International Journal of Agricultural Sciences
Volume 14 | Issue 2 | June, 2018 | 318-326
e ISSN-0976-5670
DOI:10.15740/HAS/IJAS/14.2/318-326
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RESEARCH PAPER

'Response of dual purpose barley (*Hordeum vulgare* L.) varieties, sowing dates and fertility levels in sub- humid southern plains of Rajasthan

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Abstract : Dual propose barley varieties RD 2715 and RD 2552 proved equally effective in improving growth parameters (plant height, total tillers m^{-1} row) Dry matter accumulation at and after green fodder cutting compared to variety RD 2035. Both varieties RD 2715 at par with RD 2552, took longer duration to attain 50% heading and maturity, produced significantly higher number of effective tiller m^{-1} row, ear length, grain ear^{-1}, grain weight ear^{-1} and tes weight, recorded significantly higher green fodder yield by 6.52 and 5.17 t ha^{-1} over RD 2035, respectively. Variety RD 2552 at par with RD 2715 produced higher grain, straw and biological yield over variety RD 2035. Influence of sowing time revealed that various yield attributes *viz.,* effective tillers, ear length grains ear^{-1}, grain weight ear^{-1} and test weight were significantly improved under 15th November sowing compared to successive delay in sowing by 10 days *i.e.* on 25th November and 5th December. The crop sown on 15th November produced higher fodder, grain, straw and biological yield. Application of 75 kg N + 25 kg P_2O_5 ha^{-1} to dual purpose barley crop significantly improved plant height, total tiller m^{-1} row and dry matter at accumulation at successive growth stages before, at and after green foddder cutting over application of 60 kg N + 20 kg P_2O_5 ha^{-1}. Significant improvement in yield attributes *viz.*, effective tillers, ear length, grains ear^{-1}, test weight and grain weight ear^{-1} over application of lower fertility level *i.e.* 60 kg N + 20 kg P_2O_5 ha^{-1}. The significant improvement in aforesaid yield attributes led to highest green fodder, grain and straw yield of 30.77, 3.89 and 6.68 t ha^{-1} under application of 75 kg N + 25 kg P_2O_5 ha^{-1} as to compared 29.91, 3.60 and 6.09 t ha^{-1} under 60 kg N + 20 kg P_2O_5 ha^{-1}, respectively. Variety RD 2552 fetched highest net returns of Rs. 78398 which was found at par RD 2715 with Rs. 76580, however both recorded significantly higher net returns by Rs. 15363 and 13545 ha^{-1}, respectively over RD 2035. The highest B/C ratio of 3.84 was recorded with variety RD 2552 which was at par with RD 2715 with B/C ratio of 3.75 however both varieties recorded significantly higher B/C ratio over RD 2035.

Key Words : Dual purpose barley, Sowing dates, Productivity, Fertility level, Fodder yield

View Point Article : Choudhary, Mahesh Kumar, Yadav, Mukesh Kumar 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. *Internat. J. agric. Sci.*, **14** (2) : 318-326, **DOI:10.15740/HAS/IJAS/14.2/318-326.**

Article History : Received : 05.03.2018; **Revised :** 21.04.2018; **Accepted :** 07.05.2018

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INTRODUCTION

Barley (*Hordeum vulgare* L.) is a valuable crop because it is grown for several purposes such as food and processed food products for human being and feed for cattle and poultry birds. Barley grain is also valued for smothering and cooling effect on the body for easy digestion. Besides these conventional uses, it is an important industrial crop as it is used as raw material for beer, whisky and brewing industries. Each 100 g of barley grain comprise 10.6 g protein, 2.1 g fat, 64 g carbohydrate, 50 mg calcium, 6.0 mg iron, 31 mg vitamin B_1, 0.10 mg vitamin B_2 and 50 µg folate (Vaughan *et al*., 2006). The small and marginal farmers of Rajasthan cut the green barley and feed it to farm and milch animals as a part of their nutrition.

In recent past, India has made an impressive progress in achieving self sufficiency in food grain production by elevating productivity of several crops. However, forage production for livestock is limited and costly due to erratic rainfall especially in Rajasthan. Barley is generally grown in areas where irrigation facilities are limited, as it can tolerate moisture and salt stress to a great extent (Yadav *et al.,* 2003). It possesses high total biomass, thus there has been an increasing interest in exploiting it as a dual purpose cereal which can permit forage production in early season in addition to the grain yield later on (Singh *et al.,* 2009 and DWR, 2010a). This suggest an ample scope for growing dual purpose barley for obtaining moderate yield of green fodder as well as grain from the same crop. Growing of dual purpose barley genotypes having wider adaptability and responsive to inputs has opened a new avenue for exploiting higher green fodder and subsequent grain yield potential (DWR, 2010b). Several authors have agreed upon the importance of rapid regeneration of leaf area after forage removal to establish sufficient photosynthetic capacity to support maximum grain yield (Singh *et al.,* 2009). Barley is harvested as green fodder at vegetative stage, the opportunity for producing grain is eliminated by the plants because of less subsequent new leaf area and its ability to prevent tiller senescence during the period between jointing and anthesis (Singh *et al.,* 2009). Thus identification of high yielding adaptable dual purpose varieties as per crop growing situation is considered to be the first and foremost step for development of production technology.

