Dual purpose barley (*Hordeum vulgare* L.) in India: Performance and potential

Ajit Singh Kharub*, Ramesh Pal Singh Verma[1], Dinesh Kumar, Vishnu Kumar, Rajan Selvakumar and Indu Sharma

Directorate of Wheat Research
Karnal - 132 001, India

Abstract

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. The time of cut for green fodder was optimized and cutting 55 days after sowing was found optimum. A seed rate of 120 kg ha^{-1} and fertilizer dose of 75N:30P:20K kg ha^{-1} are optimum for dual purpose barley. Half of nitrogen and full P and K should be applied as basal and remaining half of nitrogen dose should be splited in two (half immediate after green fodder cut and half 30 days after cut). Irrigation immediately after forage cut is required for better rejuvenation. 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 and 24-35 q ha^{-1} of green fodder and grains, respectively were produced from dual purpose barley.

Key words: Dual purpose barley, forage, mixed cropping, grain quality

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Introduction

Barley (*Hordeum vulgare* L.) has been traditionally used as a grain crop for human consumption and animal feed in India. It is grown during the winter season (Rabi) in the northern plains as well as in northern hills, mostly under rainfed or limited irrigation condition on poor to marginal soils. In the recent years it has been observed that in the drier parts of northern plains there is an acute shortage of green fodder in the months of November to January. Since berseem (*Trifolium* spp), oat and sugarcane top are not available due to water shortage, in such areas, barley can be utilized as green fodder with very limited water supply or less rainfall in these areas. In drier parts of Northern plains (Rajasthan, Madhya Pradesh, Southern Haryana, South West Punjab and Western U.P.) during November to January, farmers can grow dual purpose barley over other forage crops because of its dual utilization and less water requirement (Verma et al. 2007). In these regions, animal husbandry occupies an important role and there is a big gap between demand and supply of forage. Since both the green forage and grain can be utilized for animal fodder/ feed purposes, the crop can be advantageous over oats, because of its dual utilization, faster early growth as well as less water requirement. So barley can provide important nutrition to the livestock through its green fodder and grains harvested from regenerated crop. Since the agronomic practices of dual purpose barely differ from feed and malt barely with respect to varieties, sowing time, seed rate, doses and schedule of fertilizer application and irrigation due to forage cut, experiments were under taken to optimize agronomic practices. The experiments were also conducted to optimise the stage of cutting, for forage and grain yield and in view of net profitability in dual purpose barley.

[1]Barley Breeder, ICARDA, Morocco
*Corresponding author email: *askharub@gmail.com*

Materials and methods

Experiments on dual purpose barley, covering different aspects were conducted at research farm, Directorate of Wheat Research, Karnal and AICW&BIP centers during 2006-11 to develop suitable crop production techniques. 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. In another experiment, different doses of seed and nitrogen levels were applied to optimize these input doses. Nitrogen scheduling and irrigation after green fodder cut were confirmed for higher forage and grain yield. An experiment was also conducted on mixed cropping with berseem or senji to increase the green forage biomass. Quality of grain after green forage was analysed for husk, protein, bold grain etc. Details of experimental details are given along with the results. Standard methodologies were followed for conducting all the experiments.

Results and discussion

Barley as a forage resource: The results of different experiments revealed that barley can produce up to 172 quintals of green forage per ha and after rejuvenation can produce 41 quintals of grain yield (Table 1). Realizing the shortfall of forage availability, barley was found important alternate

forage cum grain crop in water deficit and salt affected areas. The crop has low input requirement and plasticity of adaptation varied under different agro climatic conditions. Barseem, oats and sugarcane needs more irrigation and inputs as compared to barley and can not be grown where water is scarce. Barley being a fast growing crop with high biomass in early stages has been recognized as potential forage resource in such situations (Srimali, 2008). The study has clearly shown 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.

