GROWTH,YIELD AND ECONOMICS OF BARLEY AS AFFECTED BY SOWING TIME AND CUTTING MANAGEMENT

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Dedicated to

My

Loving Parents
and

***Respected Professors**,*

whose hopes, dreams,
and prayers have guided me through
life.

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CERTIFICATE

This is to certify that thesis entitled, **"GROWTH,YIELD AND ECONOMICS OF BARLEY AS AFFECTED BY SOWING TIME AND CUTTING MANAGEMENT"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science** in **Agronomy,** embodies the result of a piece of bona fede research work carried out by **Md. Sohel Rana,** Registration **No. 15-06446** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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SAU, Dhaka **The**

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ABSTRACT

The experiment was conducted at Sher-e-Bangla Agricultural University during the period from November, 2021 to March, 2022 for assessing different varieties of barley in dual purpose influenced by sowing time and cutting management. The three factorial experiment considered two Barley variety,A: BARI Barley-8 and BARI Barley-9 and comprised of three factors viz. factor B: different sowing times (4), S_1=15th October, S_2=1st November, S_3=15th November and S_4=30th November; factor C: Cutting management (4); C_0=Uncut, C_1=cutting at 40 DAS, C_2=cutting at 50 DAS and C_3=cutting at 60 DAS. This experiment was laid out in a split plot design with three replications. Data were collected on different aspects of growth, yield attributes and economic traits. From the findings of the study it was observed that, among with others growth and yield contributing parameters, highest grain yield (3.35 t/ha) was obtained from the $V_2S_2C_0$ combination (BARI Barley 9, sowing at 1st November and no cutting). On the other hand, the lowest grain yield (2.08 t/ha) was obtained from the combination of $V_1S_4C_3$ (BARI Barley -8, sowing at 30th November and cutting at 60 DAS). The highest BCR (2.35) was obtained from the $V_2S_2C_0$ combination (BARI Barley- 9, sowing at 1st November and cutting at 40 DAS). On the other hand, the lowest BCR (1.81) was obtained from the combination of $V_1S_4C_3$ (BARI Barley-8, sowing at 30th November and cutting at 60 DAS). From economic point of view, it was apparent that, the combination of $V_2S_2C_2$ combination (BARI Barley-9, sowing at 1st November and cutting At 50 DAS) treatment was more profitable than rest of the treatment combinations even with lower yield but additional economic return from selling the fodder.

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LIST OF ABBREVIATION AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agriculture Organization
et al.	=	And others
DAS	=	Days after Sowing
Mg	=	Milligram
kg	=	Kilogram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources Development Institute
g	=	Gram
cm	=	Centimeter
wt	=	Weight
LSD	=	Least Significant Difference
^{0}C	=	Degree Celsius
NS	=	Not significant
Max	=	Maximum
Min	=	Minimum
%	=	Percent
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of Coefficient of Variance

CHAPER 1

INTRODUCTION

Bangladesh is an agricultural country. Agriculture is Bangladesh's single biggest generating industry, accounting for around 14.23% of national GDP and employing over 60% of the entire labor force (BBS, 2022). The livestock sub-sector is critical to the development of the country's rural economy, supplying balanced and affordable nutritional food such as meat and milk. Livestock is also a valuable asset for agricultural households. The livestock sub-sector accounts for 3.4% of the overall labor force and employs around 20% of the workforce. However, one of the main reasons for the low productivity of our livestock is malnutrition, under-nutrition or both, beside the low genetic potential of the animals. Fodder plays an important role in case of meat and dairy production. The country is highly deficient in respect of availability of green fodder, dry fodder and concentrates. To mitigate the continued shortage of green fodder for animal consumption conventional barley crops need to be grown for dual purpose for fodder and grain under irrigated farming system.

Barley (*Hordeum vulgare* L.) is a rabi cereal crop which is cultivated mainly for grain production and world first ranked grain crop in terms of cultivated area, production and productivity. It can also be grown as a dual-purpose crop for providing good quality fodder as well as grains. The area, production and productivity of barley in Bangladesh is 0.45 m ha., 1.38 m ton and 3.04 t ha^{-1}, respectively. Barley is an important crop grown not only for grain in the world but also for forage production in some countries, such as the United States, Argentina, and Australia, but in Bangladesh, this kind of experience is still unexploited. Barley is a good source of high-quality forage, rich in protein, energy, nutrients and low in fibre when other forage species are low in quantity and quality. However, the best cultivars for grain-only production may not be the best for dual-purpose production; therefore, it is crucial to select cultivars that are suitable for a grazing and grain system.

Planting time is one of the utmost important agronomic management factors affecting both fodder and grain yield in barley. Early and normal sowing has longer growth duration which consequently provides an opportunity to accumulate more biomass as compared to late sowing and hereafter manifested in higher grain and biological yield. On the other hand, cutting may reduce grain yield in barley, due to leaf area limitations and tiller senescence during reproduction phase if crop is not managed properly. The normal vegetative growth is required after cutting to produce reasonable yield, so optimum sowing time and management of cutting is an important to realize the optimum yield of green fodder and grains from dual purpose barley.

Barley possesses high total biomass, thus the small and marginal farmers of our country used green barley fodder for milch animals. Looking to its high total biomass and salt tolerance nature, there has been an increasing interest in exploiting barley as a dual-purpose cereal which can permit forage production in early season in addition to the grain yield at later stage (Kharub *et al.,* 2014). 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. Suitable high yielding variety, cutting schedules and sowing time are considered to be most important prerequisite for realizing higher green fodder as well as grain yield. Several authors have agreed upon the importance of rapid regeneration of leaf area after forage removal to establish sufficient photosynthetic capacity to support maximum grain yield (Singh *et al.,* 2009). Barley is harvested as green fodder at vegetative stage, the opportunity for producing grain is eliminated by the plants because of less subsequent new leaf area and its ability to prevent tiller senescence during the period between jointing and anthesis (Singh *et al.,* 2009).

Keeping these points in view, the present investigation was conducted to study the agronomical, morphological and economic traits for screening the best barley cultivar(s) for dual purpose under different sowing time and cutting schedules.The experimental objectives are given bellow-

1. To identify the best cultivars of barley on the basis of grazing and grain recovery for dual purpose
2. To find out the suitable sowing time of barley crop for its production
3. To determine cutting time of barley for its dual purpose, and
4. To assess the combined effect of variety, sowing time and cutting height for optimum grass forage and grain yield

CHAPTER 2

REVIEW OF LITERATURE

Research works are very limited regarding influence of cutting management on different Barley crops for assessing their role as dual purpose crop in Bangladesh. It is an attempt to find out the performance of barley under different cutting management practices in relation to dual-purpose. To facilitate the research work, different literatures from abroad have been reviewed in this chapter under the following headings:

2.1 Effect of sowing time of dual-purpose barley

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.

2.1.1 Effect of date of sowing on growth

Razzaque and Rafiquzzaman (2006) found 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) experimented to determine 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) opined 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. The number of tillers per plant was found non significant with sowing date.

2.1.2 Effect of date of sowing on yield and yield attributes of barley grains and its fodder

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 conducted 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.

Razzaque and Rafiquzzaman (2006) opined 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). Razzaque 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) experimented 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 earning.

Sharma (2007) conducted 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.

2.1.3 Effect of date of sowing on quality of barley fodder

Noworolnik (2013) result revealed 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, Suweren and KWS of cultivars with higher tillering ability, can be considered to be cultivars more tolerant to delayed sowing date

2.2 Effect of genotypes on dual purpose barley

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.

2.2.1 Effect of varieties on growth of barley

Ghasemi *et al.* (2004) combined analysis of variance for green fodder indicated significant differences among the cultivars. 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 The highest and lowest grain yield belonged to triticale cultivar 4116 and barley cultivar Dasht, respectively.

Alam *et al.* (2007) studied 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 RD2715 was superior in terms of plant height compare to RD2552 and the variety RD-2552 was higher in leaf: stem ratio as compare to variety RD-2035.

Singh *et al.* (2012) opined 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 ear-head.

Musavi *et al.* (2012) conducted the experimental result 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.

2.2.2 Effect of varieties on Yield and yield attributes of barley grains and its fodder

Kharub *et al.* (2007) stated that the multilocational 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. 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 RD2715 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 (570.8) 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) opined 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) conducted the experiment that the effect of genotype of barley, on the fodder and grain yield revealed that dual purpose variety (RD-2035) gave higher grain yield as compared to grain (RD2552) variety. The straw production was higher in RD-2552 as compared to RD-2035.

2.2.3 Effect of varieties on quality parameters of barley fodder

Kaur *et al.* (2013) result revealed 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) opined that the effect of genotype of barley, on the chemical composition of barley fodder revealed that grain variety (RD-2552) had higher total ash, CP and hemicelluloses content as compared to dual purpose variety (RD-2035), but reverse trend was observed with respect to OM, ADF and cellulose contents.

2.3 Effect of cutting management on barley

Salama *et al.* (2021) conducted a two-year field study to explore the variations in forage and grain yields and their characteristics of barley seeded with 100, 125, and 150 kg ha^{-1} and cut at 45, 55, and 65 days after sowing (DAS). Cutting barley at early growth stages (45 DAS and 55 DAS) resulted in the production of higher forage yield with higher quality, in terms of high crude protein and low fibre content, compared to late forage cut at 65 DAS. Meanwhile, early forage cutting resulted in the least amount of reduction in the final grain yield and, thus, grain income. The percentage reduction in grain income associated with forage cutting at 45, 55, and 65 DAS, amounted to 5.70%, 19.60% and 31.00%, respectively. However, the net returns obtained from the dual-purpose system, when forage was cut at 45 and 55 DAS were $104.27 (11.4%), and $67.91 (7.4%), respectively, greater than that obtained in the grain-only system. Economic analysis showed that the extra income from early forage cutting was sufficient to compensate the grain yield reduction in the dual-purpose system. Dual 16 purpose barley production, thus, proved to be highly feasible in the region due to the good price of the barley forage.

Verma (2019) carried out field trials to identify the barley genotypes with higher green forage yield at cut with minimum impact on the grain and straw yields of the regenerated crop. The cut for green forage was taken at 55 days after sowing. There was significant effect observed on traits like plant height, spikes·m^{-2} for cut treatment over no-cut, while spike length and grains $spike^{-1}$ were not affected much.

Meena *et al.* (2017) conducted a field experiment to study the performance of dual-purpose varieties, cutting schedules and fertility levels to growth and productivity of barley (*Hordium vulgare* L.). The experiment consisted combinations of two dual purpose barley varieties (RD 2715 and RD 2552), three cutting schedules (40 DAS, 50 DAS and 60 DAS) and three fertility levels (RDF: 60 kg N + 20 kg P2O5 ha^{-1}, RDF + 25% extra N and RDF + 50% extra N). Dual purpose barley varieties were not significantly influenced on day to 50% heading and maturity of crop after green fodder cutting. Variety RD 2552 recorded significantly higher grain, straw and biological yield over RD 2715. The results revealed that various cutting schedule failed to record perceptible variation on plant height, number of total tillers, dry matter and LAI at 35 DAS. But cutting of barley for green fodder at 60 DAS produced the maximum plant height, number of total tillers, dry matter and LAI as compare to 40 and 50 DAS. In general, overall improvement in growth of green fodder could be ascribed to favourable internal environment of the plants as well as external environment (atmospheric conditions) to which it was exposed during its life cycle. Later at 15, 30, 45 days after green fodder cutting and at harvest, plant height and dry matter increased under cutting of forage at 40 DAS over 50 and 60 DAS. Days to 50% heading was recorded significantly increased under cutting of green fodder at 40 DAS, but days to maturity was obtained the highest at 60 DAS could be due to the availability of favourable environmental conditions (external and internal) led to better growth of each components and available for each plant 17 which dictated the availability of various growth inputs to individual plants in the community and also the extent of competition between and within plant for various growth inputs. It is an establish fact that the growth of crop is outcome of genomic and environment interaction. The grain, straw and biological yield were significantly higher when cutting was done at 40 DAS for green fodder but maximum green fodder yield was produced at 60 DAS. This may be due to the more yield attributes and growth with earlier cutting of green fodder. Green fodder cutting at 60 DAS produced highest green fodder yield (29.80 t·ha^{-1}), as compare to 40 DAS and 50 DAS, while grain (4.10 t·ha^{-1}), straw (7.09 t·ha^{-1}) and biological yield (11.19 t·ha^{-1}), produced significantly higher at 40 DAS over 50 DAS and 60 DAS green fodder cutting.

Singh *et al.* (2017) opined that 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. It was 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.

