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AGRONOMIC EVALUATION OF DUAL PURPOSE BARLEY VARIETIES UNDER DIFFERENT CUTTING MANAGEMENT SYSTEM

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SUMMARY

A field experiment was conducted at the Research Farm, Department of Agronomy, College of Agriculture, CCS HAU, Hisar (Haryana), India during *Rabi,* 2018-19. The experiment was laid out in a split-plot design in three replicates, keeping cutting management (No cut, cut at 56 DAS, cut at 68 DAS) in main plot and varieties (BH 393, BH 946, RD 2552 and RD 2715) in sub-plot. Highest plant height (64.8 cm and 79.6 cm) and green fodder yield (17.40 t/ha and 23.21 t/ha) were recorded with the variety RD 2552 and RD 2715 at 56 DAS and 68 DAS, respectively. Lowest canopy temperature was also recorded with RD 2715 at both the stages. The results also showed that highest grain and straw yield of 5.05 t/ha and 9.30 t/ha, respectively was produced in no cut treatment. Yield attributes *viz.* Effective tillers/m^2, test weight and no. of grains per ear-head were also found maximum in no cut treatment. Among the varieties, RD 2552 recorded with highest grain and straw yield (3.01 t/ha and 5.80 t/ha). Significantly highest effective tillers/m^2 of 318.2 was also found with RD 2552. Canopy temperature was significantly lower in the variety RD 2552, however, maximum value of NDVI and SPAD were recorded in RD 2552 and RD 2715. However, highest no. of grains per earhead was recorded with BH 393(49.3). Highest B:C was observed with the no cut treatment (2.18) and in the variety RD 2552 (1.61). Delay in cutting for green fodder decreased the regenerating capacity and consequently the grain yield of barley for dual purpose. The varieties *viz.* RD 2552 and RD 2715 out yielded than the BH 393 and BH 946, which are commonly used for feed purpose in north-western plain zone of the country. Although no-cut is more economical but in fodder scarcity conditions, RD 2552 and RD 2715 varieties of barley may be recommended as dual purpose.

Key words : Barley, cutting management, grain and straw yield, NDVI and varieties

India supports nearly 536.76 million livestock population with 36% cattle and 20.4% buffaloas. But at the same time country is facing shortage of green fodder, dry crop residues and concentrate feed ingredients to the tune of 35.6, 11.0 and 44.0 per cent, respectively (IGFRI VISION, 2050).The green fodder shortages during late winters and early spring are major limiting factors of livestock production in many countries including India (Afshar *et al*., 2014). Furthermore, In India majority farmers comes under small and marginal categories with rearing large number of livestock and they are unable to spare their land solely for fodder production. Barley is a one of important *rabi* season cereal crop and its cutting provides a reasonable quantity of quality green fodder during lean period in many countries (Singh *et al*., 2017). In India it is grown in 690 thousand hectare area with 1750 thousand tons production and 2.88t/ha average productivity (Anonymous, 2019). The major barley growing states in India are Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh and Punjab. Looking to its fast, rigorous growth and high potential of biomass, there has been an increasing interest in exploiting barley as a dual purpose (fodder and grain) crop (Singh *et al*., 2017). Under favourable environmental conditions and good agronomic management practices, dual purpose barley can give good fodder and grain yields due to lower risk of lodging incidence, rapid crop growth rate and fast recovery (Pal *et al*., 2009). The economic advantages of dual purpose barley compared with grain only barley have been reported by many researchers in different agro-climatic conditions in different countries (Decker *et al*., 2009; Rawat, 2011 and Kaur *et al*., 2009). The dual-purpose system would be profitable only if the green fodder production obtained can compensate the grain yield penalty at the final harvest. Various factors *viz.,* variety, sowing time, seed rate, fertilization, irrigation and cutting management etc. are affect the yield potential of dual purpose barley.

The objective of getting higher fodder yield from barley with minimum reduction in grain yield could only be achieved *via* varietal selection and enhancing early vegetative growth by optimizing crop management practices. Selection of a variety adaptable for any particular area, particularly for dual purpose, is one of the most inevitable factors to get the maximum production because different varieties perform differently and their regeneration capacity is different for diverse environmental conditions (Rawat, 2011). Cutting schedule can also play important role in realizing higher green fodder as well as grain yield. Considering the above facts and paucity of research findings on these aspects, the present study was carried out to evaluate the comparative performance of barley cultivars for dual-purpose under different cutting schedule in sandy loam soils of semi-arid conditions.