Table 1. Grain and forage productivity (mean of different varieties/ locations)

Cut/Uncut	Grain yield, q ha^{-1}	Forage yield, q ha^{-1}
Uncut	43.2	0.0
Cut 40 DAS	38.7	83.6
Cut 55 DAS	41.2	172.7
Cut 70 DAS	33.8	195.3

Suitable varieties for different agro-climatic conditions: The multi-locational experiments taken up to identify varieties for dual purpose barley resulted that two released varieties of feed barley (RD2035 and RD2552) can be used as dual purpose barley with good yield of the green forage (between 200 to 250 q ha^{-1}) and the grain yield (24 to 32 q ha^{-1}) from regenerated crop in North Western plain Zone (Table 2). Another variety RD 2715 has been released as dual purpose barley for Central zone, which gave on an average 160 q ha^{-1} of fodder and 27.0 q ha^{-1} grain yield. In case of Northern hills, multilocational experiments indicated that the released varieties BHS 169 and HBL 276 had good potential for green fodder and grain yield from regenerated crop along with new dual purpose variety BHS 380. In North Eastern Plain Zone, Azad and RD 2552 were found to give better grain and forage yields as dual purpose barley (AICWBIP reports 2006 & 2007) as compared to other released varieties.

Table 2. Fodder and grain yield of different varieties in different Agro-climatic conditions

Zone / Production conditions	Varieties	Forage yield, (q ha^{-1})	Grain yield, (q ha^{-1})
North Western Plains,	RD 2035	228	27.6
irrigated, timely sown	RD 2552	216	27.7
North Eastern	Azad	190	33.8
Plains, irrigated, timely sown	RD 2552	233	34.7
Central Zone	RD 2715	160	27.7
Northern Hills,	HBL 276	52.8	12.0
rainfed, timely sown	BHS 169	53.0	15.7

Optimum Date of Forage Cut: For dual purpose barley crop, the stage for forage cutting is 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 (Table 3). At this stage, the reduction in grain yield over cut at 40 days was around 25 per cent but significant gain in forage yield was observed. Similarly increase in forage yield was not enough to compensate the yield reduction at 70 days cut over cut at 55 days (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. The amount of green fodder however was affected by rainfall (amount and frequency), as barley is cultivated as rainfed crop in hills. It gives forage at crucial stage (during winter) when no other green fodder is available for animal feed at lower and middle hills.

Table 3. Grain and forage yield at different stages of cut in plains and hills

Cutting treatment	Grain yield, q ha^{-1}	(%) Decrease	Forage yield, q ha^{-1}	(%) Increase
Plains				
Uncut	43.5	-	0.0	-
Cut 40 DAS	38.6	-11.3	84.0	-
Cut 55 DAS	32.2	-25.9	157.0	86.9
Cut 70 DAS	21.4	-50.8	230.0	174.0
Hills				
Uncut	26.1	-	0.0	-
Cut 50 DAS	22.2	-14.9	22.6	-
Cut 70 DAS	19.4	-25.6	40.9	80.9
Cut 90 DAS	13.6	-47.9	72.6	221.2

Seed and fertilizer requirement: The seed rate and fertiliser are the main inputs for increasing the productivity of fodder and grain. The productivity of green forage as well as grain increased to a significant level by using additional 25 per cent of seed and fertilizer dose as compared to the recommended dose (Table 4). Seed rate can be enhanced to 125 kg ha^{-1} from 100 kg ha^{-1} for getting higher productivity of green forage as well as grain and 25 per cent higher fertilizer (75kg N ha^{-1}) should be given after cut for maximising grain productivity. It helps in increasing the biomass of green forage and crop stand after regeneration and ultimately the grain yield.

