegetative growth and thus brought about the tallest plants. Our study showed significant decreases in plant height by delay cutting compare to uncut, which is in agreement with previous studies on dual purpose wheat and barley (Khalil *et al*., 2011; Iqbal *et al*., 2016; Waheddullah *et al*., 2018).

Effects of sowing date on biomass accumulation

Irrespective of delay in sowing time of barley from 30 October to 30 December had reduced dry matter production significantly at 30 DAC, anthesis and maturity stage (Table 1). Dry matter ranged from 28.5 g mrl^{-1} (mrl, meter row length) to 48.5 g mrl^{-1} at 30 DAC, 204.5 g mrl^{-1} to 275.2 g mrl^{-1} at anthesis and 332.6 g mrl^{-1} to 415.5 g mrl^{-1} at maturity stage in sowing time from 30 October to 30 December. Maximum dry matter was found at 30 October seed sowing at all growth stage of plant. It may be due to the effect of satisfactory environmental conditions at seed sowing time, which resulted in taller and healthier plant. Waheddullah *et al*. (2018) reported that early seed sowing influenced plant biomass that improved the photosynthesis, leaf area, leaf area index and vegetative growth of plants compared to delay seed sowing.

Effects of cutting schedules on biomass accumulation

Cutting of barley at different ZGSs had decreased the dry biomass production significantly compared to uncut barley throughout the growing period (Table 1). Dry matter ranged 36.9 g mrl^{-1} to 47.5 g mrl^{-1} at 30 DAC, 220.3 g mrl^{-1} to 265.8 g mrl^{-1} at anthesis period and 360.6 g mrl^{-1} to 452.3 g mrl^{-1} at maturity stage when the plants were cutting at GS19 (maximum growth stage) to ZGS31 (stem elongation stage). Maximum dry matter accumulation (52.3, 315.2 and 475.5 g mrl^{-1} at 30 DAC, anthesis and maturity stage, respectively) was found at uncut plant. It could be due to the no decapitation stress resulted in higher and vigorous plants which contributed to increase dry matter accumulation in uncut plant compare to cutting at different growth stage for fodder purpose (Waheddullah *et al*., 2018).

Table 1. Effects of sowing date and cutting schedule on growth parameter at different stages of crop

Treatment		Plant height (cm)			Dry matter (g mrl^{-1})		
		30 DAC	Anthesis	Maturity	30 DAC	Anthesis	Maturity
Sowing date	30-Oct	46.3 a	80.6 a	92.6 a	48.5 a	275.2 a	415.5 a
	15-Nov	41.5 b	75.8 b	88.3 b	42.6 b	260.4 b	405.3 b
	30-Nov	35.5 c	63.2 c	76.2 c	36.3 c	245.8 c	385.7 c
	15-Dec	30.2 d	50.7 d	63.7 d	32.8 d	225.7 d	360.3 d
	30-Dec	22.7 e	33.5 e	45.6 e	28.5 e	204.5 e	332.6 e
LSD (0.01)		1.8	1.9	1.4	1.5	3.5	2.8
CV%		5.99	5.03	6.78	8.02	8.11	7.43
Cutting management	Uncut	67.5 a	87.2 a	98.3 a	52.3 a	315.2 a	475.5 a
	Cutting at ZGS19	42.9 b	78.3 b	90.2 b	47.5 b	265.8 b	452.3 b
	Cutting at ZGS29	38.8 c	64.6 c	77.5 c	44.6 c	250.4 c	410.5 c
	Cutting at ZGS31	20.6 d	32.8 d	45.5 d	36.9 d	220.3 d	360.6 d
LSD (0.01)		1.9	1.8	1.4	1.5	2.8	2.6
CV%		7.90	7.14	8.95	7.99	7.35	7.41

Effects of sowing date and cutting managements on yield contributing characteristics