Kaur *et al.* (2013) conducted a field experiment that forage cut of barley at 60 DAS produced significantly higher dry fodder yield (24.2 q ha^{-1}) than the forage cut at 45 DAS (11.1 q ha^{-1}) and this gave 119% higher dry fodder than the forage cut at 45

DAS. They also reported that barley 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 18 forage cut at 45 DAS. Barley forage cut at 60 DAS had produced significantly higher yield of crude protein (24.2 q ha^{-1}), crude fibre (2.10 q ha^{-1}), ether extract (6.4 q ha^{-1}), mineral matter (0.62 q ha^{-1}), nitrogen free extract (2.31 q ha^{-1}) and digestible dry matter (0.62 q ha^{-1}) than forage cut at 45 DAS.

Kharub *et al.* (2013) stated that barley for green forage and grain can be grown in semi-arid and arid climatic conditions where no other green forage is available in winter months due to shortage of irrigation water or insufficient rains. New varieties have been developed zone wise for dual purpose barley and their performance has been evaluated in this study. Different varieties were screened for dual purpose barley by taking multilocation experiments. In one experiment, different varieties were grown and green forage was taken at 40, 55 and 70 days after sowing to optimize the date of cutting for green forage. For dual purpose barley crop, the stage for forage cutting is the most important on which both forage and grain yield depends. If cut is given early, forage yield will be reduced and if cut is given slight late, plant regeneration and the grain yield will be affected. Multi-location experiment results have shown that the crop can be given one cut at about 55 days after sowing for green forage in plains and the regenerated crop can be utilized for grain purpose which gives satisfactory levels of grain yield. At this stage, the reduction in grain yield over cut at 40 days was around 25% 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 (Kharub *et al.*, 2007). Therefore, cut at 55 days after sowing was found optimum in Northern plains and central zone. In case of Northern Hills, coordinated experiments conducted under rainfed conditions indicated that the optimum stage of cutting is around 70–75 days after sowing. Irrigation immediately after forage cut is required for better rejuvenation. The results of different experiments revealed that barley can produce up to 172 quintals of green forage ha^{-1} and after rejuvenation can produce 41 quintals of grain yield. Berseem, oats and sugarcane needs more irrigation and inputs as compared to barley and cannot be grown where water is scarce. The study has clearly shown 19 that dual purpose (forage and feed) barley crop is significantly beneficial as compared to barley grown for feed purpose only in dry areas where green forage is a scarce commodity. Barley grown with senji or mustard was equivalent with barley alone in producing green fodder and grain. Dual purpose barley provides nutrition rich green fodder for the livestock at the time of scarcity and at the same time also provides acceptable quality grain for human consumption. On an average, 180–240 q ha^{-1} and 24–35 q ha^{-1} of green fodder and grains, respectively were produced from dual purpose barley.

Jain and Nagar (2010) reported that barley crop cut at 45 days after sowing yielded the highest grain yield (28.7 q ha^{-1}). It was numerically low (3.75%) in no-cut crop and reduced significantly by 20.1% in 55 days cut crop. Pal and Kumar (2009) carried out an experiment for evaluation of dual-purpose barley for fodder and grain under different cutting schedules. The researchers observed the highest grain yield of barley in no-cut crop.

Kharub *et al.* (2007) opined that at 55 days stage, the reduction in grain yield of barley over cut at 40 days was around 25% but significant gain in forage yield was observed. Similarly increase in forage yield of barley was not enough to compensate the yield reduction at 70 days cut over cut at 55 days.

Boss and Carlson (2001) showed that earlier cutting of barley appeared to be of higher forage quality than late cutting.

Abdullah *et al.* (2000) conducted a field investigation that barley cutting for forage at the age of 65 days was superior (5.17 $t \cdot ha^{-1}$) to cutting at the age of 50 days (2.10 $t \cdot ha^{-1}$). Utilization of vegetative growth for forage at the age of 65 days has resulted in a reduced barley 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.

Yau *et al.* (1989) carried out an experiment to study the effects of green-stage grazing on rainfed barley in northern Syria. The researchers reported from their experimental work that single grazing at the tillering stage reduced both grain and straw yield of barley.

2.4 Economics of dual-purpose barley production

Chakrawarty and Kushwaha (2007) conducted through anylsis that 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) opined 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.

CHAPTER 3

MATERIALS AND METHODS

This chapter deals with the materials and methods of the experiment with a brief description on experimental site, climate, soil, land preparation, planting materials, experimental design, fertilizer application, irrigation and drainage, intercultural operation, data collection, data recording and their analysis. The details of investigation for achieving stated objectives are described below.

3.1 Experimental period

The experiment was conducted at the research field of the department of Agronomy, Sher-e-Bangla Agricultural University during the period from November, 2021 to March, 2022.

3.2 Geographical location

The experimental site was located at 23°46′ N latitude and 90°23′ E longitude with an altitude of 8.45 m.

3.3 Agro-Ecological Region

The experimental site belongs to the agro-ecological zone of "Madhupur Tract", AEZ-28 (Appendix I). This was a region of complex relief and soils developed over the Madhupur clay, where floodplain sediments buried the dissected edges of the Madhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain. For better understanding, the experimental site is shown in the AEZ Map of Bangladesh.

3.4 Climate and weather

The geographical location of the experimental site was under the sub-tropical climate characterized by three distinct seasons. The monsoon or rainy season 38 extending from May to October, which is associated with high temperature, high humidity and heavy rainfall. The winter or dry season from November to February, which is associated with moderately low temperature and the pre-monsoon period or hot season from March to April, which is associated with less rainfall and occasional gusty winds. Information regarding monthly maximum and minimum temperature, rainfall, relative humidity and sunshine during the period of study of the experimental site was collected from Bangladesh Meteorological Department, Agargaon and is presented in Appendix II.

3.5 Soil

The soil of the experimental area was silty clay in texture, red brown terrace soil type, olive–grey with common fine to medium distinct dark yellowish-brown mottles. Soil pH was 5.9 and had organic carbon 0.43%. The land was well drained with good irrigation facilities. The experimental site was a medium high land. It was above flood level and sufficient sunshine was available during the experimental period. The morphological characters of soil of the experimental plots are as following - Soil series: Tejgaon, General soil: Non-calcareous dark grey. The physicochemical properties of the soil are presented in Appendix II.

3.6 Planting materials

Improved variety of barley: BARI barley-8 and BARI barley-9 was used as planting material for the present study. These varieties are recommended for rabi season. The seeds were collected from BARI, Gazipur.

3.7 Treatments

The experiment consisted of two sets of treatments. The treatments were different sowing date and cutting managements. Cutting management treatments were applied at 5 cm above ground. The treatments are mentioned below:

Factor A: Four sowing times;

1. S_1=15th October,
2. S_2=1st November,
3. S_3=15th November and
4. S_4=30th November)

Factor B: Four cutting schedules

1. C_0=Uncut,
2. C_1=cutting at 40 DAS,
3. C_2=cutting at 50 DAS and
4. C_3=cutting at 60 DAS).

Factor C: Two barley varieties

1. V_1= BARI barley-8
2. V_2=BARI barley -9

3.8 Experimental design

The experiment was conducted as a split-split plot design, with three replications. Each plot was of (3.00 × 1.50) m^2 = 4.50 m^2 in size.

3.9 Seed cleaning

Seeds were cleaned up by separating the seeds from any other types of seed, odd looking seed, inert matter (bricks, stones) etc.

3.10 Sterilization of seed

Prior to sowing, the seeds were surface sterilized with Autostin 50 WDG. 2 to 3 gm of Autostin 50 WDG for per kg seed was mixed with small amount of water and then the seeds were sterilized for 20 minutes on 26 November 2021.

3.11 Final land preparation

The land was first opened with a tractor drawn disc plough on 24 November 2021. Thereafter, the land was ploughed and cross-ploughed to obtain good tilth. Deep ploughing was done to produce a good tilth, which was necessary to get better yield of the crop. Laddering was done in order to break the soil clods into small pieces followed by each ploughing. All the weeds and stubbles were cleared off from the experimental field. The final land preparation was done and subsequently field layout was completed on 25 November 2021 according to experimental specification.

3.12 Fertilizer application

The land was fertilized with cow dung, urea, triple super phosphate, muriate of potash, gypsum, boric acid and zinc sulphate according to the following:

Compost/Cow dung 10.00 t·ha^{-1}, Urea (46% N) 160.00 kg ha^{-1}, TSP (20% P_2O_5) 150 kg ha^{-1}, MoP (60% K_2O) 110 kg ha^{-1}, Gypsum (18% S) 125 kg ha^{-1} and Zinc sulphate (36% Zn) 12.50 kg ha^{-1}. The whole amount of triple super phosphate, muriate of potash, gypsum, and zinc sulphate were applied at the time of final land preparation. Urea was applied in two equal splits at 20 and 40 DAS at 15 December 2021 and 5 January 2022, respectively.

3.13 Sowing of seeds

Seeds were sown on from 15th October, 1st November, 15th November and 30th November, 2021 by hand. 1.75 kg seed (55 g seed plot^{-1}) were sown in line at recommended rate and then covered properly with soil. The line to line distance for the Barley crops was 25 cm and plant to plant distance was 5 cm, thus plant spacing was 125 cm^2. There were 10 row per plot.

3.14 Intercultural operation

The following intercultural operations were done for ensuring the normal growth of crop:

3.14.1 Thinning

Emergence of seedling was seen within 10 days after sowing. Overcrowded seedlings were thinned out. Thinning was performed after 20 days of sowing on 15 December, 2021 which was done to remove unhealthy and lineless seedlings.

3.14.2 Weeding

The experimental field was kept free from weeds by hand weeding as per requirements.

3.14.3 Irrigation

The first irrigation was done at crown root initiation stage (20 DAS) on 15 December, 2021. Second irrigation was provided at 40 DAS on 5 January 2022. Well managed drainage system was also installed for draining out excess water.

3.14.4 Plant protection measures

Field was infested by Fusarium or Sclerotium root rot during the early growing stage of seedlings. Spraying Bavistin at recommended dose controlled these fungi. The fungicide was sprayed three times at 7–10 days interval. Rodents were also controlled by using rodenticide at recommended dose. The crop was protected from birds and rats during the grain-filling period. Zinc phosphide was applied to control rat. Net was given to protect the Barley grain from birds.

3.15 General observations of the experimental field

Regular observation was done to inspect the growth stages of the crop. The field was observed time to time to detect any kind of infestation by weeds, insects and diseases so that considerable losses by pest could be minimized.

3.16 Application of cutting treatments

Different levels of cutting management treatments (Uncut, cutting at 40 DAS, cutting at 50 DAS and cutting at 60 DAS) were applied on barley plants at 5 cm above ground by scissor/sickle.

3.17 Sampling

Five plants of the inner rows from each plot were selected randomly and growth and yield parameters data were taken from these 5 plants at maturity.

3.18 Harvesting and post-harvest operation

The barley plants were harvested depending upon the maturity. Harvesting was done manually from each plot. Maturity of crop was determined when 80% of the grains became white shiny in colour. At maturity, when leaves, stems and spikes became yellowish in colours, then the plants were harvested. One square meter area from the central position of each plot was harvested for yield data and it was converted to $t{\cdot}ha^{-1}$. The selected sample plants were then harvested, bundled, tagged and carefully carried to the threshing yard in order to collect data. The crop bundles were sun dried by spreading those on the threshing floor. The grains were separated from the plants by beating the bundles with bamboo sticks and thereafter were cleaned. The grains and straw were cleaned and sun dried for 3 days.The weights of the sun-dried grained straw were also taken from the same demarcated area and were converted to $t{\cdot}ha^{-1}$.

3.19 Recording of data

The growth parameters during study were recorded at 15 days interval started from 30 DAS up to 60 DAS from plants grown in the plot while the yield data and yield attributes parameters were collected at harvest.

3.19.1 Crop growth parameters

a) Plant height
b) Number of leaves plant^{-1}
c) Fresh weight of tillers (g)
d) Dry weight of tillers (g)

3.19.2 Yield and yield contributing parameters

a) Number of grains spike^{-1}

b) Number of unfilled grains spike^{-1}
c) Weight of grains spike^{-1}
d) Spike length
e) Grain yield
f) Straw yield
g) Biological yield
h) Harvest index

3.19.3 Economic parameters

a) Cost of cultivation
b) Gross return
c) Net return
d) Benefit Cost ratio(Gross return/Total cost)

3.20 Procedure of data collection

3.20.1 Crop growth parameters

3.20.1.1 Plant height

The plant height of barley plant was considered from the top surface level of soil to the tip of the longest leaf at booting stage and flowering stage. At maturity stage, the plant height of Barley plant was measured from the top surface level of soil to the tipper end of the longest spike. Plant height was measured at three growth stages (30 DAS, 45 DAS and 60 DAS) from five plants in each plot and the average was recorded in centimetre.