Table 4. Grain and forage yield under different nitrogen and seed rate

Seed Rate Kg/ha	Nitrogen application, Kg ha^{-1}							
	60	75	90	Mean	60	75	90	Mean-
	Forage yield				Grain yield			
100	172	186	188	182.0	33.2	36	36.4	35.2
125	187	205	206	199.3	35.7	38.5	38.0	37.4
150	192	208	208	202.7	36.0	38.3	38.2	37.5
Mean	183.7	199.7	200.7	194.7	35.0	37.6	37.5	36.7

CD (0.05)	Seed rate	Nitrogen	Grain yield	Seed rate	Nitrogen
Forage yield	5.81	6.33		2.36	1.82

Irrigation and nitrogen scheduling: This trial was conducted at five locations in the North-western plains zone with two varieties (RD 2552 and RD 2035) in main plots and five N schedules in the sub plots (Table 5). Results indicated that all treatments were at par in grain yield but highest yield was obtained in three splits (1/3 at basal+1/3 immediate after cut+1/3 tillering stage after cut) closely followed by two splits (1/2 at basal + 1/2 immediate after cut) and then three (1/2 at basal + 1/4 immediate after cut + 1/4 tillering stage after cut). In forage yield, the highest yield was obtained in two splits (2/3 at basal + 1/3 immediate after cut) and this was significantly superior to others mainly because of higher application of nitrogen before cut (Table 5). The experiment was conducted for three crop seasons and it was concluded that the N scheduling of 1/2 at basal + 1/4 immediate after cut + 1/4 tillering stage after cut is best for forage and grain yield (Table 5). Equally effective is the treatment where ½ nitrogen was applied as basal and ½ immediate after forage cut.

Table 5. Grain and forage yield under different N schedules

Treatments	Grain yield, q ha^{-1}			Forage yield, q ha^{-1}			Grain equivalent yield, q ha^{-1}		
	RD 2552	RD 2035	Mean	RD 2552	RD 2035	Mean	RD 2552	RD 2035	Mean
T1	35.49	36.64	36.07	151.8	159.8	155.8	43.08	44.63	43.86
T2	36.24	37.66	36.95	153.1	161.7	157.4	43.90	45.75	44.82
T3	37.91	38.78	38.35	141.3	149.1	145.2	44.98	46.24	45.61
T4	36.47	36.50	36.48	140.3	149.3	144.8	43.49	43.97	43.72
T5	34.18	34.46	34.32	162.8	163.2	163.0	42.32	42.62	42.47
Mean	36.06	36.81	36.43	149.9	156.6	153.2	43.55	44.61	43.76
CD (0.05)	Varieties (A)	N schedule (B)	CD (0.05)	Varieties (A)	N schedule (B)	CD (0.05)	Varieties (A)	N schedule (B)	
G yield	NS	1.11	F yield	NS	6.35	GEY	NS	1.71	

T1-1/2 at basal+1/2 immediate after cut T2-1/2 at basal + 1/4 immediate after cut + 1/4 tillering stage after cut T3- 1/3 at basal + 1/3 immediate after cut + 1/3 tillering stage after cut T4- 1/3 at basal + 2/3 immediate after cut T5- 2/3 at basal + 1/3 immediate after cut

Mixed cropping for higher fodder productivity: Mixed cropping in barley either with mustard or with senji was experimented with a objective to increase green forage yield with out diminishing the grain yield. Fodder yield increased in mixed cropping with mustard or senji as compared to barley alone (Anonymous 2007). Mixed cropping and barley alone were found to be similar in grain equivalent yield as there was reduction in regeneration and tillering in barley under mixed cropping. Reduction in grain yield was observed as 12.6, 18.2 and 15.7 per cent in barley alone, barley +mustard and barley + senji, respectively, as compared to uncut (Table 6).

The grain and fodder yield were significantly decreased under late sown compared to early and normal sown crop. Additional benefit of Rs. 6000 to 10000 can be earned by growing barley as dual crop instead of pure grain crop.

