Indian Journal of Agronomy **69** (1): 65–70 (March 2024)
DOI: 10.59797/ija.v69i1.5484

Research Paper

Dual purpose barley (*Hordeum vulgare*) for better remunerations through higher fodder and grain production under different cutting schedules

NEELAM[1], SURESH KUMAR[2], SATPAL[3], V.S. HOODA[4] AND SHWETA[5]

Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana 125 004

Received: December 2023; Revised accepted: March 2024

ABSTRACT

A field experiment was conducted during the winter (*rabi*) seasons of 2019–20 and 2020–21 at the research farm of Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana to evaluate the dual purpose barley for higher remunerations through increased production of fodder and grain under different cutting schedules. The experiment was conducted in a split-plot design with 5 fodder cutting management practices, viz. No fodder cut; Fodder cutting at 50–60 DAS (days after sowing) above 5 cm cutting height; Fodder cutting at 50–60 DAS above 10 cm cutting height; Fodder cutting at 60–70 DAS above 5 cm cutting height; Fodder cutting at 60–70 DAS above 10 cm cutting height in main plot and 4 dual purpose barley varieties, viz. 'BH 393', 'BH 946', 'RD 2552' and 'RD 2715' under sub-plots, replicated thrice. On the mean basis of 2 years experiment, maximum plant height, tillers/m^2 and GFY (green fodder yield) were recorded with fodder cutting at 60–70 DAS irrespective of their cutting heights. Maximum GFY of 8.19 t/ha was found in variety 'RD 2715'. At grain harvest, maximum effective tillers/m^2 (415.2), no. of grains/ear-head (48.11), grain yield (4.82 t/ha) and straw yield (7.43 t/ha) were recorded in fodder cut at 50–60 DAS above 10 cm height. Among the varieties, 'BH 946' exhibited maximum effective tillers/m^2 (416), test weight (45.51 g), grain yield (5.25 t/ha) and straw yield (7.62 t/ha). Highest benefit cost (B:C) ratio was fetched with the grain production after taking fodder cut at 50–60 DAS above 10 cm height (2.36) and barley variety 'BH 946' (2.61) among the tested dual-purpose barley varieties.

***Key words*:** Barley, Dual-purpose, Economics, NDVI, Yield

India's livestock wealth is enormous with nearly 535.78 million (DAHD, 2019) and more than 70% population is dependent on agriculture and animal husbandry sector for earning. It also generates employment for about 18.8% of Indian population. Country's livestock sector contributes 4.11% to the GDP and 25.6% to total Agriculture GDP (GoI, 2021), but there is net deficit of 11.24, 23.40 and 29.0% green fodder, dry fodder and concentrate feed material, respectively (Roy *et al*., 2021). Therefore, the supply of green forage must rise @1.69% per annum to meet the requirement. India is leader in world milk production (GoI, 2022) although the animal productivity is 1538 kg/year which is low as compared to world average (2238 kg/year) might be owing to malnutrition or deficit of feed/fodder (Vijay *et al*., 2018; Prajapati *et al*. 2019). During the late winters and early spring, the shortage of green fodder is the major limiting factor of livestock production worldwide (Afshar *et al*., 2014) and in the absence of green fodder, farmers become dependent on straw. Furthermore, increased pressure of food production on land for the increasing human population leaves a small proportion of available land for further forage cultivation. As a result, livestock mainly depends on crop residues which are low in nutritional quality and crude protein. The demand of dairy products also increased in recent years due to urbanization and burgeoning population which ultimately requires warranted research on better utilization of crop residues and enhancing quality of diet for livestock in India to increase the milk production.