3.20.1.2 Number of leaves plant^{-1}

Number of leaves plant^{-1} was counted at 30, 45 and 60 DAS by counting total number of leaves individually from five plants in each plot and the average was recorded as number of leaves plant^{-1}.

3.20.1.3 Fresh weight of tillers (g)

Fresh weight of plant was recorded at the time of 30, 45 and 60 DAS by collecting fresh whole plant samples. Data were recorded as the average of 5 sample plants plot^{-1} selected at random from the outer rows of each plot leaving the border line and expressed in gram.

3.20.1.4 Dry weight of tillers (g)

Dry matter weight of plant was recorded at the time of 30, 45 and 60 DAS by drying whole plant samples. The total plant was oven dried at 72°C temperature until a constant level from which the weight of plant dry matter was recorded. Data were recorded as the average of 5 sample plants plot^{-1} selected at random from the outer rows of each plot leaving the border line and expressed in gram.

3.20.2 Yield contributing parameters

3.20.2.1 Number of grains spike^{-1}

The total number of grains spike^{-1} was collected randomly from grains of 5 spikes plant^{-1} from 5 individual plants and then average number of grains spike^{-1} of barley plant was recorded.

3.20.2.2 Number of unfilled grains spike^{-1}

The total number of unfilled grains spike^{-1} was collected randomly from unfilled grains of 5 spikes plant^{-1} from 5 individual plants and then average number of unfilled grains spike^{-1} of barley plant was recorded.

3.20.2.3 Weight of grains spike^{-1}

Cleaned and dried grains from 5 spikes plant^{-1} from 5 individual plants were collected randomly from each plot and weighed by using a digital electric balance. When the grains retained 12% moisture, then the average weight of grains spike^{-1} of barley plant was recorded and expressed in gram.

3.20.2.4 Spike length

The length of spike was measured with a meter scale from 5 selected spikes plant^{-1} from 5 individual plants and the average value was recorded and expressed as spike length of that barley plant in cm.

3.20.2.5 Grain yield

After proper drying, the grain yield of 1 m^2 area was recorded which had effective tillers from each plot in 1 m^2 area and expressed on 12% moisture basis. Grain moisture content was measured by using a digital moisture tester. Grain yield was then converted into t ha^{-1}

3.20.2.6 Straw yield

Straw yield was determined from each plot, after separating the grains. The subsamples were oven dried to a constant weight. Straw yield was finally converted into t ha^{-1}.

3.20.2.7 Biological yield

Biological yield was determined using the following formula:

Biological yield (t ha^{-1}) = [Grain yield (t ha^{-1}) + Straw yield (t ha^{-1})]

3.20.2.8 Harvest index

Harvest Index denotes the ratio of economic yield to biological yield. Harvest index was determined with the following formula of Donald (1963):

Harvest Index (%) = [Economic Yield (Grain weight)/Biological Yield (Total dry weight)] × 100.

It was expressed in percentage.

3.20.3 Economic analysis

Economic analysis was done to find out the cost effectiveness of different treatments like different levels of inputs and bending process in cost and return were done in details according to the procedure of Alam *et al.* (1989).

3.20.3.1 Analysis for total cost of production

All the material and non-material input cost, interest on fixed capital of land and miscellaneous cost were considered for calculating the total cost of production.

3.20.3.2 Gross income

Gross income was calculated on the basis of sale of grain and fodder on the basis of current market value.

3.20.3.3 Net return

Net return was calculated by deducting the total production cost from gross income for each treatment combination.

3.20.3.4 Benefit cost ratio (BCR)

The economic indicator BCR was calculated by the following formula for each treatment combination.

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross income per hectare}}{\text{Total cost of production per hectare}}$$

3.21 Statistical analysis

The collected data on different parameters were compiled and analysed following the analysis of variance (ANOVA) techniques by split-split plot design, to find out the statistical significance of experimental results. The collected data were analysed by computer package program MSTAT-C software. The significant differences among the treatment means were compared by Least Significant Difference (LSD) at 5% levels of probability.

CHAPTER 4

RESULTS AND DISCUSSION

This chapter includes the presentation and discussion of the results found from the experiment. The results have been presented, discussed and possible interpretations were given in tabular and graphical forms. The results obtained from the experiment have been presented under separate headings and sub-headings as follows:

4.1 Growth parameters

4.1.1 Plant height

Effect of different variety

At 30, 45 and 60 DAS, plant height of barley showed statistically significant variation due to effect of different varieties (Table 01). Across the selected variety, plant height ranged from 36.05 cm to 50.57 cm. BARI Barley 9 (V_2) showed the tallest plant (40.14, 45.33 and 50.57 cm) at 30, 45 and 60 DAS, respectively.

Effect of sowing dates

Plant height (cm) showed statistically significant variation due to effect of different sowing dates (Table 01). The tallest plant (41.33, 52.70 and 61.75 cm) at 30, 45 and 60 DAS, respectively for the sowing date of 1st November (S_2). At 30, 45 and 60 DAS, sowing date of 30th November (S_4) was recorded to have the shortest plant (35.70, 39.80 and 45.91 cm, respectively).

Effect of cutting managements

The plant height of barley was significantly influenced by different cutting treatments at 30, 45 and 60 DAS (Table 01). At 30, 45 and 60 DAS, the tallest plant (41.50, 56.71 and 64.70 cm, respectively) was recorded from the treatment C_0 (no cut). On the other hand, at 30, 45 and 60 DAS, the short stature plant (34.33, 40.50 and 48.50 cm, respectively) was observed in treatment C_3 (cutting at 60 DAS). The results obtained from the present study were in conformity with the findings of Pravalika and Gaikwad (2021), Verma (2019) and Rahate *et al.* (2019) who observed reduction in plant height due to different cutting treatments. According to Broumand *et al.* (2010), forage clipping had significant effect on plant height. no clipping of forage had obtained the highest plant height while the lowest stem height was related to forage clipping.

Table 01. Effect of varieties, sowing dates and cutting management at different days after sowing (DAS) and harvest on Barley plant height

Treatments	Plant height (cm) at		
	30 DAS	45 DAS	60 DAS
Variety			
V_1	36.05 b	40.19 b	46.90 b
V_2	40.14 a	45.33 a	50.57 a
LSD (0.05)	2.13	4.05	8.11
CV%	5.99	5.03	6.78
Sowing time			
S_1	38.10 b	45.15 b	58.50 a
S_2	41.33 a	52.70 a	61.75 a
S_3	36.15 b	41.76 b	50.45 b
S_4	35.70 c	39.80 c	45.91 c
LSD (0.05)	2.18	2.90	4.13
CV%	7.44	7.02	5.93
Cutting management			
C_0	41.50 a	56.71a	64.70 a
C_1	40.15 b	47.25 b	60.67 b
C_2	37.16 b	42.91 c	51.70 c
C_3	34.33 c	40.50 d	48.50 d
LSD (0.05)	2.45	2.33	3.19
CV%	7.90	7.14	8.95

[In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability; V_1= BARI barley 8, V_2 = BARI barley 9; S_1=15th October, S_2=1st November, S_3=15th November and S_4=30th November; C_0=Uncut, C_1=cutting at 40 DAS, C_2=cutting at 50 DAS and C_3=cutting at 60 DAS]

Table 02. Combined effect of different varieties, sowing dates and cutting management at different days after sowing (DAS) and harvest on Barley plant height

Treatments			Plant height (cm) at		
			30 DAS	45 DAS	60 DAS
V_1	S_1	C_0	38.33 b	50.67 b	59.75 bc
		C_1	36.10 c	43.15 c	56.80 bc
		C_2	35.50 c	38.75 d	48.15 c
		C_3	31.71 de	36.89 d	43.50 d
	S_2	C_0	41.48 b	56.75 b	63.65 ab
		C_1	40.10 b	46.50 c	60.50 b
		C_2	36.20 b	42.80 c	51.75 c
		C_3	34.33 b	39.95 d	47.55 cd
	S_3	C_0	40.35 b	52.50 b	60.70 b
		C_1	37.15 c	45.10 c	57.82 bc
		C_2	36.15 c	41.70 c	50.13 c
		C_3	35.75 c	38.90 d	45.55 d
	S_4	C_0	37.30 b	48.70 bc	58.90 bc
		C_1	33.10 c	42.15 c	55.10 bc
		C_2	35.40 b	38.50 d	47.13 d
		C_3	30.90 e	35.19 e	40.67 e
V_2	S_1	C_0	37.30 b	52.50 b	60.75 b
		C_1	35.15 c	44.10 c	57.85 bc
		C_2	34.70 b	39.90 d	49.13 c
		C_3	33.81 d	37.91 d	44.55 d
	S_2	C_0	45.50 a	58.75 a	65.51 a
		C_1	41.50 b	47.50 b	61.70 b
		C_2	38.21 b	43.90 c	52.70 bc
		C_3	35.30 c	41.91 c	48.31 c
	S_3	C_0	41.33 b	54.55 b	61.75 b
		C_1	38.13 b	46.20 c	58.80 bc
		C_2	37.10 b	42.75 c	51.15 c
		C_3	36.50 c	39.95 d	46.56 d
	S_4	C_0	39.33 b	49.50 bc	59.80 bc
		C_1	34.15 c	43.10 c	56.15 bc
		C_2	38.45 b	39.10 d	48.15 c
		C_3	31.95 de	36.15 d	41.65 de
LSD (5%)			3.93	3.70	4.01
CV (%)			7.19	7.50	8.22

[In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability; V_1= BARI barley 8, V_2 = BARI barley

9; S_1=15th October, S_2=1st November, S_3=15th November and S_4=30th November; C_0=Uncut, C_1=cutting at 40 DAS, C_2=cutting at 50 DAS and C_3=cutting at 60 DAS]

Combined effect of varieties, sowing dates and cutting management

Significant interaction effect between the varieties, different sowing dates and cutting management was observed on plant height at 30, 45 and 60 DAS (Table 02). At 30, 45 and 60 DAS, the tallest plant (45.50, 58.75 and 65.51 cm, respectively) was recorded from the treatment $V_2S_2C_0$ (BARI Barley 9 + 1st November sowing + no cut). On the other hand, at 30, 45 and 60 DAS, the short stature plant (30.90, 35.19 and 40.67 cm, respectively) was observed in treatment $V_1S_4C_3$ (BARI barley 8, 30th November sowing and cutting at 60 DAS).

4.1.2 Number of leaves plant^{-1}

Effect of varieties

At 30, 45 and 60 DAS, number of leaves per plant showed statistically significant variation due to effect of different barley variety (Table 03). Across the selected variety, number of leave ranged 8.05 to 15.67. BARI barley 9 (V_2) showed the highest leaf (10.14, 12.50 and 15.67) at 30, 45 and 60 DAS, respectively. On the other hand, at 30, 45 and 60 DAS, BARI Barley 8 (V_1) was recorded to have the lowest leaf (8.05, 10.15 and 14.50 respectively).

Effect of sowing dates

Number of leaf per plant showed statistically significant variation due to effect of different sowing dates (Table 03). The highest leaf (10.15, 12.40 and 15.30) at 30, 45 and 60 DAS, respectively for the sowing date of 1st November (S_2). At 30, 45 and 60 DAS, sowing date of 30th November (S_4) was recorded to have the lowest leaf (9.50, 10.84 and 11.94), respectively).

Effect of cutting managements

Number of leaf per plant of Barley was significantly influenced by different cutting treatments at 30, 45 and 60 DAS (Table 03). At 30, 45 and 60 DAS, the highest leaf no. (10.25, 12.40 and 15.14, respectively) was recorded from the treatment C_0 (no cut). On the other hand, at 30, 45 and 60 DAS, the lowest leaf no. (8.25, 9.55 and 10.75, respectively) was observed in treatment C_3 (Cutting at 60 DAS). The result corroborates with the findings of AL-dulami and AL-khalifawi (2016) who reported earlier cutting was superior for obtaining higher number of leaves in oat.

