Forage Res., **42** (4) : pp. 211-217 (2017) **http://forageresearch.in**

DUAL PURPOSE BARLEY–AN EFFECTIVE SOLUTION FOR FODDER SCARCITY IN SEMI-ARID REGION–A REVIEW

MUKESH KUMAR*, BHAGAT SINGH, ASHISH JAIN[1] AND A. K. DHAKA

Department of Agronomy
CCS Haryana Agricultural University,
Hisar-125 004 (Haryana), India
(e-mail : mukeshkumarkainwal@gmail.com)
(Received : 2 January 2017; Accepted : 17 January 2017)

SUMMARY

Dual purpose barley is an excellent alternate crop for fodder purpose due to its good nutritive value, high palatability and availability of fodder during lean period. Barley crop can be given one cut for green forage and the regenerated crop can be utilized for grain purposes. Thus, barley can serve as supplementary crop for augmenting the green forage demand in the arid/semi-arid areas of northern plains under limited irrigations and in hills under rainfed conditions. The economics goes in favour of dual purpose crop instead of only grain crop in forage scarcity areas of northern plains. The crop can be given one cut at 50-55 DAS in plains and 70-75 DAS in hills for green forage and satisfactory levels of grain yield from the regenerated crop can be utilized as feed or food. On an average, 180-240 and 24-35 q/ha of green fodder and grains, respectively, were produced from dual purpose barley. It responds well to sowing time, fertility levels and time of cutting which vary from location to location. 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. Seed rate can be enhanced to 125 kg/ha from 100 kg/ha for getting higher productivity of green forage as well as grain and 25 per cent higher fertilizer (75 kg N/ha) should be given after cut for maximising grain productivity. Variety RD 2035 is suitable for dual purpose as it is superior in fodder, grain yield and GEY and to get best performance of dual purpose barley varieties, nitrogen (75 kg N/ha) should be applied in three splits i. e. 1/3 as basal+1/3 immediate after cut+1/3 at next irrigation.

Key words : Dual purpose barley, varieties, green fodder yield, nutrition

Barley (*Hordeum vulgare* L.) is an important coarse cereal crop of India, being grown in **rabi** season in northern plains as well as in northern hills, mostly under rainfed or limited irrigation condition on poor to marginal soils. It is a widely adapted small-grain annual cereal and is a key feed and fodder in India (Kharub *et al.*, 2013).Traditionally considered as a poor man's crop, barley in India is favoured because of its low input requirement and better adaptability to harsh environments, likely drought, salinity/alkalinity and marginal lands. Barley occupied nearly 5.90 lac hectare area producing nearly 15.05 lac tonnes grain, with a productivity of 2552 kg/ha during 2015-16 in India (Anonymous, 2016). Barley has been traditionally used as a grain crop for human consumption and animal feed in India. It is not only useful for feed, malting and food purposes but also its b -glucanse is helpful in lowering the risk of cardio-vascular diseases (Kharub *et al*., 2013). The barley products like "Sattu" (in summers because of its cooling effects on human body) and Missi Roti have been traditionally used in India (Verma *et al*., 2011). 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 **rabi** season. 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 later on (Yadav *et al.,* 2003; Singh *et al.,* 2012a). The crop can be given one cut at 50-55 DAS in plains and 70-75 DAS in hills for green forage and satisfactory levels of grain yield from the regenerated crop can be utilized as feed or food. On an average, 180-240 and 24-35 q/ha of green fodder and grains, respectively were produced from dual purpose

[1]Department of Genetics & Plant Breeding.

barley. Since berseem and oats are not available due to water shortage, in such areas, barley being a fast growing crop with high biomass in early stages 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 **rabi,** farmers can grow dual purpose barley over other forage crops because of its dual utilization and less water requirement (Verma *et al*., 2007). So, with the development of high yielding dual purpose barley varieties, barley can serve as alternative for augmenting the green forage demand in the arid and semi-arid areas of northern plains under limited irrigations along with satisfactory levels of grain yield from the regenerated crop, which can also be utilized as feed for cattle or for human consumption.