Barley (*Hordeum vulgare* L.) is one of the important *rabi* season crop grown for grain, however, harvested during vegetative stage for green forage particularly, in dry region of south Asia. Its cutting for fodder provides a good quality green fodder, having high content of crude protein and *in vitro* dry-matter digestibility (IVDMD) in lean period in many countries. In India, it is cultivated in the area of 690 thousand hectares with production and productivity of 1750 thousand tonnes and 2.88 t/ha, respectively (DAHD, 2019). It is fast growing and have high potential of biomass production, so the interest has now been

[1]**Corresponding author's Email:** berkesia.neelam@gmail.com
[1]Assistant Professor (Agronomy), [3,4,5]Assistant Scientist (Agronomy), [2]Joint Director, Directorate of Research, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana 125 004

increased in exploiting the barley for dual purpose (Singh *et al*., 2017). There are many constraints associated with fodder production like low price, insect-pests and poor quality seed (Singh *et al*., 2021). Under good agronomic management practices and favourable agro-climatic conditions dual purpose barley crop can produce high quality green fodder and grains (Pal and Kumar, 2009). The higher green fodder and grain yield could be achieved by the selection of suitable variety and augmenting initial vegetative growth by the agronomic management of monetary and non-monetary resources. The most inevitable factor, particularly for dual purpose is the selection of an adaptable variety for a particular area because the varieties perform differently under varied climate and their regeneration capacity also affected by this (Rawat, 2011). Cutting management i.e. days to cutting and cutting height can be an important factors affecting the overall yield (Neelam *et al*., 2022). Considering the paucity of research findings on the above, the present work was planned to evaluate the dual purpose barley for better remunerations through higher fodder and grain production under different cutting schedules.

MATERIALS AND METHODS

A field experiment was conducted during the winter (*rabi*) seasons of 2019–20 and 2020–21 at the Research Farm of Chaudhary Charan Singh Haryana Agricultural University, Hisar (29°15′ N and 75°72′ E and 216 m amsl) Haryana. Study area is characterized as semi-arid, with an average annual rainfall of 400 mm. The soil of the experimental field was sandy loam in, alkaline in reaction (*p*H 8.1), low in organic carbon (0.35%) and available nitrogen (131 kg/ha), medium in available phosphorous (15 kg/ha), and potassium (272 kg/ha). The total rainfall received during the crop period was 133.8 mm and 728.3 mm in 2019–20 and 2020–21, respectively. The minimum and maximum temperature varied from 2.4 to 35.1°C and 2.6 to 37.2°C during 1st and 2nd year of the experiment, respectively. The experiment was conducted in a split-plot design with 5 fodder cutting management practices, viz. No fodder cut; Fodder cutting at 50–60 DAS (days after sowing) above 5 cm cutting height; Fodder cutting at 50–60 DAS above 10 cm cutting height; Fodder cutting at 60–70 DAS above 5 cm cutting height; Fodder cutting at 60–70 DAS above 10 cm cutting height in main plot and 4 dual purpose barley varieties, viz. 'BH 393' and 'BH 946' (grain only); 'RD 2552' and 'RD 2715' (dual purpose) under sub-plots, replicated thrice. The crop was sown on 30th October and 1st November, in 2020 and 2021, respectively with 22.5 cm row spacing and a hand plough. Recommended dose of fertilizer i.e. 60 kg N and 30 kg P_2O_5/ha were applied through urea and diammonium phosphate (DAP) (sowing). In no fodder cut treatment, nitrogen fertilizer (urea) was applied as per the Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana package and practices, but in cutting treatments, it was applied in 3 equal splits i.e. at sowing; after 1st irrigation; and after green fodder cutting. Irrigation was applied at the critical stages as per the requirement. Height of 5 randomly selected plants was measured at harvest with the help of wooden scale from the base to the top of the ear head. The effective tillers were counted in 5 selected rows in each plot and then averaged. From the spikes, the grains were separated from spikelet and the number of grains was counted and the grains per spikes were calculated. The canopy temperature (CT) and Normalized difference vegetation (NDVI) were measured between 12:00 to 14:00 hours on the bright days with clear sky at green fodder cutting (according to the cutting schedules) and at 120 DAS.