MATERIALS AND METHODS

Experimental Site : A field experiment was conducted during 2018-19 at the Research Farm (29.15 N and 75.72 E and 216 m amsl) of Department of Agronomy, College of Agriculture CCS HAU, Hisar (Haryana), India. The location is characterized as semiarid, with an average annual precipitation of 400 mm. The mean weekly meteorological data recorded during the crop season is presented in Fig. 1. The soil of experimental field was alkaline, sandy loam in texture (60.90% sand, 21.50% silt and 17.60% clay), with a pH of 8.1 and electrical conductivity of 0.29 dS/m.The plough layersoil contained 0.35% organic carbon (low), 131 kg/ha available N (low), 15 kg/ha available P (medium), and 272 kg/ha available K (medium) (Table 1).

TABLE 1
Initial physico-chemical properties of soil (0-15 cm depth) at the experimental site

Parameter	Value
Sand (%)	60.90
Silt (%)	21.50
Clay (%)	17.60
Texture	Sandy loam
pH (1:2.5, soil: water suspension) at 25 C	8.1
EC (1:2.5, soil: water suspension) dSm-1 at 25°C	0.29
Organic carbon (%)	0.35
Available nitrogen (kg ha-1)	131.0
Available phosphorus (kg ha-1)	15.0
Available potassium (kg ha-1)	272.0

Experimental Design : The influences of cutting management and varieties on forage and grain yield of barley in grain-only and dual-purpose systems (one cut forage removal) were investigated. The experiment was laid out in a split-plot design consisting of three main plots (cutting management-No cut, cut at 56 DAS, cut at 68 DAS) and four subplots (varieties-BH 393, BH 946, RD 2552 and RD 2715) and replicated thrice. All cultivars are six-rowed feeding cultivars and are commonly cultivated in the Haryana and Rajasthan region.

Agronomic management : Seedbed was prepared by doing primary and secondary tillage practices to a depth of 20–25 cm. Individual net plot size was 8.00 m × 2.02 m. The experiment was sown on 22 November 2018 at a soil depth of approximately 5.0 cm with 22.5 cm row spacing using a hand plough. Based on soil test values, 60 kg N and 30 kg P_2O_5/ha were applied through urea and DAP. Nitrogen fertilizer (urea) was top-dressed in two equal splits in no cut

TABLE 1
Effect of cutting management on yield of different barley varieties

Cutting schedule	Grain yield (t/ha)	Biological yield (t/ha)	Straw yield (t/ha)	Plant height (cm)	Effective tillers/ m^2	Test weight (g)	No. of grains/ earhead	Canopy temp. (°C)	NDVI	SPAD meter value
No cut	5.05^a	14.35^a	9.30^a	106.3^a	345.5^a	49.74^a	52.4^a	25.8*	0.36^b	25.9^b
Cut at 56 DAS	2.08^b	5.92^b	3.84^b	70.1^b	258.9^b	41.95^b	45.5^b	25.5*	0.49^a	27.5^{ab}
Cut at 68 DAS	1.29^c	3.67^c	2.38^c	58.4^c	231.4^c	38.97^c	40.5^c	25.5*	0.49^a	31.1^a
Varieties										
BH 393	2.75^b	7.06^c	4.31^b	69.2^d	272.3^b	43.14^{ab}	49.3^a	25.8^a	0.42^b	23.6^c
BH 946	2.64^b	7.81^b	5.16^a	80.0^b	268.2^b	43.56^{ab}	47.6^{ab}	26.3^a	0.42^b	27.1^b
RD 2715	2.83^{ab}	8.24^{ab}	5.41^a	88.6^a	255.8^b	45.54^a	45.4^{bc}	25.5^{ab}	0.46^a	31.6^a
RD 2552	3.01^a	8.82^a	5.80^a	75.4^c	318.2^a	41.98^b	42.2^c	24.9^b	0.49^a	30.5^a

(*non-significant).

treatment: at the time of sowing and after first irrigation, but in cutting treatments, urea was top-dressed in three equal splits *i.e.* at the time of sowing, after first irrigation and after forage removal. Whole quantity of P was given at the time of sowing. Irrigation was scheduled at 30-35 DAS and 80-85 DAS in un-cut treatments, whereas in cut-treatments, three irrigations were given *i.e.* at 30-35 DAS, after cut and at panicle initiation stage.