Under favourable conditions (mainly sufficient water availability), grain yield increment due to defoliation has been attributed to a lower incidence of lodging, moderation of foliar disease, and rapid recovery of leaf area; in stressed conditions, it has been related to lower transpiration (conservation of soil moisture), delayed phonology, and greater remobilization of stem reserves to grains (Harrison *et al*., 2012). Dual purpose barley has a brittle rachis; therefore, it was used to establish permanent pasture in marginal lands, stony fields, and hilly areas in which agricultural equipment for sowing is not available each year. Management of dual purpose barley for both forage and seed production would improve the diversity options for livestock producers. Barley grazed at the pre-stem elongation stage allows recovery and production of grain yield equivalent to that of ungrazed stands; therefore, dual purpose barley is becoming more popular because it tolerates grazing at the pre-stem elongation stage (El-Shatnawi *et al*., 2004). Prior knowledge of the defoliation effects on plants is thus crucial for successful pasture management. An attempt has been made to review the impacts of agronomic practices on the success of dual purpose barley systems supported by the literatures.

Date of Sowing

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. Maximum yield was received from crop sown on 15 October and 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 t/ha (Sharma, 2007). Mani *et al*. (2006) at Hisar reported 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. Noworolnik (2013) reported that the delayed sowing resulted in decreased number of earheads 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. The higher dry matter yield in 65 days old crop may be attributed to availability of more time duration for the growth of 65 days old crop than 45 and 55 days old crop (Kaur *et al.*, 2013). Choudhary and Chaplot (2015) at Udaipur, Rajasthan reported that early sown on 15 November resulted in higher protein content and accumulation of N and P in green fodder, grain and straw over late sowing on 25 November and 5 December. However, TDN content in green fodder increased with delay in sowing.

Selection of Variety

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 for specific situation like irrigation, temperature, humidity, soil condition, etc. for its growth and yield. Kharub *et al.* (2007) in multi-location experiments taken up to identify suitable variety for dual purpose barley reported that two released varieties of feed barley i. e. RD 2035 and RD 2552 could be used as dual purpose barley with good yield of the green forage (200 to 250 q/ha) and the grain yield (24 to 32 q/ha) 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 of fodder and 27.0 q/ha grain yields. Sharma (2009) also reported that barley variety RD 2715 recorded maximum green fodder yield of 229.2 q/ha, which was statistically at par with RD 2552. Whereas lowest fodder production was attained with PL 751 (191.2 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. Whereas Singh *et al*. (2016) at Hisar suggested that variety RD 2035 could be taken for dual purpose as it was superior in fodder (173.9 q/ha), grain (45.0 q/ha) and grain equivalent yield (5592 q/ha). Kapoor *et al.* (2010) reported that RD 2715 was superior in terms of plant height compared to RD 2552 and the variety RD 2552 was higher in leaf : stem ratio as compared to variety RD 2035. Kaur *et al.* (2009) reported that 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) and PL 172 (37.7 q/ha) were statistically at par but gave significantly higher grain yield than PL 426 (30.2 q/ha) during first year. During second year, variety RD 2552 (56.4 q/ha) gave significantly higher grain yield than the other two varieties. Kaur *et al.* (2013) reported that PL 172 produced significantly higher dry fodder yield (19.4 q/ha) than 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) studied the effect of genotype of barley on the fodder and grain yield and revealed that dual purpose variety RD 2035 gave higher fodder yield and lower grain yield as compared to variety RD 2552.

The straw production was higher in RD 2552 as compared to RD 2035. Jarial (2015) reported that in Tehri Garhwal BHS 380 produced substantially higher quantities of grain (4.78 t/ha), straw (7.31 t/ha) besides 3.78 t/ha of green fodder during lean season, likewise in Pithorgarh district BHS 380 yielded higher quantity of grain (7.23 t/ha) and straw (13.80 t/ha) besides 1.28 t/ha of green fodder during lean season, under delayed sowing in December. Barley variety BHS 366 produced 9 and 24 per cent more green forage (57.9 q/ha) than BHS 352 and BHS-365, respectively.

The forage protein content of different varieties varied from 20 to 31 per cent, whereas P and K content varied between 0.15-0.22 and 2.07-3.01 per cent. However, higher protein yield was recorded from variety BHS 367 (4.63 q/ha) and the lowest from VLB 1 (1.45 q/ha) and concluded that BHS 366 and BHS 365 were superior dual purpose varieties for obtaining good amount of quality green fodder along with a fairly good yield and economic output under mid-hill conditions (Bisht *et al*., 2009). Singh *et al.* (2012a) at MPAUT, Udaipur revealed that green fodder yield and growth character of dual purpose barley variety RD 2552 before and after green fodder cutting was significantly higher over RD 2035. The variety had higher grain and straw yield, accumulated maximum N and P in green fodder, grain and straw and total uptake compared to variety RD 2035. Kaur *et al.* (2009) also reported almost similar fodder, grain and straw yield from RD 2552 variety of barley.