In no fodder cut system, the crop was harvested only once, i.e. only for grain, but in dual cut system two cuts were taken i.e. first cut for fodder purpose and second cut for grain. The crop was harvested on 1st and 3rd April in no fodder cut system during 1st and 2nd year, respectively. But in dual cut system, the 1st harvesting for green fodder was done after 58 and 68 DAS in both the years and subsequently 2nd harvesting for grain was done on 6th and 10th April in 2020 and 2021, respectively. After threshing with the help of mini plot thresher the grain yield was measured for each net plot area. Straw yield (t/ha) was calculated by subtracting grain yield from biological yield for each of net plot area. Then both were converted into tonnes per hectare (t/ha). The economic analysis of no-cut and dual-purpose systems was carried on the basis of cost of cultivation and prevailing market price of green fodder, grains and straw. The treatments were evaluated by ANOVA and means were compared by OPSTAT software. Linear regression analysis was utilized to find out the relationship of grain yield with number of grains/earhead and test weight. The equation is as follows:

$$Y = a + bX_1 + cX_2$$

where Y, Grain yield (predicted); a, Intercept; b and c, Regression coefficients. Correlation coefficient among various parameters was also carried out.

RESULTS AND DISCUSSION

A. At fodder cut

Growth parameters: For green fodder the cut was taken as per the treatments to compare the cutting stage and height. Maximum plant height of 63.49 and 63.08 cm was recorded at 60–70 DAS, which was significantly superior over cut at 50–60 DAS at 5 and 10 cm cutting height, respectively. Tillers/m^2 were also significantly affected by cutting schedules (Table 1). At 60–70 DAS, the number of

Table 1. Effect of cutting schedules and dual-purpose barley varieties on growth and green fodder yield at fodder harvest (mean of 2 years)

Treatment	Plant height (cm)	Tillers/m²	Green fodder yield (t/ha)	NDVI
Cutting management				
No fodder cut	-	-	-	-
Fodder cutting at 50–60 DAS (above 5 cm height)	57.93	344.8	7.65	0.71
Fodder cutting at 50–60 DAS (above 10 cm height)	58.38	347.6	5.48	0.72
Fodder cutting at 60–70 DAS (above 5 cm height)	63.08	365.5	9.99	0.74
Fodder cutting at 60–70 DAS (above 10 cm height)	63.49	365.4	8.65	0.74
SEm±	1.13	5.5	0.15	0.01
CD (P=0.05)	3.43	17.0	0.46	N.S.
Varieties				
‘BH 393’	61.06	337.2	7.59	0.71
‘BH 946’	58.56	356.6	8.05	0.74
‘RD 2552’	58.33	422.7	7.94	0.73
‘RD 2715’	64.93	306.7	8.19	0.74
SEm±	0.48	4.7	0.04	0.01
CD (P=0.05)	1.47	14.1	0.12	N.S.

NDVI, Normalized difference vegetation; DAS, Days after sowing.

tillers/m^2 were found significantly higher (365.5 and 365.4) as compared to 50–60 DAS at 5 and 10 cm cutting height, respectively. Among the varieties, ‘RD 2715’ and ‘RD 2552’ recorded maximum plant height and tillers/m^2 of 64.93 cm and 422.7, respectively. Since all the varieties were grown under same agronomical and agro-climatic conditions, the difference in their response could be ascribed to their genetic potential to exploit the resources in completion of their life cycle (Choudhary *et al*., 2018)

Fodder yield and physiological parameter: Significantly maximum green fodder yield (GFY) of 9.99 t/ha was achieved in fodder cut at 60–70 DAS above 5 cm height because plants accumulated more biomass in 10 more number of days, furthermore cutting at 5 cm from base of the plants resulted in more weight of green fodder as compared to cutting above 10 cm height. Highest GFY of 8.19 t/ha was reported with ‘RD 2715’ variety due to higher biomass production. Meena *et al*., (2016) and Neelam *et al*., (2022) also recorded maximum GFY of ‘RD 2715’ variety among all the varieties tested for dual purpose. Both the factors did not affect the NDVI of dual purpose varieties of barley. This means that the photosynthesis works at a similar rate in all treatments, and changes in biomass and green fodder yield may be owing to the difference in morphology of varieties rather than metabolic events (Elis and Yıldırım, 2021).