Table 03. Effect of varieties, sowing dates and cutting management on number of leaves of barley at different days after sowing (DAS)

Treatments	Number of leaves plant^{-1} at		
	30 DAS	**45 DAS**	**60 DAS**
Varieties			
V_1	8.05 b	10.15 b	14.50 ab
V_2	10.14 a	12.50 a	15.67 a
LSD (0.05)	2.05	1.03	2.15
CV%	4.16	4.38	6.77
Sowing date			
S_1	8.03 b	10.17 c	12.33 b
S_2	10.15 a	12.40 a	15.30 a
S_3	9.05 b	11.50 b	12.50 b
S_4	9.50 b	10.84 b	11.94 b
LSD (0.05)	1.11	0.98	2.35
CV%	5.01	5.60	5.39
Cutting managements			
C_0	10.25 a	12.40 a	15.14 a
C_1	9.75 b	10.33 b	13.50 b
C_2	9.14 b	10.10 b	11.50 c
C_3	8.25 c	9.55 c	10.75 d
LSD (0.05)	0.88	1.23	1.19
CV%	6.08	7.55	7.41

[In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability; V_1= BARI barley 8, V_2 = BARI barley 9; S_1=15th October, S_2=1st November, S_3=15th November and S_4=30th November; C_0=Uncut, C_1=cutting at 40 DAS, C_2=cutting at 50 DAS and C_3=cutting at 60 DAS]

Table 04. Combined effect of varieties, sowing dates and cutting management on number of leaves of barley at different days after sowing (DAS)

Treatments			Number of leaves plant^{-1} at		
			30 DAS	45 DAS	60 DAS
V_1	S_1	C_0	8.15 b	10.33 c	12.50 b
		C_1	7.50 c	8.15 d	9.33 c
		C_2	7.15 cd	9.50 c	10.70 c
		C_3	7.50 c	8.75 d	9.50 c
	S_2	C_0	9.80 ab	11.50 b	14.50 ab
		C_1	8.75 b	9.25 c	12.75 b
		C_2	8.50 b	9.50 c	10.75 c
		C_3	7.67 c	8.74 d	9.80 c
	S_3	C_0	8.25 b	11.75 b	13.75 b
		C_1	7.15 cd	9.10 c	11.33 b
		C_2	8.50 b	10.50 c	11.70 b
		C_3	8.30 b	9.89 c	10.95 c
	S_4	C_0	8.15 b	10.00 c	12.00
		C_1	7.10 cd	8.30 d	9.00 c
		C_2	7.10 cd	9.67 c	10.25 c
		C_3	7.03 d	7.50 e	8.50 d
V_2	S_1	C_0	9.15 ab	11.30 b	13.50 b
		C_1	7.15 b	9.10 c	10.33 c
		C_2	8.10 b	10.50 c	11.75 b
		C_3	8.50 b	9.75 c	10.50 c
	S_2	C_0	10.50 a	12.50 a	15.10 a
		C_1	9.70 b	10.21 c	13.33 b
		C_2	9.15 b	10.15 c	11.67 b
		C_3	8.33 b	9.67 c	10.70 c
	S_3	C_0	10.25	12.10 ab	14.50 b
		C_1	10.05 b	11.15 b	12.30 b
		C_2	9.15 b	10.50 c	11.70 b
		C_3	9.50 b	10.90 c	10.75 c
	S_4	C_0	9.01 b	11.00 b	13.00 b
		C_1	8.10 b	10.00 c	12.00 b
		C_2	7.50 c	9.04 c	11.15 b
		C_3	7.13 cd	8.15 d	10.00 c
LSD (5%)			0.43	0.71	1.89
CV (%)			5.11	5.90	6.05

[In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability; V_1= BARI barley 8, V_2 = BARI barley

9; S_1=15th October, S_2=1st November, S_3=15th November and S_4=30th November; C_0=Uncut, C_1=cutting at 40 DAS, C_2=cutting at 50 DAS and C_3=cutting at 60 DAS]

Combined effect of varieties, sowing dates and cutting managements

Significant interaction effect due to varieties, different sowing dates and cutting management was observed regarding leaf number at 30, 45 and 60 DAS (Table 04). At 30, 45 and 60 DAS, the highest leaf no. (10.50, 12.50 and 15.10, respectively) was recorded from the treatment $V_2S_2C_0$ (BARI Barley 9, 1st November sowing and no cut). On the other hand, at 30, 45 and 60 DAS, the lowest leaf no. (7.03, 7.50 and 8.50, respectively) was observed in treatment $V_1S_4C_3$ (BARI Barley 8, 30th November sowing and cutting at 60 DAS).

4.1.3 Fresh weight (g)

Effect of different varieties

At 30, 45 and 60 DAS, fresh weight (g) of plant showed statistically significant variation due to effect of different Barley variety (Table 05). Across the varieties, fresh weight ranged from 22.15 to 75.30 g. BARI Barley 9 (V_2) showed the highest weight (28.90, 50.67 and 75.30 g) at 30, 45 and 60 DAS, respectively. On the other hand, at 30, 45 and 60 DAS, BARI Barley 8 (V_1) was recorded to have the lowest weight (22.15, 36.33 and 61.45 g respectively).

Effect of sowing dates

Fresh weight (g) of plant showed statistically significant variation due to effect of different sowing dates (Table 05). The highest weight (29.10, 51.02 and 76.33 g) at 30, 45 and 60 DAS, respectively for the sowing date of 1st November (S_2). At 30, 45 and 60 DAS, sowing date of 30th November (S_4) was recorded to have the lowest weight (23.15, 39.20 and 68.50 g), respectively).

Effect of cutting managements

Fresh weight (g) of plant of barley was significantly influenced by different cutting treatments at 30, 45 and 60 DAS (Table 05). At 30, 45 and 60 DAS, the highest weight (28.04, 50.05 and 74.50 g, respectively) was recorded from the treatment C_0 (no cut). On the other hand, at 30, 45 and 60 DAS, the lowest fresh weight (22.10, 39.21 and 62.50 g respectively) was observed in treatment C_3 (cutting at 60 DAS).

Table 05. Effect of varieties, sowing dates and cutting management on barley fresh weight (g) at different days after sowing (DAS)

Treatments	Fresh weight (g) at		
	30 DAS	45 DAS	60 DAS
Varieties			
V_1	22.15 b	36.33 b	61.45 b
V_2	28.90 a	50.67 a	75.30 a
LSD (0.05)	4.05	7.08	7.15
CV%	7.93	6.81	6.55
Sowing dates			
S_1	24.03 cd	40.13 c	70.25 b
S_2	29.10 a	51.02 a	76.33 a
S_3	27.33 b	48.53 c	71.04 b
S_4	23.15 d	39.20 d	68.50 c
LSD (0.05)	2.31	2.05	3.80
CV%	6.40	7.19	7.15
Cutting managements			
C_0	28.04 a	50.05 a	74.50 a
C_1	23.15 b	48.33 b	68.21 b
C_2	22.90 bc	45.50 b	67.05 b
C_3	22.10 c	39.21 c	62.50 c
LSD (0.05)	1.48	3.23	3.39
CV%	6.95	7.10	8.45

[In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability; V_1= BARI barley 8, V_2 = BARI barley 9; S_1=15th October, S_2=1st November, S_3=15th November and S_4=30th November; C_0=Uncut, C_1=cutting at 40 DAS, C_2=cutting at 50 DAS and C_3=cutting at 60 DAS]

Combined effect of varieties, sowing dates and cutting management

Significant interaction of varieties,sowing dates and cutting management was observed on fresh weight (g) at 30, 45 and 60 DAS (Table 06). At 30, 45 and 60 DAS, the highest weight (28.04, 50.05 and 74.50 g, respectively) was recorded from the treatment $V_2S_2C_0$ (BARI barley 9, 1st November sowing and no cut). On the other hand, at 30, 45 and 60 DAS, the lowest fresh weight (19.50, 31.80 and 58.67 g, respectively) was observed in treatment $V_1S_4C_3$ (BARI barley 8, 30th November sowing and cutting at 60 DAS).

Table 06. Combined effect of varieties, sowing dates and cutting management on barley fresh weight (g) at different days after sowing (DAS)

Treatments			Fresh weight (g) at		
			30 DAS	45 DAS	60 DAS
V_1	S_1	C_0	24.50 b	44.30 b	64.80 b
		C_1	20.00 c	43.10 b	64.00 b
		C_2	20.00 c	41.50 c	60.30 cd
		C_3	20.00 c	32.00 ef	58.90 cd
	S_2	C_0	25.00 b	45.70 b	67.00 b
		C_1	21.00 c	45.00 b	64.15 b
		C_2	20.33 c	43.50 b	61.50 d
		C_3	20.04 c	34.00 d	60.00 cd
	S_3	C_0	24.80 b	44.90 b	65.00 b
		C_1	20.00 c	43.50 b	64.10 b
		C_2	20.00 c	42.90 b	60.50 cd
		C_3	20.00 c	33.00 e	60.00 cd
	S_4	C_0	24.10 b	44.18 b	64.80 b
		C_1	20.00 c	43.04 b	63.00 b
		C_2	19.70 cd	41.00 c	60.05 cd
		C_3	19.50 d	31.80 f	58.67 d
V_2	S_1	C_0	25.09 b	46.15 b	70.50 ab
		C_1	21.18 c	45.10 b	64.25 b
		C_2	20.55 c	43.75 b	63.30 b
		C_3	20.28 c	34.25 e	60.15 c
	S_2	C_0	28.04 a	50.05 a	74.50 a
		C_1	27.15 b	48.33 b	68.21 b
		C_2	26.90 b	45.50 b	67.05 b
		C_3	23.10 b	36.21 d	65.50 b
	S_3	C_0	26.05 b	48.15 b	71.80 ab
		C_1	25.10 b	46.20 b	65.20 b
		C_2	24.70 b	44.75 b	64.33 b
		C_3	22.58 c	35.20 d	61.50 c
	S_4	C_0	25.01 b	46.10 b	70.00 ab
		C_1	21.10 c	45.00 b	64.14 b
		C_2	20.50 c	43.70 b	62.70 c
		C_3	20.15 c	34.10 d	60.00 c
LSD (5%)			1.95	2.71	5.09
CV (%)			7.88	5.64	8.90

[In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability; V_1= BARI barley 8, V_2 = BARI barley

9; S_1=15th October, S_2=1st November, S_3=15th November and S_4=30th November; C_0=Uncut, C_1=cutting at 40 DAS, C_2=cutting at 50 DAS and C_3=cutting at 60 DAS]

4.1.4 Dry weight (g) per plant

Effect of varieties

For 30, 45 and 60 DAS, dry weight (g) of plant showed statistically significant variation due to effect of different barley variety (Table 07). Across the selected variety, dry weight ranged from 3.15 to 40.85 g. BARI barley 9 (V_2) showed the highest dry weight (3.90, 16.15 and 40.85 g) at 30, 45 and 60 DAS, respectively. On the other hand, at 30, 45 and 60 DAS, BARI barley 8 (V_1) was recorded to have the lowest dry weight (3.15, 14.00 and 34.50 g respectively).

Effect of sowing dates

Dry weight (g) of plant showed statistically significant variation due to effect of different sowing dates (Table 07). The highest dry weight (3.95, 16.25 and 40.75 g) at 30, 45 and 60 DAS, respectively for the sowing date of 1st November (S_3). At 30, 45 and 60 DAS, sowing date of 30th November (S_4) was recorded to have the lowest dry weight (2.89, 10.73 and 29.80 g), respectively).

Effect of cutting managements

Dry weight (g) of plant of Barley was significantly influenced by different cutting treatments at 30, 45 and 60 DAS (Table 07). At 30, 45 and 60 DAS, the highest dry weight (3.75, 15.95 and 40.50 g, respectively) was recorded from the treatment C_0 (no cut). On the other hand, at 30, 45 and 60 DAS, the lowest dry weight (2.80, 10.75 and 28.75 g respectively) was observed in treatment C_3 (Cutting at 60 DAS).

Table 07. Effect of varieties, sowing dates and cutting management on barley dry weight at different days after sowing (DAS)

Treatments	Dry weight (g) at		
	30 DAS	45 DAS	60 DAS
Varieties			
V_1	3.15 b	14.00 b	34.50 b
V_2	3.90 a	16.15 a	40.85 a
LSD (0.05)	0.54	0.97	1.55
CV%	8.02	8.11	7.43
Sowing dates			
S_1	3.00 b	12.33 b	31.00 b
S_2	3.33 b	13.70 b	34.33 b
S_3	3.95 a	16.25 a	40.75 a
S_4	2.89 c	10.73 c	29.80 c
LSD (0.05)	0.41	0.95	4.91
CV%	6.33	5.08	5.24
Cutting managements			
C_0	3.75 a	15.95 a	40.50 a
C_1	3.33 b	13.80 b	34.33 b
C_2	3.10 b	12.35 b	31.10 b
C_3	2.80 c	10.75 c	28.75 c
LSD (0.05)	0.48	1.23	3.40
CV%	7.99	7.35	7.41

[In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability; V_1= BARI barley 8, V_2 = BARI barley 9; S_1=15th October, S_2=1st November, S_3=15th November and S_4=30th November; C_0=Uncut, C_1=cutting at 40 DAS, C_2=cutting at 50 DAS and C_3=cutting at 60 DAS]

Combined effect of varieties, sowing dates and cutting managements

Significant interaction effect between the varieties, different sowing dates and cutting management was observed on dry weight (g) at 30, 45 and 60 DAS (Table 08). At 30, 45 and 60 DAS, the highest dry weight (3.70, 15.90 and 40.55 g, respectively) was recorded from the treatment $V_2S_2C_0$ (BARI Barley 9, 1st November sowing and no cut). On the other hand, at 30, 45 and 60 DAS, the lowest dry weight (2.50, 9.90 and 25.75 g, respectively) was observed in treatment $V_1S_4C_3$ (BARI Barley 8, 30th November sowing and cutting at 60 DAS).