Measurements of physiological, growth and yield parameters

To determine crude protein content, first N content was estimated through Kjeldahl method and then multiplied by 5.83 (AOAC, 1995). In the no-cut system, plants were harvested on 5April, 2019 (134 days after sowing); whereas, in dual purpose system, harvesting was done on 10April, 2019 (139 days after sowing). Biological yield (grain + straw weight) and grain yield (adjusted to 13% moisture content) was determined and based upon both the yields, harvest index was calculated. Canopy temperature (CT) was recorded at 0.5 m from the edge of the plot and 0.5 m above the canopy with an approximately 30-60 °C from the horizontal by using hand held infrared thermometer (model AG-42, Tele temp crop Fullerton) . The canopy temperature (CT) was measured between 12:00 to 14:00 hour on the bright sunny day with clear sky. Normalized difference vegetation index (NDVI) measurements were taken between 12:00 to 14:00 hour on sunny days by passing the Greenseeker (model 505, NTech Industries, Inc., Ukiah, CA, USA) over the plots at a height of 50 cm. sensor. For chlorophyll estimation, SPAD meter values were recorded by using portable chlorophyll meter(model SPAD-502) at 120 DAS. CT and NDVI reading were recorded at the time of cutting and at 120 DAS. The financial analysis of the grain-only (no-cut) and dual-purpose systems were carried out based on cost of cultivation and prevailing market price of produce (Rs. 1440, 300 and 150 for grain, dry fodder and green fodder (t/ha), respectively).

Statistical analysis

Multiple linear regression analysis was used to determine the relationship of grain yield with the yield contributing characters. The function takes the following equation:

$$Y = a + bX_1 + cX_2 + dX_3 + eX_4$$

Where, Y is the predicted grain yield (q/ha), a is the intercept point, b, c, d and e are regression coefficients associated with different yield attribute *viz*., number of effective tillers, test weight and no. of grains per earhead. Significant differences ($p<0.05$) among means of experimental results were evaluated by ANOVA and means were compared by DUNCAN'S test. Correlation among various parameters was done by using SPSS.

RESULTS AND DISCUSSION

The analysis of growth and yield attributes *viz*. plant height, effective tillers, test weight, no. of grains per earhead of barley showed significant

TABLE 2
Green fodder yield and other parameters at first cutting in dual purpose systems

Cutting schedule and variety	Plant height (cm)	Number of tillers/m^2	Green fodder yield (t/ha)	NDVI	Crude protein content in fodder (%)
Cut at 56 DAS					
BH 393	58.3	305.0	13.91	0.72	8.8
BH 946	50.9	309.7	16.02	0.73	8.6
RD 2715	64.8	292.3	17.40	0.75	8.5
RD 2552	48.8	331.0	15.95	0.74	9.2
Cut at 68 DAS					
BH 393	73.3	305.3	21.39	0.74	7.6
BH 946	64.3	314.7	20.48	0.73	7.4
RD 2715	79.6	295.0	23.21	0.77	7.5
RD 2552	64.1	334.0	22.30	0.79	8.2
SEm±	2.8	11.4	1.28	0.02	0.23
CD (P=0.05)	8.2	N.S.	3.80	N.S.	0.67

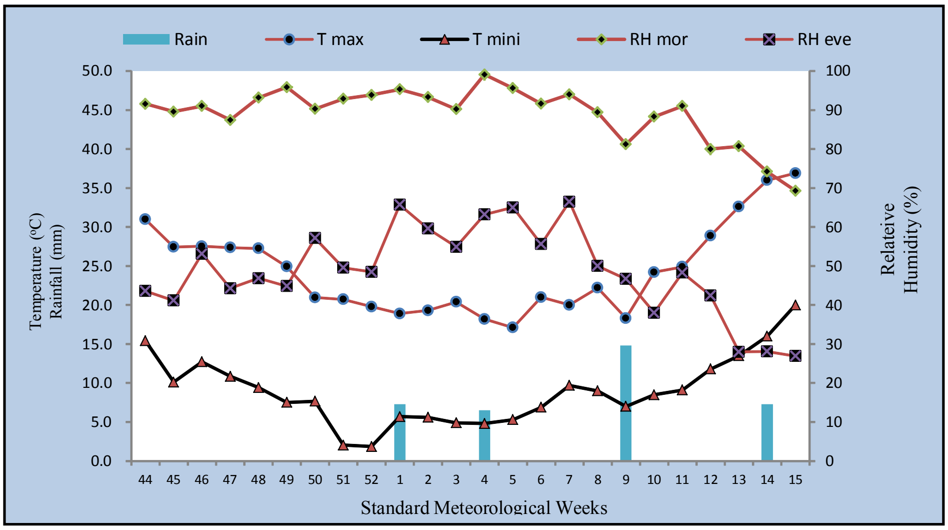

Fig. 1. Mean weekly weather data during rabi season of 2018-19.