Seed sowing date and cutting managements had significant effect on yield contributing characteristics of barley (Table 2). The effective tillers ranged from 86.75 mrl^{-1} to 145.25 mrl^{-1}, spike length ranged from 5.75 cm to 8.85 cm, fertile spikelet ranged from 20.65 no. spike^{-1} to 38.86 no. spike^{-1}, infertile spikelet 3.05 no. spike^{-1} to 4.75 no. spike^{-1} and 1000-grain weight ranged from 26.75 g to 35.64 g were recorded in different treatments (Table 2). From this study, it was observed that delay in sowing of barley seed from 30 October to 30 December had significantly decreased all the yield attributes. The maximum yield attributes were found in sowing of barley at 30 October. The reason could be the highest period of time of the vegetative growth documented in early seed sown barley which enabled the plant to gain and use maximum resources and harvest the highest number of yield attributes. The maximum number of fertile spikelet (no. spike^{-1}) was obtained in earlier sown crop was possibly due to extended growing season contribute higher photosynthetic assimilation and translocate from source to sink , which caused in higher production of grain along with grain filling. Yield attributes differed significantly in seed sowing times might be clarified that seed sowing at the period of higher temperature, the plant could not get amiable atmosphere for proper vegetative growth and productivity. Previous studies stated that late seed sowing of wheat and barley might be exposed to high temperature after and during flowering stage of crops subsequent in decreased number of fertile spikelet and number grains spike^{-1} and increased number of infertile spikelet and number of unfilled grain spike^{-1} (Fayed *et al*., 2015; Farooq *et al*., 2016).

Cutting of barley for fodder purpose at different Zadoks growth stage had decreased significantly all the yield traits related to uncut barley (Table 2). The effective tillers ranged 105.91 no. mrl^{-1} to 165.6 no. mrl^{-1}, spike length ranged 4.56 cm to 8.78 cm, fertile spikelet ranged 24.4 no. spike^{-1} to 38.5 no. spike^{-1}, infertile spikelet 2.86 no. spike^{-1} to d 4.86 no. spike^{-1} and 1000-grain weight ranged from 27.7 g to 36.2 g were recorded from this study. Our results suggested that the highest yield attributes was found in uncut conditions and the lowest was found in cutting at ZGS31 except infertile spikelet. The cause for the lowest number of effective tillers in cut treatments might be due to failure of regeneration of new tillers after cutting the plants and vice-versa. On the other hand, the reason of the lowest spike length and 1000-grain weight in cut treatments might be due to drain on photosynthetic assimilation occurred as a result of regeneration because of cutting thus decreasing translocation of assimilates to spike and grain formation. Furthermore, attaining lower grain weight in cutting treatments may be due to elimination of photosynthetic organs (leaf) by clipping which adversely affected source sink relationship.

Table 2. Effects of seed sowing date and cutting management on yield contributing characters

Treatment		Effective tiller (No. mrl^{-1})	Fertile spikelet (No. spike^{-1})	Spike length (cm)	Infertile spikelet (No. spike^{-1})	1000 grain weight (g)
Sowing date	30-Oct	145.3 a	38.9 a	8.85 a	2.93 e	35.6 a
	15-Nov	135.7 b	36.6 b	8.58 b	3.05 d	34.6 b
	30-Nov	115.3 c	32.6 c	8.25 c	3.25 c	31.6 c
	15-Dec	100.3 d	28.5 d	7.36 d	3.78 b	28.4 d
	30-Dec	86.8 e	20.7 e	5.75 e	4.75 a	26.8 e
LSD (0.01)		2.10	1.40	0.20	0.30	1.2
CV%		7.55	9.03	9.10	8.75	9.01
Cutting management	Uncut	165.6 a	38.5 a	8.8 a	2.7 d	36.2 a
	Cutting at ZGS19	140.8 b	35.6 b	8.6 b	2.7 c	34.4 b
	Cutting at ZGS29	126.5 c	30.8 c	6.8 c	3.8 b	30.6 c
	Cutting at ZGS31	105.9 d	24.4 d	4.6 d	4.9 a	27.7 d
LSD (0.01)		2.20	0.25	0.21	0.20	0.30
CV%		7.90	7.01	7.64	8.60	7.55

Effects of sowing date and cutting management on green fodder and grain yield of barley

Delay in seed sowing from 30 October to 30 December had significantly reduced grain, straw and biological yield (Table 3). The considerably higher grain, straw and biological yield (3.25 t ha^{-1}, 4.5 t ha^{-1} and 7.75 t ha^{-1}, respectively) were recorded in 30 October sown crop, while significantly lower grain, straw and biological yield (1.91 t ha^{1}, 2.5 t ha^{-1} and 4.36 t ha^{-1}, respectively) were recorded in 30 December sown crop. Our study revealed the similar trend with Singh *et al*. (2013) and Choudhary and Chaplot (2015) stated that early seed sowing at the end of October to starting of November lead to in higher yield attributes, grain, straw yield and green fodder yield over late sowing for dual purpose barley.