Table 08. Combined effect of different varieties, sowing dates and cutting management on barley dry weight (g) at different days after sowing (DAS)

Treatments			Dry weight (g) at		
			30 DAS	45 DAS	60 DAS
V_1	S_1	C_0	2.95 b	13.50 b	35.75 b
		C_1	2.60 b	12.00 b	32.50 b
		C_2	2.44 b	12.00 b	29.30 cd
		C_3	2.26 bc	9.60 cd	25.40 cd
	S_2	C_0	3.00 ab	14.00 b	36.80 b
		C_1	2.70 b	12.10 b	32.60 b
		C_2	2.60 b	12.00 b	29.90 cd
		C_3	2.50 b	9.76 cd	25.70 cd
	S_3	C_0	2.98 b	13.70 b	35.90 b
		C_1	2.70 b	12.00 b	32.50 b
		C_2	2.50 b	12.00 b	29.33 cd
		C_3	2.46 b	9.67 cd	25.50 cd
	S_4	C_0	2.90 b	13.00 b	35.55 b
		C_1	2.40 bc	12.00 b	32.00 b
		C_2	2.33 bc	11.00 b	28.98 cd
		C_3	2.21 c	9.50 d	25.00 d
V_2	S_1	C_0	3.00 ab	14.10 b	38.00 b
		C_1	2.95 b	12.50 b	33.00 b
		C_2	2.80 b	12.00 b	30.05 b
		C_3	2.70 b	10.00 c	26.33 cd
	S_2	C_0	3.70 a	15.90 a	40.55 a
		C_1	3.35 ab	13.81 b	34.30 b
		C_2	3.15 ab	12.34 b	31.14 b
		C_3	2.89 b	10.70 c	28.60 cd
	S_3	C_0	3.10 ab	14.50 b	38.50 b
		C_1	3.05 ab	12.80 b	34.00 b
		C_2	3.00 ab	12.15 b	30.15 b
		C_3	2.80 b	10.40 c	27.50 c
	S_4	C_0	3.00 ab	14.00 b	37.00 b
		C_1	2.75 b	12.30 b	32.70 b
		C_2	2.70 b	12.00 b	29.95 b
		C_3	2.50 b	9.90	25.75
LSD (5%)			0.35	2.78	4.10
CV (%)			7.60	7.51	6.45

[In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability; V_1= BARI barley 8, V_2 = BARI barley

9; S_1=15th October, S_2=1st November, S_3=15th November and S_4=30th November; C_0=Uncut, C_1=cutting at 40 DAS, C_2=cutting at 50 DAS and C_3=cutting at 60 DAS]

4.2 Yield and yield contributing parameters

4.2.1 Number of grains spike^{-1}

Effect of varieties

The number of grains spike^{-1} data showed significant variation due to different selected varieties of Barley (Table 9). BARI barley 9 (V_2) was reported to have maximum number of grains spike^{-1} (45.50) whereas the minimum was 40.75 grains spike^{-1} (No.) was observed from BARI barley 8 (V_1).

Effect of sowing dates

For different sowing dates the number of grains spike^{-1} data showed significant variation (Table 9). Sowing date of 1st November (S_2) was reported to have maximum number of grains spike^{-1} (45.67) whereas the minimum was 35.50 grains spike^{-1} (No.) was observed from the sowing date of 30th November (S_4).

Effect of cutting managements

The number of grains spike^{-1} data did showed significant variation due to effect of different cutting treatments (Table 9). The treatment C_0 (no cut) was recorded to have the maximum number of grains spike^{-1} (44.50), whereas the minimum was 31.33 from treatment C_3 (cutting at 60 DAS). The result was in contrary with the findings of Verma (2019) who mentioned grains spike^{-1} was not significantly affected due to cutting treatments. Malik and Babli (2017) observed grains spike^{-1} decreased with increase in cut for fodder.

Combined effect of varieties, sowing dates and cutting management

Interaction effect between the varieties, different sowing dates and cutting management was found significant on number of grains spike^{-1} at harvest in cereals (Table 10). The maximum number of grains spike^{-1} (44.60) was obtained from the $V_2S_2C_0$ combination (BARI Barley 9, sowing at 1st November and no cutting). On the other hand, the minimum number of grains spike^{-1} (28.90) was obtained from the combination of $V_1S_4C_3$ (BARI Barley 8, sowing at 30th November and cutting at 60 DAS).

4.2.2 Number of unfilled grains spike^{-1}

Effect of different varieties

The number of unfilled grains spike^{-1} data showed significant variation due to different selected varieties of Barley (Table 9). BARI Barley 9 (V_2) was reported to have maximum number of unfilled grains spike^{-1} (3.25) whereas the minimum was 2.60 grains spike^{-1} (No.) was observed from BARI Barley 8 (V_1).

Effect of sowing dates

For different sowing dates the number of unfilled grains spike^{-1} data showed significant variation (Table 9). Sowing date of 1st November (S_2) was reported to have maximum number of unfilled grains spike^{-1} (3.33) whereas the minimum was 2.14 grains spike^{-1} (No.) was observed from the sowing date of 30th November (S_4).

Effect of cutting managements

The number of unfilled grains spike^{-1} data showed significant variation due to effect of different cutting treatments (Table 9). The treatment C_0 (no cut) was recorded to have the maximum number of unfilled grains spike^{-1} (3.30), whereas the minimum was 2.15 from treatment C_3 (cutting at 60 DAS).

Combined effect of varieties, sowing dates and cutting management

Interaction effect between the varieties, different sowing dates and cutting management was found significant on number of unfilled grains spike^{-1} at harvest in cereals (Table 10). The maximum number of unfilled grains spike^{-1} (3.33) was obtained from the $V_2S_2C_0$ combination (BARI barley 9, sowing at 1st November and no cutting). On the other hand, the minimum number of unfilled grains spike^{-1} (1.94) was obtained from the combination of $V_1S_4C_3$ (BARI barley 8, sowing at 30th November and cutting at 60 DAS).

4.2.3 Weight of grains spike^{-1}

Effect of varieties

The of weight of grains spike^{-1} data showed significant variation due to different selected varieties of Barley (Table 9). BARI barley 9 (V_2) was reported to have highest weight of grains spike^{-1} (2.75 g) whereas the minimum was (1.25 g) grains spike^{-1} (No.) was observed from BARI barley 8 (V_1). The results mentioned above are in conformity with the findings of Salama *et al.* (2021) who also mention weight of grains was significantly affected due to different cereal crops.

Effect of sowing dates

Different sowing dates the weight of grains spike^{-1} data showed significant variation (Table 9). Sowing date of 1st November (S_2) was reported to have highest weight of grains spike^{-1} (2.81 g) whereas the minimum was (1.15 g) grains spike^{-1} (No.) was observed from the sowing date of 30th November (S_4).

Effect of cutting managements

The weight of grains spike^{-1} data showed significant variation due to effect of different cutting treatments (Table 9). The treatment C_0 (no cut) was recorded to have the highest weight of grains spike^{-1} (2.80 g), whereas the minimum was (1.10 g) from treatment C_3 (cutting at 60 DAS).

Combined effect of varieties, sowing dates and cutting management

Interaction effect between the varieties, different sowing dates and cutting management was found significant on weight of grains spike^{-1} at harvest in cereals (Table 10). The highest weight of grains spike^{-1} (2.90 g) was obtained from the $V_2S_2C_0$ combination (BARI barley 9, sowing at 1st November and no cutting). On the other hand, the lowest weight of grains spike^{-1} (1.00 g) was obtained from the combination of $V_1S_4C_3$ (BARI barley 8, sowing at 30th November and cutting at 60 DAS).

4.2.4 Spike length

Effect of varieties

The spike length data showed significant variation due to different selected varieties of Barley (Table 9). BARI barley 9 (V_2) was reported to have highest length of spike (16.90) whereas the lowest was (15.75) observed from BARI barley 8 (V_1).

Effect of sowing dates

For different sowing dates the spike length data showed significant variation (Table 9). Sowing date of 1st November (S_2) was reported to have highest length of spike (16.95) whereas the lowest was (14.32) observed from the sowing date of 30th November (S_4).

Effect of cutting managements

Spike length data showed significant variation due to effect of different cutting treatments (Table 9). The treatment C_0 (no cut) was recorded to have the highest length of spike (16.89), whereas the lowest was (14.33) from treatment C_3 (cutting at 60 DAS). Verma (2019) also mentioned that cut treatment did not exert any significant effect on spike length of barley.

Combined effect of varieties, sowing dates and cutting managements

Interaction effect between the varieties, different sowing dates and cutting management was found significant on spike length at harvest in cereals (Table 10). The highest length of spike (16.98) was obtained from the $V_2S_2C_0$ combination (BARI barley 9, sowing at 1st November and no cutting). On the other hand, the lowest spike length (12.05) was obtained from the combination of $V_1S_4C_3$ (BARI barley 8, sowing at 30th November and cutting at 60 DAS).

Table 09. Effect of different varieties, sowing dates and cutting management at different days after sowing (DAS) and harvest on Barley yield contributing parameters

Treatments	Number of grains $spike^{-1}$	Number of unfilled grains $spike^{-1}$	Weight of grains $spike^{-1}$ (g)	Spike length (cm)
Variety				
V_1	40.75 b	2.60 b	1.25 b	15.75 b
V_2	45.50 a	3.25 a	2.75 a	16.90 a
LSD (0.05)	3.05	0.65	0.50	1.05
CV%	8.41	8.05	7.93	7.50
Sowing time				
S_1	40.50 b	2.67 b	1.41 b	15.70 b
S_2	45.67 a	3.33 a	2.81 a	16.95 a
S_3	38.90 c	2.50 b	1.33 b	15.00 b
S_4	35.50 d	2.14 c	1.15 c	14.32 c
LSD (0.05)	3.10	0.89	0.20	0.62
CV%	7.55	9.03	9.15	8.74
Cutting management				
C_0	44.50 a	3.30 a	2.80 a	16.89 a
C_1	41.70 b	2.50 b	1.33 b	15.55 b
C_2	38.50 c	2.33 b	1.25 b	15.00 b
C_3	31.33 d	2.15 c	1.10 c	14.33 c
LSD (0.05)	2.10	0.53	0.38	0.62
CV%	7.90	7.01	7.64	8.60

[In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability; V_1= BARI barley 8, V_2 = BARI barley 9; S_1=15th October, S_2=1st November, S_3=15th November and S_4=30th November; C_0=Uncut, C_1=cutting at 40 DAS, C_2=cutting at 50 DAS and C_3=cutting at 60 DAS]

Table 10. Combined effect of varieties, sowing dates and cutting management on yield contributing parameters of barley at different days after sowing (DAS)