difference among the different cutting schedules (Table 1). The no-cut (grain-only) treatment provided significantly higher value of all the yield attributes compared to other treatments. The no-cut treatment produced 345.5 effective tillers m^{-2}, which increased by33.4 and 49.3 in number as compared to cutting at 56 and 68 DAS, respectively. Similarly, No-cut provided significantly higher test weight (49.74g) than other treatments, which increased by 7.79 and 10.77 g compared to cutting at 56 DAS and 68 DAS, respectively. Grain growth occurs only after anthesis period and is depends on the rate and period of grain filling (Dibakar *et al.*, 2018). The lower grain weight with cutting schedules might be due to the higher temperature during grain filling period, which perhaps reduced the rate of grain filling and its duration. Whereas, in no-cut treatment, the crop had the

TABLE 3
Effect of cutting management and varieties on economic returns

Cutting schedule	Cost of production (Rs. x 000)	Gross returns (Rs. x 000)	Net returns (Rs. x 000)	B:C
No cut	46.1	100.648^{a}	54.55^{a}	2.18^{a}
Cut at 56 DAS	52.5	65.194^{b}	12.69^{b}	1.24^{b}
Cut at 68 DAS	52.5	58.479^{c}	5.98^{c}	1.11^{c}
Varieties				
BH 393	50.37	70.178^{b}	19.81^{b}	1.42^{b}
BH 946	50.37	71.773^{b}	21.41^{b}	1.45^{b}
RD 2715	50.37	77.243^{a}	26.88^{a}	1.56^{a}
RD 2552	50.37	79.900^{a}	29.53^{a}	1.61^{a}

favourable conditions and sufficient time span before heading to attain the maximum height, leaf area and assimilate more stem reserves which have had carry over effect on grain weight and numbers, which have been reflected in yield attributes. Brief exposure to high temperature of plants during grain filling may enhance senescence; reduce grain weight and ultimately the yield (Wahid *et al.*, 2007). The no-cut treatment recorded maximum grain yield of 5.05 t/ha, which was 142 and 291% higher over cutting scheduled at 56 and 68 DAS, respectively. The higher value of yield attributes resulted in higher yield. The delayed sowing might have been the reason for shortening of life cycle in cutting treatments, which resulted in shortening of days taken to heading and forced maturity due to the steep rise in temperature started during 11thstandard week and produced very less grain yield. Ram and Gupta (2016) reported 3-4% decrease in yield for 1°C rise in aerial temperature above 25°C during grain growth period. The grain yield decreased when the stage of 1st cut was delayed because in dual purpose crop, regeneration potential is determined by the stage of 1st cut. It is important to determine the right stage of harvesting to obtain the higher green fodder as well as grain yield from the crop (Singh *et al.*, 2017). Similar findings were also reported by Kharub *et al.* (2013). Cutting treatments had no significant effect on canopy temperature; whereas, maximum value of NDVI (0.49) and SPAD (31.1) were recorded with the cutting at 68 DAS treatment, which were significantly higher over no-cut, however, on a par with cut at 56 DAS treatment. These noticeable differences in NDVI and SPAD might have attributed to the fact that the crop was green and accumulating photosynthates till then in the cutting treatments.