Among the cutting schedules, the early cutting (ZGS19, maximum growth stage) was recorded with significantly the highest grain (2.75 t ha^{-1}), straw (3.25 t ha^{-1}) and biological yield (6.00 t ha^{-1}), while late cutting (ZGS31, stem elongation stage) resulted with the lowest grain (1.4 t ha^{-1}), straw (1.8 t ha^{-1}) and biological yield (3.2 t ha^{-1}) (Table 3). The causes of significant decrease of yield in cut treatments compared to uncut barley was conceivably due to deduction of photosynthetic organs that lead to in lower vegetative growth rate, net assimilation rate, biomass accumulation, number of effective tillers, 1000-grain weight and the reverse was obtained for uncut treatment.

Delay in seed sowing of barley from 30 October to 30 December significantly reduced green fodder yield of dual purpose barley (Table 3). The highest green fodder yield (15.8 t ha^{-1}) was recorded in 30 October sown seed and the lowest (12.4 t ha^{-1}) in 30 December sown seed. The cause is obtainability of optimum growth conditions of temperature, moisture, light and essential plant nutrients to earlier seed sown treatments which lead to in higher fresh fodder production. The delay in cutting of barley for fodder was lead to increasing fodder yield (Table 3). The delay in cutting from ZGS29 to ZGS31 resulted in increasing fodder yield over ZGS19 cutting stage. The highest green fodder yield (10.8 t ha^{-1}) was found in cutting at ZGS31 (stem elongation stage) and the lowest (2.85 t ha^{-1}) in ZGS19 (vegetative growth stage). In case of cutting at ZGS29 (maximum tillering stage), green fodder yield was 6.7 t ha^{-1}. Cutting at maximum tillering stage might be balanced between grain yield and fodder yield compared to cutting at stem elongation stage (Naveed *et al.,* 2015). The reasons are to higher regeneration capacity of plant cutting at tillering stage than stem elongation stage for green fodder. Similar results were found in the study of Salama (2019) and Waheddullah *et al*. (2018) who reported that cutting barley at early growth stages (45 and 55 DAS) caused significant increase in green fodder yield and crude protein content contrast to late cutting at 65 DAS.

Table 3. Effects of sowing date and cutting management on grain yield, straw yield, biological yield and green fodder yield

Treatment		Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Green fodder yield (t ha^{-1})
Sowing date	30-Oct	3.25 a	4.50 a	7.75 a	15.75 a
	15-Nov	2.95 b	4.33 b	7.21 b	15.26 b
	30-Nov	2.80 c	4.20 c	6.80 c	14.80 c
	15-Dec	2.46 d	3.24 d	5.70 d	13.70 d
	30-Dec	1.91 e	2.45 e	4.36 e	12.36 e

Treatment		Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Green fodder yield (t ha^{-1})
LSD (0.01)		0.18	0.27	0.52	0.21
CV%		7.42	8.24	8.50	9.02
Cutting management	Uncut	3.50 a	4.58 a	8.08 a	0
	Cutting at ZGS19	2.75 b	3.25 b	6.00 b	2.85 c
	Cutting at ZGS29	2.50 c	2.65 c	5.15 c	6.65 b
	Cutting at ZGS31	1.40 d	1.76 d	3.16 d	10.75 a
LSD (0.01)		0.21	0.24	0.38	1.05
CV%		6.80	7.45	8.12	7.80

Conclusion

Sowing date and cutting management had significantly influenced the growth factors, yield attributes and yield of barley. This study suggests that early sowing at 30 October and cutting at ZGS29 (maximum tillering stage) is the most suitable management practices for green fodder and grain yield of barley.

Acknowledgement

The authors would like to express their gratitude to the Sher-e-Bangla Agricultural University Research System (SAURES) for proving financial support for this study.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this manuscript.

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