B. At grain harvest

Growth and yield attributes: Maximum plant height of 108.46 cm was recorded in no fodder cut treatment which was found at par with fodder cut at 50–60 DAS above 10 and 5 cm height and significantly higher from fodder cutting at 60–70 DAS at both the heights (Table 2). This might be owing to better regenerative capacity of dual purpose barley when cut was taken above 10 cm height from the base as compared to cutting above 5 cm. The irrigation and nitrogen were applied after green fodder cutting in dual cut system which enhanced the growth, and tilleing started about 15–20 days after cutting. Effective tillers/m^2 and number of grains per ear-head were maximum in fodder cut at 50–60 DAS above 10 cm height. Cutting at the earliest, the predominant apex is eliminated and then tiller production restarts and could drive to a higher number of effective tillers/metre row length (Zeleke, 2019). Maximum test weight (45.37 g) was found in no-cut treatment, which was at par with fodder cut at 50–60 DAS above 5 and 10 cm height. The developmental delay caused by late cutting does not have enough time for spike formation and dry matter to accumulate in the spike. In varieties, maximum height was attained in ‘RD 2715’ (111.20 cm) which was followed by ‘BH 946’ (110.69 cm). Highest effective tillers/m^2 (416) were found in variety ‘BH 946’. The increased plant height and effective tillers of ‘BH 946’ seems to have more leaf area and better utilization of solar radiation thereby resulting in higher photosynthates accumulation after green fodder cutting. Highest number of grains/earhead was recorded with ‘BH 393’ (48.51) variety. Significantly highest test weight was recorded with ‘BH 946’ (45.51 g) and the lowest was found in ‘RD 2715’.

Grain and straw yield: Data (Table 2) revealed that the

Table 2. Effect of cutting schedules and barley varieties on growth, yield and yield attributes of barley at harvest for grain (mean of 2 years)

Treatment	Plant height (cm)	Effective tillers/ m^2	Grains/ ear-head	Test weight	Grain yield (t/ha)	Straw yield (t/ha)	CT* (°C) Ambient temp. (24.4 °C)	NDVI at 120 DAS
Cutting management								
No fodder cut	108.46	387.6	47.18	45.37	4.66	6.79	17.69	0.75
Fodder cutting at 50–60 DAS (above 5 cm height)	106.03	394.8	47.11	44.04	4.67	6.86	17.68	0.77
Fodder cutting at 50–60 DAS (above 10 cm height)	107.18	415.2	48.11	44.93	4.82	7.43	18.45	0.78
Fodder cutting at 60–70 DAS (above 5 cm height)	99.42	335.6	43.92	40.49	4.02	5.78	19.22	0.75
Fodder cutting at 60–70 DAS (above 10 cm height)	101.44	338.3	43.03	41.14	3.90	5.67	18.47	0.76
SEm±	1.29	8.15	0.19	0.50	0.09	0.11	0.02	0.01
CD (P=0.05)	3.89	24.5	0.61	1.52	0.29	0.33	N.S.	N.S.
Varieties								
'BH 393'	92.90	358.8	48.51	44.17	4.67	5.83	18.64	0.75
BH 946'	110.69	416.0	47.77	45.51	5.25	7.62	17.69	0.78
'RD 2552'	103.24	390.8	45.03	43.12	4.37	7.36	18.32	0.78
'RD 2715'	111.20	331.4	42.17	39.97	3.37	5.21	18.56	0.75
SEm±	0.98	4.53	0.55	0.44	0.06	0.11	0.14	0.006
CD (P=0.05)	2.95	13.6	1.65	1.32	0.18	0.33	0.42	0.02

CT, Canopy temperature; NDVI, Normalized difference vegetation; DAS, Days after sowing. NDVI was recorded at 120 days after sowing in No fodder cut as well as in dual cut system.

highest grain (4.82 t/ha) and straw yield (7.43 t/ha) were obtained when fodder cut was taken at 50–60 DAS above 10 cm height, which was at par with no fodder cut and fodder cut at 50–60 DAS above 5 cm height, but significantly superior over the fodder cutting at 60–70 DAS with both cutting heights. When averaged, the increase in grain yield at 50–60 DAS (cut above 5 or 10 cm height) was 1.82 and 19.80% over no fodder cut and fodder cut at 60–70 DAS (cut above 5 or 10 cm height). Beji (2016) also reported the gain in grain yield after a cutting during vegetative stage of barley, which could be associated with decrease of lodging. He further documented that the practice of cutting helps to get the nutritious forage, but may reduce the production (grain and straw), particularly when cut was scheduled at later stage. Tian *et al*., (2012) explored that forage harvested before growth stage 30 i.e. before stem elongation could provide a valuable feed without reducing the grain yield significantly. Among the varieties, 'BH 946' recorded with highest grain (5.25 t/ha) and straw yield (7.62 t/ha), respectively. The grain yield of 'BH 946' was 12.41, 20.3 and 55.78% higher over 'BH 393', 'RD 2552' and 'RD 2715' varieties, respectively. Variety 'BH 946' also