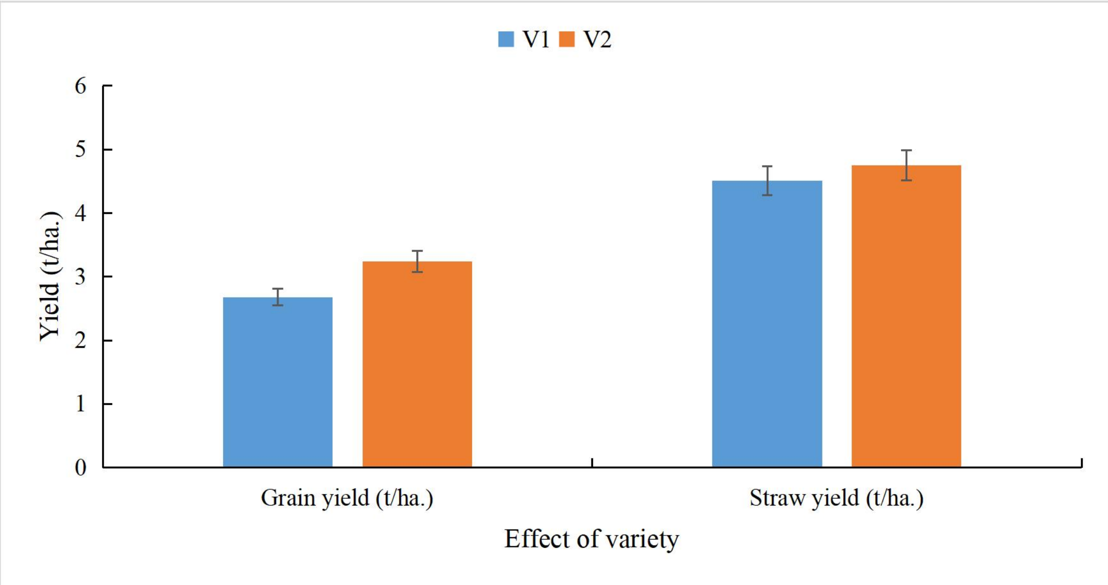
Treatments			Number of grains $spike^{-1}$	Number of unfilled grains $spike^{-1}$	Weight of grains $spike^{-1}$ (g)	Spike length (cm)
V_1	S_1	C_0	41.25 b	3.10 b	2.70 ab	15.20 b
		C_1	40.10 b	2.40 c	1.50 b	14.33 b
		C_2	35.70 c	2.20 c	1.30 b	13.15 c
		C_3	30.40 d	2.13	1.08 c	12.20 cd
	S_2	C_0	43.55 ab	3.25 ab	2.84 ab	16.90 ab
		C_1	41.33 b	2.70 c	1.64 b	15.57 b
		C_2	37.90 c	2.33c	1.33 b	14.98b
		C_3	31.50 d	2.25c	1.15 c	13.80 c
	S_3	C_0	42.55 b	3.20 ab	2.80 ab	15.90 b
		C_1	40.30 b	2.50 c	1.60 b	14.77 b
		C_2	36.91 c	2.30 c	1.31 b	13.67 c
		C_3	30.45 d	2.21 c	1.10 c	12.50 c
	S_4	C_0	40.03 b	3.00 b	2.67 ab	15.00 b
		C_1	38.06 b	2.30 c	1.50 b	14.17 b
		C_2	34.67 c	2.10 c	1.10 c	13.11 c
		C_3	28.90 e	1.94 d	1.00 d	12.05 d
V_2	S_1	C_0	43.00 ab	3.03 b	2.70 ab	16.50 ab
		C_1	41.04 b	2.50 c	1.25 b	14.80 b
		C_2	37.10 c	2.12 c	1.10 c	14.50 b
		C_3	32.25 d	2.10 c	1.05 cd	13.33 c
	S_2	C_0	44.60 a	3.33 a	2.90 a	16.98 a
		C_1	41.75 b	2.67 c	1.50 b	15.50 b
		C_2	38.58 b	2.33 c	1.33 b	15.10b
		C_3	31.50 d	2.25 c	1.15 c	14.25 b
	S_3	C_0	43.50 ab	3.15 ab	2.80 ab	16.75 ab
		C_1	41.25 b	2.60 c	1.45 b	15.00 b
		C_2	37.50 c	2.30 c	1.30 b	14.90 b
		C_3	31.45 d	2.15 c	1.10 c	13.50 c
	S_4	C_0	42.00 b	3.00 b	2.60 ab	15.50 b
		C_1	40.05 b	2.24 c	1.21 b	14.55 b
		C_2	35.75 c	2.10 c	1.09 c	13.75 c
		C_3	30.33 d	2.00 c	1.01 d	12.16 cd
LSD (5%)			4.93	0.16	0.31	1.04
CV (%)			6.30	7.10	8.95	10.92

[In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability; V_1= BARI Barley 8, V_2 = BARI Barley 9; S_1=15th October, S_2=1st November, S_3=15th November and S_4=30th November; C_0=Uncut, C_1=cutting at 40 DAS, C_2=cutting at 50 DAS and C_3=cutting at 60 DAS]

4.2.5 Grain yield (t/ha.)

Effect of varieties

The grain yield (t/ha) data showed significant variation due to different varieties of barley (Table 11). BARI barley 9 (V_2) was reported to have highest grain yield (3.24 t/ha) whereas the lowest was (2.68 t/ha) observed from BARI Barley 8 (V_1) (Figure 1).



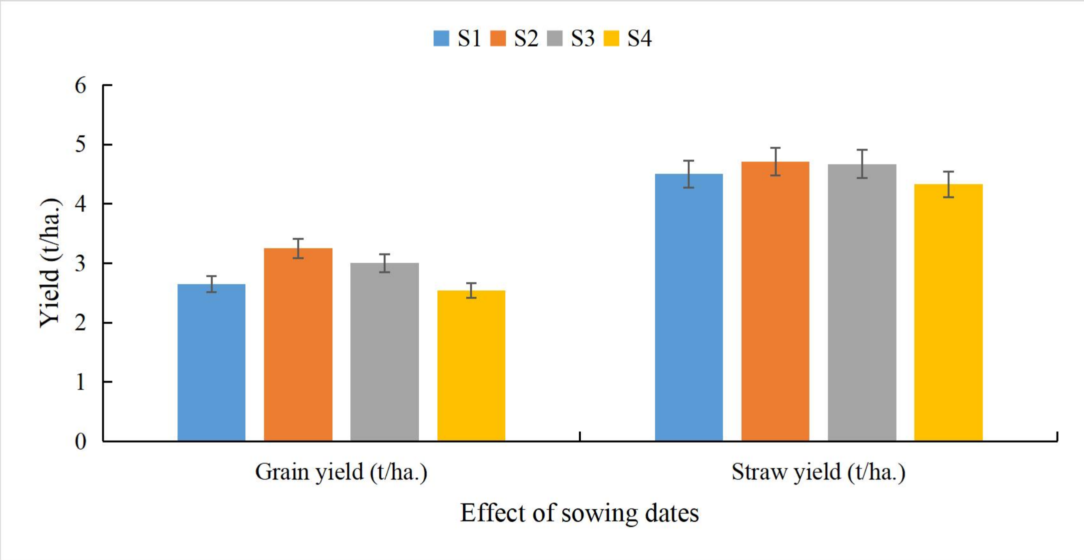
[Here, V_1= BARI barley 8, V_2 = BARI barley 9]

[LSD0.05= **0.038**]

Figure 1. Effect of varieties on yield of barley

Effect of sowing dates

For different sowing dates the grain yield (t/ha) data showed significant variation (Table 11). Sowing date of 1st November (S_2) was reported to have highest grain yield (3.25 t/ha) whereas the lowest (2.54 t/ha) was observed from the sowing date of 30th November (S_4) (Fig- 2).



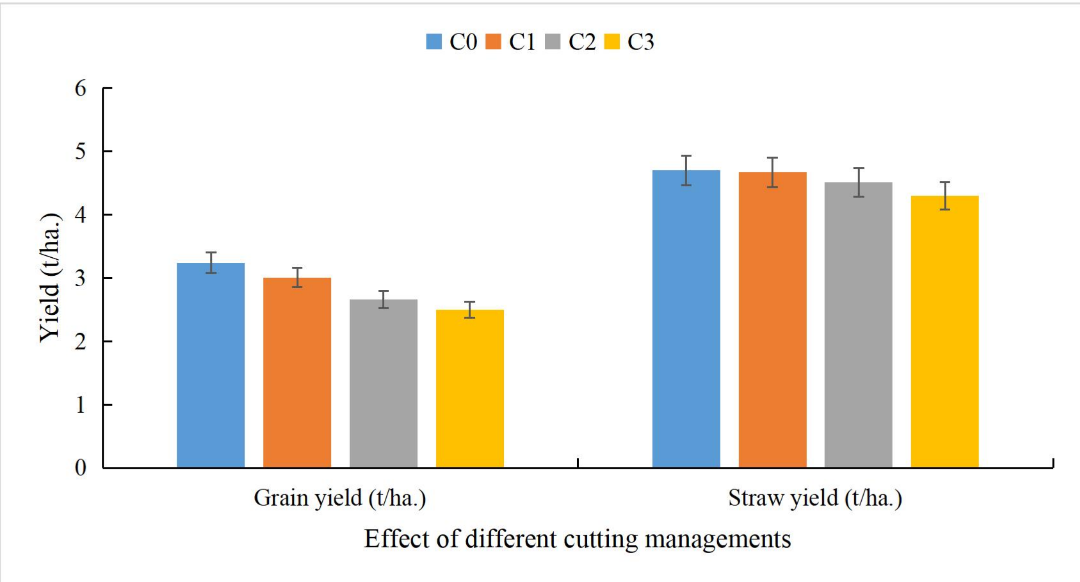
[Here, S_1=15th October, S_2=1st November, S_3=15th November and S_4=30th November]

(LSD $_{0.05}$ = 0.06, 0.11 and 0.22 at 15th October, S_2=1st November, S_3=15th November and S_4=30th November respectively)

Figure 2. Effect on sowing dates on yield of barley

Effect on cutting managements

The grain yield data showed significant variation due to effect of different cutting treatments (Table 11). The treatment C_0 (no cut) was recorded to have the highest grain yield (3.24 t/ha), whereas the lowest was (2.50 t/ha) from treatment C_3 (cutting at 60 DAS). Broumand *et al.* (2010) stated that grain yield was significantly influenced by forage clipping. The maximum grain yield was related to no clipping of forage and the lowest one was obtained by forage clipping.



[Here, C_0=Uncut, C_1=cutting at 40 DAS, C_2=cutting at 50 DAS and C_3=cutting at 60 DAS]

(LSD $_{0.05}$ = 0.06, 0.11 and 0.22 at uncut,cutting at 40 DAS and cutting at 50DAS)

Figure 3. Effect of cutting managements on yield of barley

Combined effect of varieties, sowing dates and cutting managements

Interaction effect between the varieties, different sowing dates and cutting management was found significant on grain yield at harvest in cereals (Table 12). The highest grain yield (3.35 t/ha) was obtained from the $V_2S_2C_0$ combination (BARI barley 9, sowing at 1st November and no cutting). On the other hand, the lowest grain yield (2.08 t/ha) was obtained from the combination of $V_1S_4C_3$ (BARI barley 8, sowing at 30th November and cutting at 60 DAS).

4.2.6 Straw yield (t/ha.)

Effect of different variety

The straw yield (t/ha) data showed significant variation due to different varieties of barley (Table 11). BARI barley 9 (V_2) was reported to have highest straw yield (4.75 t/ha) whereas the lowest was (4.51 t/ha) observed from BARI barley 8 (V_1). Broumand *et al.* (2010) reported cultivation of different cereals had significant effects on straw yield

Effect of sowing dates

Different sowing dates the straw yield (t/ha) data showed significant variation (Table 11). Sowing date of 1st November (S_2) was reported to have highest straw yield (4.71 t/ha) whereas the lowest was (4.33 t/ha) observed from the sowing date of 30th November (S_4).

Effect of cutting managements

Straw yield data showed significant variation due to effect of different cutting treatments (Table 11). The treatment C_0 (no cut) was recorded to have the highest straw yield (4.70 t/ha), whereas the lowest was (4.30 t/ha) from treatment C_3 (cutting at 60 DAS). Broumand *et al.* (2010) found significant difference between forage clipping and no clipping of forage regarding straw yield. The highest straw yield was related to no clipping of forage and the lowest one was achieved by forage clipping at 40 DAS.

Combined effect of varieties, sowing dates and cutting managements

Interaction effect between the varieties, different sowing dates and cutting management was found significant on straw yield at harvest in cereals (Table 12). The highest grain yield (4.72 t/ha) was obtained from the $V_2S_2C_0$ combination (BARI barley 9, sowing at 1st November and no cutting). On the other hand, the lowest straw yield (4.00 t/ha) was obtained from the combination of $V_1S_4C_3$ (BARI barley 8, sowing at 30th November and cutting at 60 DAS).

4.2.7 Biological yield (t/ha.)

Effect of varieties

The biological yield (t/ha) data showed significant variation due to different selected varieties of barley (Table 11). BARI barley 9 (V_2) was reported to have highest biological yield (7.94 t/ha) whereas the lowest was (7.18 t/ha) observed from BARI barley 8 (V_1)

Effect of sowing dates

For different sowing dates the biological yield (t/ha) data showed significant variation (Table 11). Sowing date of 1st November (S_2) was reported to have highest biological yield (7.94 t/ha) whereas the lowest was (6.89 t/ha) observed from the sowing date of 30th November (S_4).

Effect of cutting managements

Biological yield data showed significant variation due to effect of different cutting treatments (Table 11). The treatment C_0 (no cut) was recorded to have the highest biological yield (7.95 t/ha), whereas the lowest was (6.80 t/ha) from treatment C_3 (cutting at 60 DAS).