Table 6. Grain, fodder and grain equivalent (GE) yield in q ha^{-1}

Cutting treatment	Date of sowing								
	Early, 43 week			Normal, 46 week			Late, 49 week		
	Grain	Fodder	GE	Grain	Fodder	GE	Grain	Fodder	GE
Uncut	51.1	0	51.1	46.15	0.0	46.1	41.85	0	41.8
Cut 55 DAS	43.45	161.6	53.7	41.1	150.3	50.7	36.05	129.9	43.6
Cut 55DAS(B+M)	42.7	163.7	53.8	38.05	190.6	51.85	33.8	148.8	43.1
Cut 55 DAS(B+S)	43.7	162.4	54.25	39	187.8	51.35	33.75	145.3	43.0
Mean	45.25	157.5	52.45	41.05	180.0	49.35	36.4	168.5	42.9

Quality of grain in dual purpose barley: It has been observed that optimum levels of green fodder and grain yield are achieved at cut 55 days after sowing. In order to observe the effect of cutting dates on grain quality the grain samples from Karnal have shown that that the test weight, which is an indicator of better grain filling was highest at 55 days cut closely followed by cut at 40 days (Table 7). The uncut treatment recorded lower test weight amongst the cutting treatments. Husk percent was higher in uncut barley as compared to cut treatments and it was reduced as the date of cutting increased from 40 to 55 DAS and further increased at 70DAS. Protein percent was higher in uncut barley grain as compared to cut treatments. Protein percent in 70 days cut was higher as compared to 55 days cut may be more due to shriveled grain. Bold grain percent reduced in all the varieties as the date of cutting progressed. Interestingly, bold grain percent was lower in uncut barley grain as compared to 40 days cut; it may be mainly due to more lodging in uncut barley affecting adversely the grain development. Similarly the thin grain proportion was higher in RD 2552 as compared to other two varieties.

Table 7. Effect of cutting on grain quality of different varieties in dual purpose barley

Cut treatment	RD2035	RD2552	Mean
	Test weight (kg hl^{-1})		
Uncut	58.12	53.93	56.03
Cut 40	57.29	57.43	57.36
Cut 55	59.16	58.09	58.63
Cut 70	58.54	56.60	57.57
	Husk (%)		
Uncut	8.43	9.63	9.03
Cut 40	8.53	9.10	8.82
Cut 55	8.03	7.67	7.85
Cut 70	8.13	8.37	8.25
	Protein (%)		
Uncut	9.28	9.17	9.23
Cut 40	8.79	8.69	8.74
Cut 55	7.73	7.75	7.74
Cut 70	8.18	8.12	8.15
	Bold grain (%)		
Uncut	73.6	66.3	69.95
Cut 40	72.1	77.1	74.60
Cut 55	64.9	71.6	68.25
Cut 70	55.1	57.9	56.50
	Thin grain (%)		
Uncut	7.30	11.80	9.55
Cut 40	8.63	8.33	8.48
Cut 55	8.77	8.63	8.70
Cut 70	13.17	13.13	13.15

The percentage of thin grains increased as the date of cutting increased in all the three varieties and the uncut treatment had higher thin grain proportion than cut at 40 and 55 DAS. The lodging observed in uncut had adversely affected the grain development and cutting at 40 & 55 DAS could escape the lodging. However cutting at 70 DAS affected all the four traits adversely. In addition to satisfactory grain and fodder yield at 55 days cut, the grain quality is also acceptable as compared to other treatments. Grain filling and protein content was not much affected by cutting at 55 days for fodder. Bold grain percent significantly reduced as the date of cutting progressed and the percentage of thin grains increased as the date of cutting increased.

The bold and thin grains were optimum at 55 days cut. Barley superiority over oat in forage quality in terms of dry matter crude protein, crude fiber, digestible crude protein, hemi cellulose, digestible nutrients has already been reported (Srimali, 2008).

Barley can be utilized as a source of green fodder in rainfed, arid to semiarid conditions where other water loving crops like barseem, oats, sugarcane etc cannot be grown due to water shortage. The crop can be given one cut between at 50-55 days after sowing for green fodder in plains and 70 days after sowing in Hills and the regenerated crop can be utilized for grain purposes. Since both the green fodder and grain can be utilized for animal fodder/ feed purposes, the crop can be advantageous over oats, because of its dual utilization as well as less water requirement as it needs only two to three irrigations.

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