Kharub *et al*. (2013) reported that after harvesting of green fodder, the crop was raised for grain purpose and it was observed that barley variety RD 2552 attained significantly higher number of effective tillers compared to RD 2035. Green fodder yield of barley genotypes ranged between 119.50 and 238.50 q/ha with the average of 178.70 q/ha, and maximum was found in RD 2859 followed by RD 2715 and RD 2857 with green fodder yield of 219.50 and 209.25 q/ha, respectively. Looking to the green fodder of fresh crop and seed yield of regenerated crop, genotypes BH 971 and UPB 1036 appeared to be the most productive and appropriate for dual purpose cultivation in arid Rajasthan (Sharma, 2015).

Kaur *et al.* (2013) reported 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%). PL 172 variety produced significantly higher crude protein yield (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). Hundal *et al.* (2014) studied the effect of barley genotype on the chemical composition of barley fodder and revealed that variety RD 2552 had higher total ash, crude protein and hemicelluloses content as compared to dual purpose variety RD 2035, but reverse trend was observed with respect to OM, ADF and cellulose contents.

The variation in growth, quality and fodder yield of different varieties might be due to the genetically constituents of the varieties. Choudhary and Chaplot (2015) at Udaipur, Rajasthan reported that among dual purpose barley varieties, RD 2715 and RD 2552 were equally efficient as both registered highest concentration of protein and N and P uptake by green fodder, grain and straw compared to variety RD 2035. Variety RD 2552 had significantly higher concentration of TDN in green fodder than RD 2715 and 2035.

Seed Rate and Nutrition Management

The effect of N fertilization on barley regrowth after defoliation has not been extensively investigated. Defoliation removes nitrogen (N) accumulated in plant aerial parts. It has been found that N availability plays an important role in crop regrowth after defoliation (Pandey, 2005; Tian *et al*., 2012). Using supplementary N fertilizer after forage removal, therefore, is a common practice in dual purpose systems in many areas (Pandey, 2005; Tian *et al*., 2012). The seed rate and fertilizer are the main inputs for increasing the productivity of fodder and grain. Linear increase in forage production with increasing pre-plant N application and grain yield increased as N rate increased. Kharub *et al*. (2013) reported that a seed rate of 120 kg/ha and fertilizer dose of 75 N : 30P : 20K kg/ha were optimum for dual purpose barley. 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. Seed rate can be enhanced to 125 kg/ha from 100 kg/ha for getting higher productivity of green forage as well as grain and 25 per cent higher fertilizer (75 kg N/ha) should be given for maximising grain productivity. It helps in increasing the biomass of green forage and crop stand after regeneration and ultimately the grain yield. 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). Optimization of N use will result in enhanced N use efficiency, which is economically viable and environmentally sound (Ladha *et al*., 2005). Singh *et al*. (2012a) at Udaipur, Rajasthan revealed that application of 125 and 150 per cent RDF improved growth parameters, yield attributing parameters, grain, straw yield, N and P uptake over 100 per cent RDF. Protein content increased and crude fibre content of green fodder decreased with increasing fertility levels. However, TDN remains stable under varying fertility levels.

With highest net returns and B : C ratio application of 125 per cent RDF proved most economically beneficial. Singh *et al*. (2012b) also revealed that the application of nitrogen in three splits i. e. 1/3 at basal+1/3 immediate after cut+1/3 at 100 DAS recorded significantly higher grain yield compared to other nitrogen application schedules. The higher yield in three splits may be attributed to better availability of nitrogen to the crop during entire season. However, application of nitrogen in two splits i. e. 2/3 at basal+1/3 immediate after cut was found to be best for obtaining the higher green fodder yield. Singh *et al*. (2012c) at Hisar, based on two years' study concluded that variety RD 2035 could be taken as dual purpose crop as it was superior in fodder, grain and GEY than RD 2552 with 75 kg N/ha applied 1/3rd N+1/3rd N+1/3rd N at sowing, after fodder cut and at 2nd irrigation (85 DAS). Choudhary *et al*. (2014) at Bikaner, Rajasthan resulted that green fodder yield (GFY) obtained per kg of nitrogen applied (PFPn) sharply declined beyond 30 kg N/ha. In terms of GFY, significant response of basal application of nitrogen was noticed up to 40 kg N/ha (124.25 q/ha). In case of DMY, significant positive response was noticed only up to 30 kg N/ha. NDF, ADF and lignin content remained unaffected due to nitrogen application. The crude fat and mineral contents exhibited significant and positive response up to 30 kg N/ha. Crude protein content tended to increase up to 80 kg N/ha. Beyond 30 kg N/ha only 60 and 80 kg N/ha produced significant and positive effect on CP content. Choudhary and Chaplot (2015) Udaipur, reported that application of 75 kg N+25 kg P_2O_5/ha significantly improved protein and TDN content, N and P uptake by fodder, grain and straw over 60 kg N+20 kg P_2O_5/ha.