The plant height, no. of effective tiller, test weight and number of grains per earhead were varied significantly among the varieties (RD 2715, RD 2552, RD 2715 and BH 393). This could be due to the combined effect of genotypic characters of the varieties and better adaptation in the prevailed environmental conditions. Significantly highest grain and straw yields of 3.01 and 5.80 t/ha were recorded under RD 2552, which were on a par with RD 2715 (2.83 t/ha and 5.41 t/ha). The maximum yield with the variety RD 2552 might be due to maximum no. effective tillers/m^2 and low canopy temperature, which kept the canopy cooler, that could have helped to avoid the heat stress during grain filling period. Similar results were also reported by Nirmala *et al*. (2016).The maximum plant height of 88.6 cm was recorded with the variety RD 2715, which was statistically superior over other varieties. Variety RD 2552 put forth significantly highest number of effective tillers m^{-2} *i.e*. 318.2, whereas recorded lowest test weight of 41.98 g. The response of varieties to the cutting schedules is depicted in Fig. 2 & 3 in terms of different physiological parameters *viz*. CT, NDVI and SPAD. It could be revealed from the data that the canopy temperature was significantly lower in the variety RD 2552 *i.e*. 24.9 °C, which was closely followed by the temperature recorded in the variety RD 2715. Conversely, maximum values of NDVI and SPAD were recorded in RD 2552 and RD 2715, respectively, which were found significantly higher as compared to BH 393 and BH 946. This reflects that the relationship of canopy temperature and NDVI & SPAD is negatively correlated and the former two varieties could have attained more leaf area index and photosynthates that had transported in greater amount towards the sink during their grain filling stage.

Perusal of the data from Table 2 revealed that maximum plant height and green fodder yield were recorded in RD 2715 at both the stages with the value of 64.8 and 79.6 and 17.4 and 2.32 t/ha, respectively, whereas maximum number of tillers/m^2 were observed with the variety RD 2552 (331 and 334 at 56 and 68 DAS, respectively). Nirmala *et al*. (2016) also reported maximum green fodder yield with the variety RD 2715 under dual purpose system. The increase in green fodder yield is summation of growth contributing factors controlled by both genetically and agronomical manipulations. Fodder yield maximization seems to be on account of overall growth as reflected from taller plant, higher number of tillers and dry matter accumulation as well as nitrogen and phosphorous uptake by green fodder. Kapoor *et al*. (2010) also reported that RD2715 was superior in terms of plant height compare to RD2552. Sharma (2009) reported that variety RD 2715 recorded maximum green fodder yield of 22.9 t/ha, which was statistically at par with RD 2552. NDVI was found maximum with RD 2552 and RD 2715. This seems that these varieties have more vegetation, photosynthetic activity and hence yielded more green fodder. Crude protein was recorded highest in variety, RD 2552 at both the stages. It was also revealed that RD 2552 recorded 31.35%, 39.9% and 6.76% increase in plant height, green fodder yield and NDVI, respectively in 12 days interval as compared to other varieties, which reveals that the variety had the maximum growth rate, whereas minimum reduction in crude protein was also recorded with this variety.

Among the cutting schedules, cost of production was Rs. 52500 in cutting treatments in comparison with no-cut treatment (Rs. 46100/ha) which was Rs. 6400 more due to the labour charges in cutting treatments (Table 3). Maximum gross returns were observed with no cut treatment with the value of Rs. 100648, which was Rs. 35454 and 42169 higher when compared with cutting treatments at 56 and 68 DAS, respectively. Maximum net returns of

TABLE 4

Interaction of barley varieties at different cutting schedulesin terms of B:C

	BH 393	BH 946	RD 2715	RD 2552	Mean (cutting schedules)
No cut	2.09	2.13	2.21	2.30	2.18
Cut at 56 DAS	1.10	1.20	1.34	1.33	1.24
Cut at 68 DAS	1.07	1.04	1.14	1.21	1.11
Mean (varieties)	1.42	1.46	1.56	1.61	

Note: CD (P=0.05) of cutting schedules and varieties were 0.11 and 0.09, respectively. However, the interaction of factor A and B was non-significant.

TABLE 5
Correlation between yield and yield attributes

	Grain yield	Plant height	Effective tiller/m²	Test weight	No. of grains/ earhead
Grain yield	1.000	0.922**	0.904**	0.933**	0.775*
Plant height		1.000	0.725	0.973**	0.713
Effective tillers/mrl			1.000	0.697	0.541
Test weight				1.000	0.838*
No. of grains per earhead					1.000

** p<0.01 and *p<0.05.

Rs. 54548 were also obtained in no cut treatment. Maximum returns in no cut treatment were due to the production of maximum grain yield. The no cut treatment also fetched maximum B:C (2.18). Gill *et al*. (2017) also recorded that the cutting of barley for fodder at 45 DAS gave higher net returns (Rs. 24284 ha^{-1}) than the forage cut at 60 DAS and uncut crop. Among the varieties, maximum gross as well as net returns were observed with the RD 2552 variety with the value of Rs.79900 and 29534, respectively, followed by variety RD 2715. Sharma (2009) also compared the performance of different barley varieties and reported that the gross returns received from green fodder, grain and straw yields were maximum in RD 2715. The variety RD 2552 and RD 2715 were found suitable and seems to be promising for the cultivation as dual purpose crop. The Performance of barley varieties at different cutting schedules is depicted in Table 4.