Table 3. Interactive effect of cutting schedules on grain yield (t/ha) of dual purpose barley varieties (mean of 2 years)

Cutting management	'BH 393'	'BH 946'	'RD 2552'	'RD 2715'	Mean A
No fodder cut	4.67	5.69	4.59	3.69	4.66
Fodder cutting at 50–60 DAS (above 5 cm height)	5.54	5.37	4.47	3.31	4.67
Fodder cutting at 50–60 DAS (above 10 cm height)	5.15	5.73	4.45	3.95	4.82
Fodder cutting at 60–70 DAS (above 5 cm height)	3.99	4.67	4.46	2.97	4.02
Fodder cutting at 60–70 DAS (above 10 cm height)	4.01	4.79	3.86	2.93	3.90
Mean B	4.67	5.25	4.37	3.37	
Factors		CD (P=0.05)		SEm±	
Factor (B) at same level of A		0.43		0.15	
Factor (A) at same level of B		0.46		0.18	

DAS, Days after sowing.

recorded maximum straw yield (7.62 t/ha), but it was at par with 'RD 2552' (7.36 t/ha). The significant enhancement in yield attributes in variety 'BH 946' exhibited in increased productivity in terms of grain and straw yield. Grain yield of 'BH 946' was found maximum among all the selected varieties of barley (Adhikari and Singh, 2022). Kharub *et al*., (2013) also reported higher grain and forage yield of 'RD 2552' as compared to 'RD 2715' (Meena *et al*., 2016). The highest dry fodder yield in variety 'BH 946' apparently an account of better growth as indicated from taller plant and production of more tillers. The interaction of cutting schedule and varieties was found significant in grain yield (Table 3). Among all the varieties 'BH 946' produced maximum yield in fodder cutting at 50–60 DAS (above 10 cm height).

Economics: Among the cutting schedules (Table 4), maximum net returns and benefit cost (B:C) ratio of ₹58,862/ha and 2.36 were fetched with the fodder cutting at 50–60 DAS (cut above 10 cm height) followed by fodder cutting at 50–60 DAS (cut above 5 cm height). Lal and Saini (2017) also recorded maximum net returns in cutting of barley at 50 DAS for green fodder, whereas, lowest was in no cut barley. Barley variety 'BH 946' gave the maximum net returns (₹68,126/ha) as well as B:C (2.61) as compared to others.

Physiological parameters: Canopy temperature and NDVI among the cutting schedules were found non-significant (Table 2). However, 'BH 946' recorded significantly lowest canopy temperature of 17.69°C, which means that the aforesaid variety had relatively coolest canopy among all the varieties owing to more chlorophyll synthesis indicating better capacity for taking up the soil moisture and maintaining better plant water status (DeJonge *et al.,* 2015). Varieties 'BH 946' and 'RD 2552' were having the highest value of NDVI (0.78) which was followed by 'BH 393' and 'RD 2715' (0.75).

Correlation and regression: Data in Table 5 pertaining to correlation of yield with the yield attributes indicates that, number of grains/earhead (r = 0.702), test weight (r = 0.800) and effective tillers/m^2 (r = 0.775) were significantly and positively correlated with the grain yield (Fig. 1a and b), whereas, NDVI (r = 0.360) was found non-significant. The grain yield was negatively correlated with CT (r = -0.529).