Meena *et al*. (2016) reported that the maximum N, P, K content and uptake in grain and straw were estimated under application of RDF+50 per cent extra N. While, N uptake by green fodder recorded higher under application of RDF+25 per cent extra N but it was at par with RDF+50 per cent extra N. The highest protein content in green fodder, grain and straw was recorded under RDF+50 per cent extra N, the same trend was observed in regards of TDN and mineral ash content in green fodder. Effect of 50 per cent extra nitrogen application on yield attributes was also reflected on yield and ultimately produced the highest green fodder (29.78 t/ha), grain (3.56 t/ha), straw (6.86 t/ha) and biological yield (10.42 t/ha). Singh *et al*. (2016) also reported that application of nitrogen in two splits i. e. 2/3rd as basal+1/3rd immediate after cut was found to be best for obtaining the higher green fodder yield.

Time and Stage of Cutting

For dual purpose barley crop, the stage for forage cutting is most important on which both forage and grain yield depend. 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. That's why it's important to determine the right stage of harvesting to obtain the highest green fodder as well as grain yield from the crop. When grown as a green fodder plus grain crop, the first cut of barley at proper vegetative growth stage provides fresh and nutritious green fodder to animal at minimal cost. The ratoon is maintained for grain. The harvest at crop maturity gives satisfactory grain yield and straw yield. Barley straw is an important feed source for cattle and small ruminants during the dry season. Kharub *et al*. (2013) under multi-location experiment reported that the crop could be given one cut at about 55 days after sowing for green forage in plains and the regenerated crop could be utilized for grain purpose which gave satisfactory levels of grain yield. 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, co-ordinated experiments conducted under rainfed conditions indicated that the optimum stage of cutting was 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. The time of cut for green fodder was optimized and cutting 55 days after sowing was found optimum. Jain and Nagar (2010) reported that when barley crop cut at 45 days after sowing yielded highest grain yield (28.7 q/ha). It was numerically low (3.75%) in no cut crop and reduced significantly by 20.1 per cent in 55 days cut crop. Kaur *et al.* (2013) at Ludhiana, reported that forage cut at 60 DAS produced significantly higher dry fodder yield (24.2 q/ha) than the forage cut at 45 DAS (11.1 q/ha) and this gave 119 per cent higher dry fodder than the forage cut at 45 DAS.

Midha *et al*. (1994) at Hisar reported that different cutting management influenced quality of fodder. Each delay in fodder cutting from 50 DAS to 80 DAS found to decrease protein content of fodder significantly and increase in ADF and NDF content while there was no effect on ether extract content. They further explained that protein content with delay in cutting decreased because of higher fodder yield which led to dilution of photosynthates. Unlike protein content, ADF and NDF content increased because of increase in fibre content of plant with increasing age. However, the total production of crude protein, ether extract, ADF and NDF increased with each delay in cutting because of increase in fodder yields. Kaur *et al.* (2013) reported that 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 forage cut at 45 DAS. Forage cut at 60 DAS had produced significantly higher yield of crude protein (24.2 q/ha), crude fibre (2.1 q/ha), ether extract (6.4 q/ha), mineral matter (0.62 q/ha), nitrogen free extract (2.31 q/ha) and digestible dry matter (0.62 q/ha) than forage cut at 45 DAS. The crop, however, can be utilized as green forage plus grain crop i. e. barley as cut green forage (slage), grain (feed, malt, food) and straw (fodder). In barley, vegetative and reproductive growths are separated in time. Sadreddine (2016) found that grain protein was significantly higher after clipping for barley (11.35% for dual purpose and 10.17% for grain production only). The grain, straw and biological yield as well as nutrient uptake by grain and straw were significantly increased when green fodder was cut at 40 DAS, while cutting at 60 DAS recorded the highest nutrient uptake by green fodder. The mineral ash and crude fiber in green fodder were higher when green fodder was cut at 60 DAS as compared to earlier cutting (Meena *et al*., 2016).