The data pertaining to correlation of yield with yield attributes (Table 5) indicate the plant height (r=0.922**, **significant at 1% level), effective tillers/m² (r = 0.904**, **significant at 1% level), test weight (r = 0.933**), and number of grains/earhead (r = 0.775*, *significant at 5% level) were highly significant and positively correlated with grain yield. The correlation of grain yield in cutting schedules and varieties were separately tested with physiological parameters like CT and NDVI was found that in cutting schedules yield was positively correlated with CT (r=0.980) and negatively correlated with NDVI (r=-0.980). This might be due to the high canopy temperature in no cut treatment because crop has dried and attained its physiological maturity till then, whereas in no cut treatments crop plants were green and had enough photosynthetic area for accumulating photosynthates and keeping its canopy cooler in comparison with no cut treatment. Among the varieties, yield have negative correlation with CT (r=-0.996, significant at 1% level) and positive with NDVI (r=0.946) because the NDVI is the indicator of greenness, which keeps the canopy temperature lower.

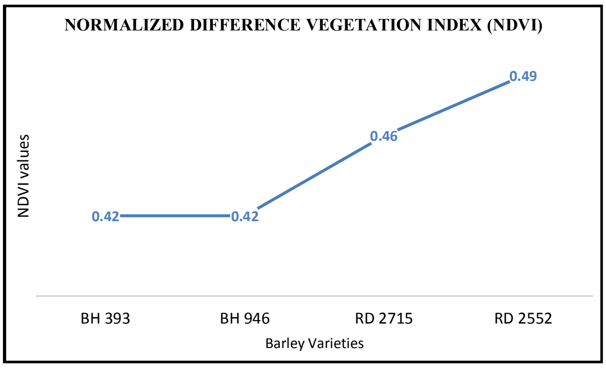

Fig. 2. NDVI values of different barley varieties at 120 DAS.

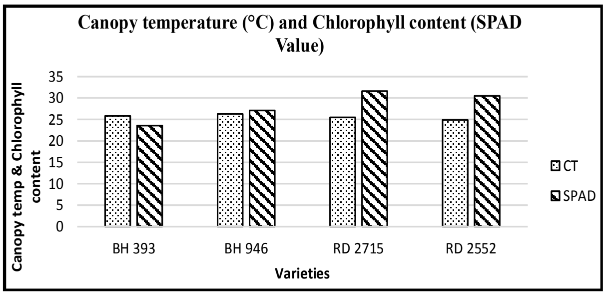

Fig. 3. Canopy temperature (°C) and chlorophyll content (SPAD meter values) of different barley varieties at 120 DAS.

The results of regression analysis depicted that 99.7% of the variation in the grain yield had been explained by the independent variables in the model. The equation developed from regression analysis is as follows:

$$GY= -119.45-.177X_1+.601X_2^*+2.824X_3-.075X_4$$

where,GY=Grain yield (q/ha)

X_1 = Plant height
X_2 = Effective tillers/m²
X_3 = Test weight
X_4 = No. of grains per earhead

According to the results, F value was found significant at <.01% level of significance, which showed that grain yield could be well estimated from the model using the above mentioned parameters.

CONCLUSION

Based on the results, It was concluded that under arid and semi-arid region, for fetching maximum B:C, no-cut (grain only) treatment was highly suitable as maximum grain yield was recorded in no-cut treatment which ultimately resulted in higher economic returns. Among the varieties, RD 2552 and RD 2715 are highly suitable to realise maximum grain yield and B:C.In areas where availability of fodder is highly critical, the barley varieties *viz*. RD 2715 and RD 2552 can be taken for dual purpose to fulfil the demand for the green fodder in comparison with other two varieties. In dual purpose condition, maximum B: C ratio (1.34) was fetched in RD 2715 with one cut at 56 DAS and subsequent cut for grain purpose.

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