Based on the 2-year study it can be concluded that barley can perform well under dual purpose. Cutting at 50–60

Table 4. Economics of different treatments as affected by cutting schedule and barley varieties (mean of 2 years)

Cutting management	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	Benefit: cost ratio
No fodder cut	39,330	89,432	50,102	2.27
Fodder cutting at 50–60 DAS (above 5 cm height)	43,065	1,01,292	58,227	2.35
Fodder cutting at 50–60 DAS (above 10 cm height)	43,065	1,01,927	58,862	2.36
Fodder cutting at 60–70 DAS (above 5 cm height)	43,065	91,899	48,834	2.13
Fodder cutting at 60–70 DAS (above 10 cm height)	43,065	87,786	44,721	2.04
Varieties				
'BH 393'	42,318	95,834	53,516	2.26
'BH 946'	42,318	1,10,444	68,126	2.61
'RD 2552'	42,318	96,268	53,950	2.27
'RD 2715'	42,318	75,323	33,005	1.78

DAS, Days after sowing.

Table 5. Correlation of the barley grain yield with yield attributes and physiological parameters

	Grain yield	No. of grains/earhead	Test weight	Tillers/metre row length	NDVI	CT
Grain yield	1**					
Grains/earhead	0.702**	1**				
Test weight	0.800**	0.536*	1			
Tillers/metre row length	0.775**	0.458*	0.709**	1		
NDVI	0.360^{NS}	0.346^{NS}	0.221NS	0.42369NS	1**	
CT	-0.529*	-0.480*	-0.419NS	-0.600**	-0.393NS	1**

*=significant at 5 %; ** = significant at 1 %; and ^{NS} = non-significant. NDVI, Normalized difference vegetation; CT, Canopy temperature.

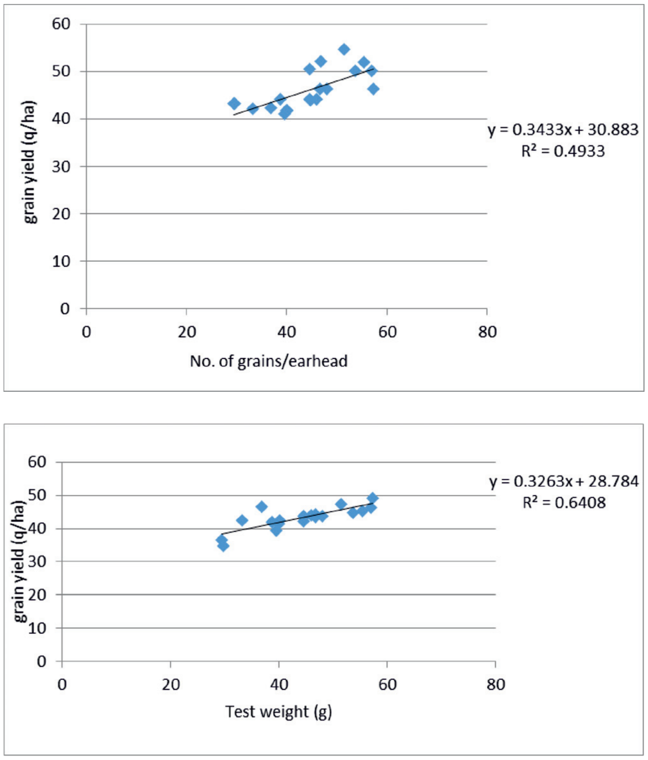

Fig. 1. (a) and (b) Regression analysis of grain yield with the number of grains per earhead and test weight.

days after sowing, irrespective of cutting height yielded at par as compared to no cut but cutting for green fodder later than that reduced the grain yield significantly. When compared to dual-purpose cultivars that have already been released, the grain-only variety yielded more.

REFERENCES

Adhikari, S. and Singh, B. 2022. Effect of nitrogen levels and barley varieties on yield attributes and yields of barley crops. *International Journal of Agricultural Research* **17**: 1–4.

Afshar, R.K., Ansari, M., Jovini, Chaichi, M.R. and Hashemi, M. 2014. Grain sorghum response to *arbuscular mycorrhiza* and phosphorus fertilizer under deficit irrigation. *Agronomy Journal* **106**: 1,212–1,218.

Beji, S. 2016. Yield and quality of dual-purpose barley and triticale in a semi-arid environment in Tunisia. *African Journal of Agricultural Research* **11**(30): 2,730–2,735.

Choudhary, M.K., Yadav, M.K. and Chaplot, P.C. 2018. Response of dual purpose barley (*Hordeum vulgare* L.) varieties, sowing dates and fertility levels in sub-humid southern plains of Rajasthan. *International Journal of Agricultural Sciences* **14**(2): 318–326.