CONCLUSION

Considerably higher revenue in the dual purpose system compared with the alone grain system in arid region. The crop can be given one cut at 50-55 DAS in plains and 70-75 DAS in hills for green forage and satisfactory levels of grain yield from the regenerated crop can be utilized as feed or food. Irrigation immediately after forage cut is required for better rejuvenation. On an average, 180-240 and 24-35 q/ha of green fodder and grains, respectively, were produced from dual purpose barley. Variety RD 2035 can be taken for dual purpose as it is superior in fodder, grain and GEY. 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. Seed rate can be enhanced to 125 kg/ha from 100 kg/ha for getting higher productivity of green forage as well as grain and 25 per cent higher fertilizer (75kg N/ha) 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. To get best performance of dual purpose barley varieties, nitrogen (75 kg N/ha) should be applied in three splits i. e. 1/3 as basal+1/3 immediate after cut+1/3 at next irrigation. Forage cut at 60 DAS had produced significantly higher yield of crude protein (24.2 q/ha), crude fibre (2.1 q/ha), ether extract (6.4 q/ha), mineral matter (0.62 q/ha), nitrogen free extract (2.31 q/ha) and digestible dry matter (0.62 q/ha) than forage cut at 45 DAS. Timely sowing for the dual purpose barley is required for optimum forage, grain and straw production from barley.

REFERENCES

Anonymous. 2016 : Progress Report of All India Coordinated Wheat and Barley Improvement project 2015-16. *Director's Report*, G. P. Singh (ed.). ICAR-Indian Institute of Wheat and Barley Research, Karnal, India. p. 96.

Bisht, J. K., S. Saha, and A. K. Srivastva. 2009 : Agronomic performance and fodder of dual purpose barley cultivars under rainfed condition of N-W Himalaya. *Forage Res.*, **35** : 12-16.

Choudhary, K. K., N. S. Yadava, S. L. Yadav, and R. C. Jat. 2014 : Green fodder yield and quality of barley (*Hordeum vulgare* L.) as affected by levels of nitrogen. *Forage Res.*, **39** : 190-196.

Choudhary, M. K., and P. C. Chaplot. 2015 : Effect of sowing dates and fertility levels on nutrient uptake and quality of dual purpose barley varieties. *Forage Res.*, **41** : 188-190.

El-Shatnawi, M. K. J., L. Z. Al-Qurran, K. I. Ereifej, and H. M. Saoub. 2004 : Management optimization of dual-purpose barley (*Hordeum spontaneum*) for forage and seed yield. *J. Range Manage*., **57** : 197-220.

Harrison, M. T., J. R. Evans, H. Dove, and A. D. Moore. 2012 : Dual purpose cereals : Can the relative influences of management and environment on crop recovery and grain yield be dissected? *Crop Pasture Sci*., **62** : 930-946.

Hundal J. S., B. Kumar, M. Wadhwa, M. P. S. Bakshi, and H. Ram. 2014 : Nutritional evaluation of dual purpose barley as fodder. *Indian J. Anim. Sci.*, **84** : 298-301.

Jain, R. K., and R. P. Nagar. 2010 : Fodder yield and other traits of barley varieties as influenced by sowing and cutting schedules. *Range Management and Agroforestry Symposium Issue*, **B** : 167-171.

Jarial, S. 2015 : Comparative analysis of fodder and grain from dual purpose barley vis-a- vis local variety in hills of Uttarakhand, India. *Indian Res. J. Ext. Edu.* **15** : 47-51.

Kapoor, R., A. Singh, and R. K. Bajaj. 2010 : Comparing forage production potential and nutritional quality of barley and oat cultivars under Punjab conditions. *Range Management and Agroforestry Symposium Issue*, **A** : 1-3.

Kaur, G., A. Singh, C. S. Aulakh, and J. S. Gill. 2013 : Variation in forage yield and quality trait of dual purpose barley under different agronomic practices. *Forage Res.*, **39** : 42-44.

Kaur, G., C. S. Aulakh, and J. S. Gill. 2009 : Evaluation of dual purpose barley (*Hordeum vulgare* L.) as influenced by varieties, row spacing and time of cutting. *Indian J. Ecol.*, **36** : 143-145.