Combined effect of varieties, sowing dates and cutting managements

Interaction effect between the varieties, different sowing dates and cutting management was found significant on biological yield at harvest in cereals (Table 12). The highest biological yield (8.07 t/ha) was obtained from the $V_2S_2C_0$ combination (BARI barley 9, sowing at 1st November and no cutting). On the other hand, the lowest biological yield (6.08 t/ha) was obtained from the combination of $V_1S_4C_3$ (BARI barley 8, sowing at 30th November and cutting at 60 DAS).

4.2.8 Harvest Index (%)

Effect of varieties

The harvest index (%) data showed significant variation due to different selected varieties of Barley (Table 11). BARI barley 9 (V_2) was reported to have highest harvest index (0.41 %) whereas the lowest was (0.37 %) observed from BARI barley 8 (V_1).

Effect of sowing dates

For different sowing dates the harvest index data showed significant variation (Table 11). Sowing date of 1st November (S_2) was reported to have highest harvest index (0.41 %) whereas the lowest was (0.36 %) observed from the sowing date of 30th November (S_4).

Effect of different cutting managements

Harvest index data showed significant variation due to effect of different cutting treatments (Table 11). The treatment C_0 (no cut) was recorded to have the highest harvest index (0.41 %), whereas the lowest was (0.35 %) from treatment C_3 (cutting at 60 DAS). The results of this study were supported by the findings of Broumand *et al.* (2010) who reported that harvest index was not significantly influenced by forage clipping. The maximum harvest index was obtained by forage clipping and the minimum one was related to no clipping of forage.

Combined effect of different varieties, sowing dates and cutting management

Interaction effect between the varieties, different sowing dates and cutting management was found significant on harvest index in cereals (Table 12). The highest harvest index (0.42 %) was obtained from the $V_2S_2C_0$ combination (BARI barley 9, sowing at 1st November and no cutting). On the other hand, the lowest harvest index (0.34 %) was obtained from the combination of $V_1S_4C_3$ (BARI barley 8, sowing at 30th November and cutting at 60 DAS).

Table 11. Effect of varieties, sowing dates and cutting management on yield of barley

Treatments	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)
Varieties				
V_1	2.68 b	4.51 b	7.18 b	0.37 b
V_2	3.24 a	4.75 a	7.94 a	0.41 a
LSD (0.05)	1.04	0.47	0.53	0.12
CV%	9.15	9.33	8.90	5.72
Sowing dates				
S_1	2.65 c	4.50 c	7.15 c	0.38 c
S_2	3.25 a	4.71 a	7.94 a	0.41 a
S_3	3.00 b	4.67 b	7.67 b	0.39 b
S_4	2.54 d	4.33 d	6.89 d	0.36 d
LSD (0.05)	0.18	0.29	1.13	0.05
CV%	8.42	8.51	7.93	5.71
Cutting managements				
C_0	3.24 a	4.70 a	7.95 a	0.41 a
C_1	3.01 b	4.67 b	7.68 b	0.39 b
C_2	2.66 c	4.51 c	7.15 c	0.37 c
C_3	2.50 d	4.30 d	6.80 d	0.35 d
LSD (0.05)	0.21	0.24	0.39	0.04
CV%	7.90	7.85	8.13	4.98

[In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability; V_1= BARI barley 8, V_2 = BARI barley 9; S_1=15th October, S_2=1st November, S_3=15th November and S_4=30th November; C_0=Uncut, C_1=cutting at 40 DAS, C_2=cutting at 50 DAS and C_3=cutting at 60 DAS]

Table 12. Combined effect of varieties, sowing dates and cutting management on yields of harvest index of barley

Treatments			Grain yield (t/ha.)	Straw yield (t/ha.)	Biological yield (t/ha.)	Harvest Index (%)
V_1	S_1	C_0	2.95 b	4.50 b	7.45 b	0.40 ab
		C_1	2.71 c	4.20 c	6.91 b	0.39 ab
		C_2	2.33 c	4.10 c	6.43 c	0.36 b
		C_3	2.15	4.03 cd	6.18 c	0.35 bc
	S_2	C_0	2.98 b	4.40 c	7.38 b	0.40 ab
		C_1	2.80 c	4.33 c	7.13 b	0.39 ab
		C_2	2.41 c	4.25 c	6.66 c	0.36 b
		C_3	2.30 c	4.17 c	6.47 c	0.36 b
	S_3	C_0	2.95 b	4.30 c	7.25 b	0.41 ab
		C_1	2.76 c	4.23 c	6.99 b	0.39 ab
		C_2	2.40 c	4.15 c	6.55 c	0.37 b
		C_3	2.28 c	4.10 c	6.38 c	0.36 b
	S_4	C_0	2.79 c	4.15 c	6.94 c	0.40 ab
		C_1	2.67 c	4.14 c	6.81 c	0.39 ab
		C_2	2.30 c	4.10 c	6.40 c	0.36 b
		C_3	2.08 d	4.00 d	6.08 d	0.34 c
V_2	S_1	C_0	3.00 b	4.50 b	7.50 b	0.40 ab
		C_1	2.90 b	4.41 c	7.31 b	0.40 ab
		C_2	2.50 c	4.33 c	6.83 c	0.37 b
		C_3	2.45 c	4.30 c	6.75 c	0.36 b
	S_2	C_0	3.35 a	4.72 a	8.07 a	0.42 a
		C_1	3.02 b	4.67 b	7.69 b	0.39 ab
		C_2	2.67 c	4.55 b	7.22 b	0.37 b
		C_3	2.51 c	4.33 c	6.84 c	0.37 b
	S_3	C_0	3.03 b	4.70 b	7.73 b	0.39 ab
		C_1	3.01 b	4.61 b	7.62 b	0.40 ab
		C_2	2.60 c	4.50 b	7.10 b	0.37 b
		C_3	2.50 c	4.30 c	6.80 c	0.37 b
	S_4	C_0	3.00 b	4.44 b	7.44 b	0.40 ab
		C_1	2.82 c	4.40 c	7.22 b	0.39 ab
		C_2	2.43 c	4.30 c	6.73 c	0.36 b
		C_3	2.31 c	4.21 c	6.52 c	0.35 bc
LSD (5%)			0.23	0.31	0.38	0.04
CV (%)			7.60	7.54	8.54	4.09

[In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability; V_1= BARI barley 8, V_2 = BARI barley 9; S_1=15th October, S_2=1st November, S_3=15th November and S_4=30th November; C_0=Uncut, C_1=cutting at 40 DAS, C_2=cutting at 50 DAS and C_3=cutting at 60 DAS]

4.3 Economic analysis

All the material and non-material input cost like land preparation, barley seed cost organic manure, fertilizers, irrigation and manpower required for all the operation, interest on fixed capital of land (Leased land by loan basis) and miscellaneous cost were considered for calculating the total cost of production from planting seeds to harvesting of barley grain and fodder from cutting managements were calculated for unit plot and converted into cost per hectare (Table 13). Price of barley grain (25 tk/kg) and fodder was considered at market rate. The economic analysis is presented under the following headlines:

4.3.1 Gross income

The combination of varieties, sowing dates and cutting managements showed different gross return among the treatment combinations (Table 13). Gross income was calculated on the basis of sale of grain and fodder from cutting managements. The maximum gross return (1,01,000 tk) was obtained from the $V_2S_3C_2$ combination . On the other hand, the minimum gross return (91300) was obtained from the combination of $V_1S_4C_0$,$V_1S_3C_0$.

4.11.2 Net return

The combination of varieties, sowing dates and cutting managements showed different net return among the treatment combinations (Table 13). The highest net return (58000 tk) was obtained from the $V_2S_2C_2$combination (BARI barley 9, sowing at 1st November and cutting at 50 DAS). On the other hand, the lowest net return (40800) was obtained from the combination of $V_2S_1C_0$ (BARI barley 9, sowing at 30th November and uncut).

Table 13. Economic analysis for different interaction of configuration

Treatments			Cost of cultivation	Gross return	Net return	BCR
V_1	S_1	C_0				
		C_1	44000	94800	50800	2.15
		C_2	46000	100300	54300	2.18
		C_3	48000	93500	41300	1.83
	S_2	C_0	50000	91300	41300	1.83
		C_1	43000	94800	51800	2.20
		C_2	45000	100300	55300	2.23
		C_3	47000	93500	46500	1.99
	S_3	C_0	49000	91300	42300	1.86
		C_1	43500	94800	51300	2.18
		C_2	45500	100300	54800	2.20
		C_3	47500	93500	46000	1.97
	S_4	C_0	49500	91300	41800	1.84
		C_1	44500	94800	50300	2.13
		C_2	46500	100300	53800	2.16
		C_3	48500	93500	45000	1.93
V_2	S_1	C_0	50500	91300	40800	1.81
		C_1	42500	97000	54500	2.28
		C_2	44500	101000	56500	2.27
		C_3	46500	95000	48500	2.04
	S_2	C_0	48500	93000	44500	1.92
		C_1	41700	97000	55300	2.33
		C_2	43000	101000	58000	2.35
		C_3	45000	95000	50000	2.11
	S_3	C_0	47000	93000	46000	1.98
		C_1	42000	97000	55000	2.31
		C_2	44000	101000	57000	2.30
		C_3	46000	95000	49000	2.07
	S_4	C_0	48000	93000	45000	1.94
		C_1	43000	97000	54000	2.26
		C_2	45000	101000	56000	2.24
		C_3	47000	95000	48000	2.02

[In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability; V_1= BARI barley 8, V_2 = BARI barley 9; S_1=15th October, S_2=1st November, S_3=15th November and S_4=30th November; C_0=Uncut, C_1=cutting at 40 DAS, C_2=cutting at 50 DAS and C_3=cutting at 60 DAS; Considering Barley price 25 tk/kg and addition fodder price from cutting managements]

4.11.3 Benefit cost ratio (BCR)

Different BCR among the different treatment combinations of different variety, sowing time and cutting managements was obtained (Table 13). The highest BCR (2.35) was obtained from the $V_2S_2C_2$ combination (BARI barley 9, sowing at 1st November and cutting at 50 DAS). On the other hand, the lowest BCR (1.81) was obtained from the combination of $V_2S_1C_0$ (BARI barley 9, sowing at 15th October and uncut).

CHAPTER 5

SUMMARY AND CONCLUSIONS

The experiment was conducted at Sher-e-Bangla Agricultural University during the period from November, 2021 to March, 2022 for assessing different varieties of Barley in dual purpose influenced by sowing time and cutting management. The experiment considered two Barley variety factor A: BARI barley 8 and BARI barley 9 and comprised of three factors viz. factor B: different sowing times (4), S_1=15th October, S_2=1st November, S_3=15th November and S_4=30th November; factor C: Cutting management (4); C_0=Uncut, C_1=cutting at 40 DAS, C_2=cutting at 50 DAS and C_3=cutting at 60 DAS: . This experiment was laid out in a split plot design with three replications. Data were collected on different aspects of growth, yield attributes and economic contributions.

Across the selected variety, plant height ranged from 36.05 cm to 50.57 cm. BARI Barley 9 (V_2) showed the tallest plant (40.14, 45.33 and 50.57 cm) at 30, 45 and 60 DAS, respectively. On the other hand, at 30, 45 and 60 DAS, BARI Barley 8 (V_1) was recorded to have the shortest plant (36.05, 40.19 and 46.90 cm, respectively). Number of leave ranged 8.05 to 15.67. BARI Barley 9 (V_2) showed the highest leaf (10.14, 12.50 and 15.67) at 30, 45 and 60 DAS, respectively. On the other hand, at 30, 45 and 60 DAS, BARI Barley 8 (V_1) was recorded to have the lowest leaf (8.05, 10.15 and 14.50 respectively), fresh weight ranged from 22.15 to 75.30 g. BARI Barley 9 (V_2) showed the highest weight (28.90, 50.67 and 75.30 g) at 30, 45 and 60 DAS, respectively. On the other hand, at 30, 45 and 60 DAS, BARI Barley 8 (V_1) was recorded to have the lowest weight (22.15, 36.33 and 61.45 g respectively). Dry weight ranged from 3.15 to 40.85 g. BARI Barley 9 (V_2) showed the highest dry weight (3.90, 16.15 and 40.85 g) at 30, 45 and 60 DAS, respectively. On the other hand, at 30, 45 and 60 DAS, BARI Barley 8 (V_1) was recorded to have the lowest dry weight (3.15, 14.00 and 34.50 g respectively).