DAHD. 2019. 20th Livestock Census. http://dahd.nic.in/about-us/divisions/statistics

DeJonge, K.C., Taghvaeian, S., Trout, T.J. and Comas, L.H. 2015. Comparison of canopy temperature-based water stress indices for maize. *Agricultural Water Management* **156**: 51–62.

Elis, S. and Yıldırım, M. 2021. Dual-purpose ability of barley and wheat at drought and heat stress condtions. *Journal of Aridland Agriculture* **7**: 103–108.

GoI. 2021. Indian Agriculture contributes to green shoots of the Indian Economy. Ministry of Finance, Govt. of India. https://pib.gov.in/PressReleasePage.aspx- ?PRID=1693205/

GOI. 2022. Ministry of Finance, Government of India. Accessed from: https://www.indiabudget.gov. in/economicsurvey/.

Kharub, A.S., Verma, R.P.S., Kumar, D., Kumar, V., Selvakumar, R. and Sharma, I. 2013. Dual purpose barley (*Hordeum vulgare* L.) in India: Performance and potential. *Journal of Wheat Research* **5**(1): 55–58.

Lal, M. and Saini, K.S. 2017. Productivity, quality and profitability of dual-purpose barley (*Hordeum vulgare* L.) under various planting techniques and cutting practices in Indo-Gangetic Plains of India. *International Journal of Current Microbiology and Applied Sciences* **6**(9): 648–654.

Meena, N.K., Choudhary, J. and Hansram, Mali. 2016. Effect of dual purpose varieties, cutting schedules and fertility levels on nutrient content, uptake, quality and yield of barley (*Hordeum vulgare* L.). *Forage Research* **42**(2): 109–114.

Neelam, Kumar, S., Satpal, Kumar, J., Devi, U. and Hooda, V.S. 2022. Agronomic evaluation of dual-purpose barley varieties under different cutting management system. *Forage Research* **47**(4): 449–455.

Pal, D. and Kumar, S. 2009. Evaluation of dual purpose barley for fodder and grain under different cutting schedules. *Range Management and Agroforestry* **30**: 54–56.

Prajapati, B., Prajapati, J., Kumar, K. and Shrivastava, A. 2019. Determination of the relationships between quality parameters and yields of fodder obtained from intercropping systems by correlation analysis. *Forage Research* **45**(3): 219–224.

Rawat, D.S. 2011. 'Performance of dual-purpose barley (*Hordeum vulgare* L.) varieties under varying seed rates and fertility management'. MSc (Ag.) Thesis, Department of Agronomy, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan.

Roy, A.K., Agrawal, R.K., Bhardwa, N.R., Misra, A.K. and Mahanta, S.K. 2021. Indian forage scenario-Region wise availability and deficit. *Indian Fodder Scenario: Redefining State Wise Status*. ICAR-AICRP on Forage Crops and Utilization, Jhansi, Uttar Pradesh, India.

Singh, M., Chauhan, A., Kumar, R., Joshi, D., Soni, P.G. and Meena, V.K. 2017. Dual purpose barley as affected by date of sowing, varieties and stage of harvesting-A review. *Agricultural Reviews* **38**: 159–164.

Singh, D.N., Bohra, J.S., Tyagi, V., Singh, T., Banjara, T.R. and Gupta, G. 2021. A review of India's fodder production status and opportunities. *Grass and Forage Science* **00**: 1–10.

Tian, L.H., Bell, L.W., Shen, Y.Y. and Whish, J.P.M. 2012. Dual-purpose use of winter wheat in western China: Cutting time and nitrogen application effects on phenology, forage production, and grain yield. Crop and Pasture Science **63**(6): 520–528.

Vijay, D., Gupta, C.K. and Malviya, D.R. 2018. Innovative technologies for quality seed production and vegetative multiplication in forage grasses. *Current Science* **114**(1): 148–154.

Zeleke, K.T. 2019. Effect of grazing time and intensity on growth and yield of spring wheat (*Triticum aestivum* L). *Journal of Integrative Agriculture* **18**(5): 1,138–1,147.