Kharub, A. S., R. P. S. Verma, and B. Sarkar. 2007 : Optimization of date of cutting for green fodder in dual purpose barley. DWR News, **1** : 4.

Kharub, A. S., R. P. S. Verma, D. Kumar, V. Kumar, R. S. Kumar, and Indu Sharma. 2013 : Dual purpose barley (*Hordeum vulgare* L.) in India : Performance and potential. *J. Wheat Res*., **5** : 55-58.

Ladha, J. K., H. Pathak, T. J. J. S. Krupnik, and C.V. Kessel. 2005 : Efficiency of fertilizer nitrogen in cereal production : Retrospects and prospects. *Adv. Agron.*, **87** : 85-156.

Mani, J. K., R. Singh, D. Singh, R. K. Pannu, and K. Singh. 2006 : Effect of sowing dates and row spacings on yield and yield attributes of barley. *Haryana J. Agron.*, **22** : 129-31.

Meena, N. K., J. Choudhary, and H. 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 Res*., **42** : 109-114.

Midha, L. K., K. S. Panwar, and N. K. Sharma. 1994 : Effect of cutting frequency and time of nitrogen application on yield and quality of oat. *Forage Res.*, **25** : 99-102.

Noworolnik, K. 2013 : Morphological and qualitative characters, and yield of spring barley depending on cultivar properties and sowing date. *Fragm. Agron.*, **4** : 105-113.

Pandey, A. K. 2005 : Effect of agronomic practices on green fodder, grain yield and economics of dual-purpose wheat (*Triticum aestivum*). *Indian J. Agr. Sci*., **75** : 27-29.

Sadreddine, B. E. J. I. 2016 : Yield and quality of dual-purpose barley and triticale in a semi-arid environment in Tunisia. *African J. Agric. Res*., **11** : 2730-2735.

Sharma, N. K. 2007 : Effect of sowing time and cutting management on fodder yield of barley. *Range Manage. Agrof*., **28** : 334-335.

Sharma, N. K. 2009 : Evaluation of dual purpose barley varieties under irrigated situation. *Range Managem. and Agrof*., **30** : 57-58.

Sharma, N. K. 2015. Relative performance of dual purpose oat and barley genotypes for green fodder and seed yield in arid Rajasthan. *Forage Res*., **41** : 160-163.

Singh, B., A. K. Dhaka, and M. Kumar. 2016 : Performance of dual purpose barley varieties under different nitrogen application schedules. *Forage Res*., **41** : 246-248.

Singh, B., A. K. Dhaka, R. K. Pannu, and S. S. Rathi. 2012c : Effect of nitrogen scheduling on fodder and grain yield of dual purpose barley varieties. Extended Summary, Vol 2. 3rd International Agronomy Congress, Nov. 26-30, New Delhi. 488-489 pp.

Singh, D., D. R. Singh, V. Nepalia, and A. Kumari. 2012a : Performance of dual purpose barley (*Hordeum vulgare* L.) varieties for green fodder and subsequent productivity under varying seed rates and fertility management. *Forage Res.*, **38** : 133-137.

Singh, G., D. R. Thakur, D. K. Parmar, and S. Manuja. 2012b : Effect of different nitrogen levels and its scheduling on dual purpose barley under rainfed conditions in north-western Himalayas. *Extended Summaries, Vol. 2*. 3rd International Agronomy Congress on Agriculture Diversification, Climate Change, Management and Livelihoods held at New Delhi from November 26-30, 2012. pp. 67-68.

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

Verma, R. P. S., A. S. Kharub, D. Kumar, B. Sarkar, R. Selvakumar, R. Singh, R. Malik, R. Kumar, and I. Sharma. 2011 : Fifty years of co-ordinated barley research in India. Directorate of Wheat Research, Karnal. *Res. Bull.*, **27** : 46.

Verma, R. P. S., A. S. Kharub, R. K. Sharma, R. Singh, and B. Mishra. 2007 : *Jau Anusandhan – Paramparik Se Vayasayik Upyog Ki Aur*. Directorate of Wheat Research, Karnal. *Res. Bull.*, **23** : 36.

Yadav, R. K., A. Kumar, and D. Lal. 2003 : Effect of cutting management and nitrogen levels on biomass production and proximate quality of barley (*Hordeum vulgare*) in saline soil. *Indian J. Agron.*, **48** : 199-202.