BARI Barley 9 (V_2) was reported to have maximum number of grains spike^{-1} (45.50), number of unfilled grains spike^{-1} (3.25), highest weight of grains spike^{-1} (2.75 g), highest length of spike (16.90), highest grain yield (3.24 t/ha), highest

straw yield (4.75 t/ha), highest biological yield (7.94 t/ha), highest harvest index (0.41 %) whereas the lowest was (0.37 %) observed from BARI Barley 8 (V_1).
The tallest plant (41.33, 52.70 and 61.75 cm) at 30, 45 and 60 DAS, respectively for the sowing date of 1st November (S_2). At 30, 45 and 60 DAS, sowing date of 30th November (S_4) was recorded to have the shortest plant (35.70, 39.80 and 45.91 cm, respectively). The highest leaf (10.15, 12.40 and 15.30) at 30, 45 and 60 DAS, respectively for the sowing date of 1st November (S_2). At 30, 45 and 60 DAS, sowing date of 30th November (S_4) was recorded to have the lowest leaf (9.50, 10.84 and 11.94), respectively), highest weight (29.10, 51.02 and 76.33 g) at 30, 45 and 60 DAS, respectively for the sowing date of 1st November (S_2). At 30, 45 and 60 DAS, sowing date of 30th November (S_4) was recorded to have the lowest weight (23.15, 39.20 and 68.50 g), respectively), highest dry weight (3.95, 16.25 and 40.75 g) at 30, 45 and 60 DAS, respectively for the sowing date of 1st November (S_3). At 30, 45 and 60 DAS, sowing date of 30th November (S_4) was recorded to have the lowest dry weight (2.89, 10.73 and 29.80 g), respectively).
Sowing date of 1st November (S_2) was reported to have maximum number of grains spike^{-1} (45.67) whereas the minimum was 35.50 grains spike^{-1} (No.) was observed from the sowing date of 30th November (S_4). 1st November (S_2) was reported to have maximum number of unfilled grains spike^{-1} (3.33) whereas the minimum was 2.14 grains spike^{-1} (No.) was observed from the sowing date of 30th November (S_4). Sowing date of 1st November (S_2) was reported to have highest weight of grains spike^{-1} (2.81 g) whereas the minimum was (1.15 g) grains spike^{-1} (No.) was observed from the sowing date of 30th November (S_4). Sowing date of 1st November (S_2) was reported to have highest length of spike (16.95) whereas the lowest was (14.32) observed from the sowing date of 30th November (S_4). Sowing date of 1st November (S_2) was reported to have highest grain yield (3.25 t/ha) whereas the lowest was (2.54 t/ha) observed from the sowing date of 30th November (S_4). Sowing date of 1st November (S_2) was reported to have highest straw yield (4.71 t/ha) whereas the lowest was (4.33 t/ha) observed from the sowing date of 30th November (S_4). Sowing date of 1st November (S_2) was reported to have highest biological yield (7.94 t/ha) whereas the lowest was (6.89 t/ha) observed from the sowing date of 30th November (S_4). Sowing date of 1st November (S_2) was reported

to have highest harvest index (0.41 %) whereas the lowest was (0.36 %) observed from the sowing date of 30th November (S_4).

At 30, 45 and 60 DAS, the tallest plant (41.50, 56.71 and 64.70 cm, respectively) was recorded from the treatment C_0 (no cut). On the other hand, at 30, 45 and 60 DAS, the short stature plant (34.33, 40.50 and 48.50 cm, respectively) was observed in treatment C_3 (Cutting at 60 DAS), the highest leaf no. (10.25, 12.40 and 15.14, respectively) was recorded from the treatment C_0 (no cut). On the other hand, at 30, 45 and 60 DAS, the lowest leaf no. (8.25, 9.55 and 10.75, respectively) was observed in treatment C_3 (Cutting at 60 DAS). At 30, 45 and 60 DAS, the highest weight (28.04, 50.05 and 74.50 g, respectively) was recorded from the treatment C_0 (no cut). On the other hand, at 30, 45 and 60 DAS, the lowest fresh weight (22.10, 39.21 and 62.50 g respectively) was observed in treatment C_3 (Cutting at 60 DAS), highest dry weight (3.75, 15.95 and 40.50 g, respectively) was recorded from the treatment C_0 (no cut). On the other hand, at 30, 45 and 60 DAS, the lowest dry weight (2.80, 10.75 and 28.75 g respectively) was observed in treatment C_3 (Cutting at 60 DAS).

The treatment C_0 (no cut) was recorded to have the maximum number of grains spike^{-1} (44.50), whereas the minimum was 31.33 from treatment C_3 (cutting at 60 DAS). The treatment C_0 (no cut) was recorded to have the maximum number of unfilled grains spike^{-1} (3.30), whereas the minimum was 2.15 from treatment C_3 (cutting at 60 DAS). The treatment C_0 (no cut) was recorded to have the highest weight of grains spike^{-1} (2.80 g), whereas the minimum was (1.10 g) from treatment C_3 (cutting at 60 DAS). The treatment C_0 (no cut) was recorded to have the highest length of spike (16.89), whereas the lowest was (14.33) from treatment C_3 (cutting at 60 DAS). The treatment C_0 (no cut) was recorded to have the highest grain yield (3.24 t/ha), whereas the lowest was (2.50 t/ha) from treatment C_3 (cutting at 60 DAS). The treatment C_0 (no cut) was recorded to have the highest straw yield (4.70 t/ha), whereas the lowest was (4.30 t/ha) from treatment C_3 (cutting at 60 DAS). The treatment C_0 (no cut) was recorded to have the highest biological yield (7.95 t/ha), whereas the lowest was (6.80 t/ha) from treatment C_3 (cutting at 60 DAS). The treatment C_0 (no cut) was recorded to have the highest harvest index (0.41 %), whereas the lowest was (0.35 %) from treatment C_3 (cutting at 60 DAS).

Gross income was calculated on the basis of sale of grain and fodder from cutting managements. The maximum gross return (101000 tk) was obtained from the V2S2C2 combination (BARI Barley 9, sowing at 1st November and cutting at 50 DAS). On the other hand, the minimum gross return (91300) was obtained from the combination of $V_1S_4C_0$ (BARI Barley 8, sowing at 30th November and uncut). The highest net return (58000 tk) was obtained from the $V_2S_2C_2$ combination (BARI barley 9, sowing at 1st November and cutting at 50 DAS). On the other hand, the lowest net return (40800) was obtained from the combination of $V_1S_4C_3$ (BARI Barley 8, sowing at 30th November and cutting at 60 DAS). The highest BCR (2.35) was obtained from the $V_2S_2C_2$ combination (BARI Barley 9, sowing at 1st November and cutting at 50 DAS). On the other hand, the lowest BCR (1.81) was obtained from the combination of $V_1S_4C_0$ (BARI barley 8, sowing at 30th November and uncut). From economic point of view, it was apparent from the above results, the combination of $V_2S_2C_0$ combination (BARI barley 9, sowing at 1st November and no cutting) treatment was more profitable than rest of the treatment combinations even with lower yield but additional economic return from selling the fodder yield.

Conclusion

Fodder production along with dairy cattle rearing is a highly profitable enterprise now a day for many small-scale farm households in Bangladesh to increase their income and to accumulate assets. Farmers are turning towards fodder production from cereal crops as fodder brought high profit to their household income. Fodder and feed scarcity, which is marked in the lean season, is a major factor limiting milk production on small-scale dairy farms in this country. Finding fodder technologies that complement current cropping patterns, practices and needs for feed with acceptable changes in inputs and risks are keys to satisfying the aspirations of many resource-poor Bangladeshis. From the above result it was revealed that, Among with others growth and yield contributing parameters, highest grain yield (3.35 t/ha) was obtained from the $V_2S_2C_2$ combination (BARI Barley 9, sowing at 1st November and cutting at 50 DAS). On the other hand, the lowest grain yield (2.08

t/ha) was obtained from the combination of $V_1S_4C_3$ (BARI barley 8, sowing at 30th November and cutting at 60 DAS).

Recommendation

Considering the results of the present experiment, further studies in the following areas are suggested:

1. More minor cereal crops may be used with different number of cutting management for getting minor cereal crop specific cutting frequency recommendation.
2. Studies of similar nature could be carried out in different agro-ecological zones (AEZ) of Bangladesh for the evaluation of zonal adaptability.

CHAPTER VI

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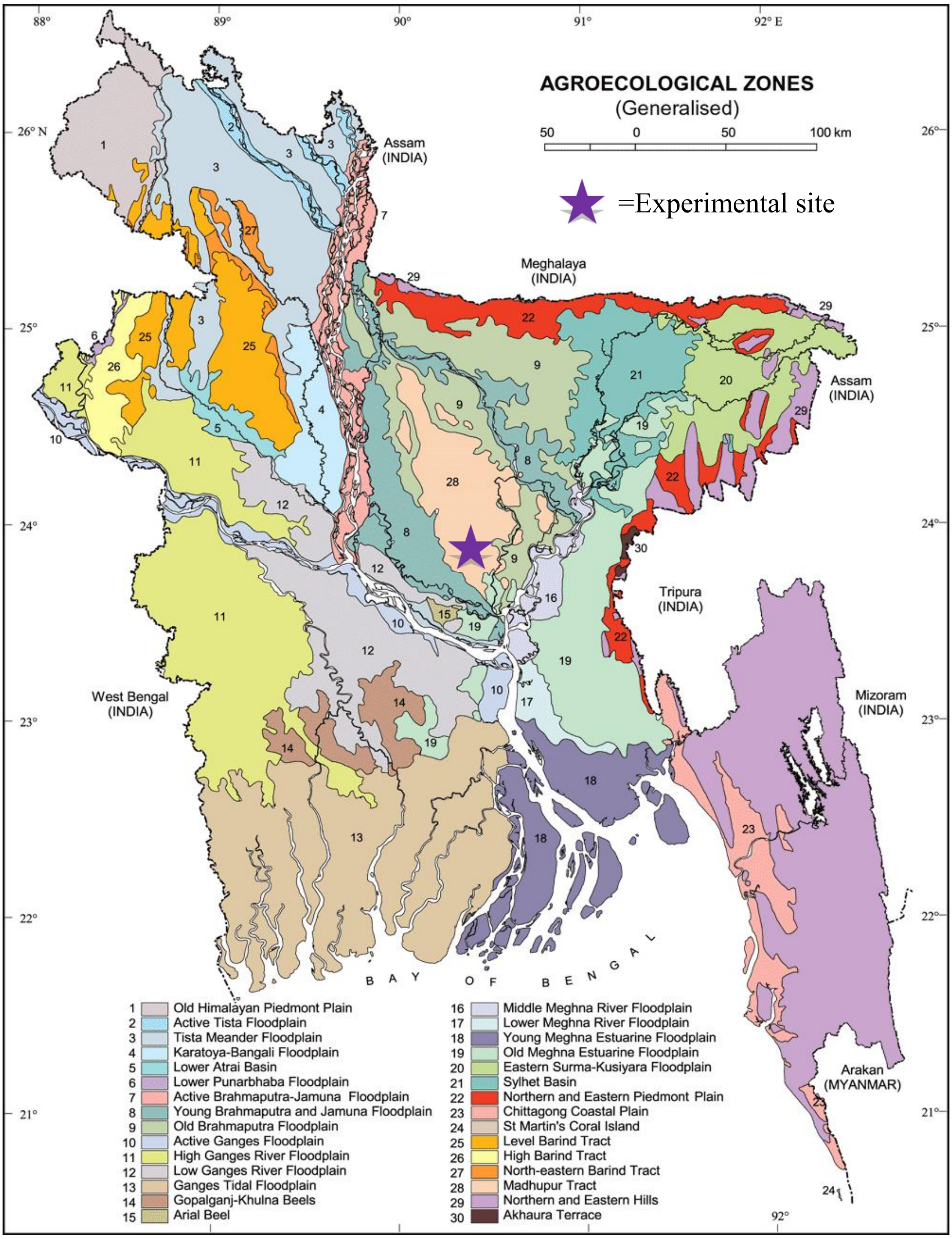
APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Monthly meteorological information during the period from November, 2021 to April, 2022

Year	Month	Air temperature (^0C)		Relative humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2021	November	28.10	11.83	58.18	47.00
	December	25.00	9.46	69.53	00.00
2022	January	25.20	12.80	69.00	00.00
	February	27.30	16.90	66.00	39.00
	March	31.70	19.20	57.00	23.00
	April	33.50	25.90	64.50	119.00

Meterological Centre, Agargaon, Dhaka (Climate Division)

Appendix III. Characteristics of soil of experimental site.

A. Morphological characteristics of the experimental site

Morphological features	**Characteristics**
Location	Sher-e-Bangla Agricultural University Agronomy research field, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly levelled

B. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

Physical characteristics	
Constituents	Percent
Sand	26
Silt	45
Clay	29
Textural class	Silty clay
Chemical characteristics	
Soil characters	Value
pH	5.9
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.03
Available P (ppm)	20.54

Exchangeable K (me/100 g soil)	0.10

Source:SRDI,Bangladesh.