MATERIAL AND METHODS

The experiment was laid out at the Instructional Farm, Rajasthan College of Agriculture, Udaipur, which is situated at 24° 35' N latitude, 72° 42' E longitude and at an altitude of 579.5 m above mean sea level. It falls under agro-climatic zone IV a (Sub-Humid Southern Plain and Aravali Hills) of Rajasthan.The experiment was conducted in Split-Plot Design with three dual purpose barley varieties namely RD 2552, RD 2715 and RD 2035 with three sowing dates and with two fertility levels. soils of experimental field was clay loam in texture, slightly alkaline in reaction (pH 7.8), medium in available nitrogen (295.3 kg ha^{-1}) and phosphorus (16.60 kg ha^{-1}) and high in available potassium status (275.70 kg ha^{-1}).

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads:

Performance of varieties :

Growth characters :

The results showed that among dual purpose varieties, RD 2715 was at par with variety RD 2552 and both these varieties grew taller, produced higher tillers and DMA at successive growth stages and at green fodder cutting compared to variety RD 2035. Likewise after green fodder cutting, the dual purpose barley variety RD 2552 being at par with RD 2715 and both grew taller, produced higher tillers and DMA at successive growth stages and harvest compared to variety RD 2035. Days to 50 % heading and maturity period of variety RD 2552 was also significantly greater by 3 and 1.8 days, respectively than variety RD 2035.It is well known fact that growth and yield potential of genotypes are interactive outcome of genetic potential, environmental conditions and agronomic support provided during the life cycle. Since all these varieties were grown under identical agronomical and climatic conditions, the differential behavior of these varieties with respect to all these growth parameters could be ascribed to their genetic capabilities to exploit available resources for their growth and development.

The increased tillers and plant height of dual purpose barley varieties RD 2552 and RD 2715 seems to have increased interception, absorption and utilization of radiant energy thereby resulting in higher accumulation of photosynthates and finally dry matter in variety RD 2715 before green fodder cutting and RD 2552 after green fodder cutting. The correlation studies further substantiate positive relationship between DMA and tiller

m^{-1} row length and plant height before green fodder cutting. Further a unit increase in tillers m^{-1} row length and plant height increased DMA by 0.270 and 0.062 g, respectively. Alike this, the DMA at harvest (after green fodder cutting) also showed strong relationship with tillers m^{-1} row length and plant height at harvest. The unit increase in these parameters increased DMA at harvest by 0.050 and 0.024 g $plant^{-1}$. The finding of this investigation fall in line with those observed by Sirohi (2001); Yadav (2001) and Rawat (2011).

Yield attributes :

The dual purpose barley variety RD 2715 produced significantly higher green fodder yield which was at par with RD 2552 but both proved significantly superior over RD 2035 (Table 1). The green fodder yield is sum of growth contributing factors controlled by both genetically and agronomical manipulation. The highest green fodder yield in variety RD 2715 seems to be an account of overall improvement in growth as evinced from taller plant, higher production of tillers and dry matter. Among dual purpose barley varieties, variety RD 2552 recorded higher effective tillers m^{-1} row length, $grains^{-1}$ ear, ear length, grain weight ear^{-1} and test weight followed by variety RD 2715, however both varieties significantly improved aforesaid yield attributes over RD 2035. The significant improvement in yield components in variety RD 2552 and RD 2715 manifested in increased productivity of these varieties in terms of grain, straw and biological yield by 19.46, 7.34, 11.88 and 12.09, 12.07, 7.67 per cent, respectively over RD 2035 (Table 2).

It is an established fact that high growth rate and vigour attained by plant during vegetative stage after first cutting results in accumulation of more dry matter, which in turn diverts more quantity of photosynthates towards sink during reproductive phase. The variation in growth characters during vegetative growth stage due to varieties under present investigation might have responsible for variation in yield attributes also. Similar finding were also reported by Singh and Singh (2006) and Mattas *et al*. (2011). They revealed that yield attributes are mainly controlled by the genetic makeup of genotype but upto some extent, it also affected by environmental conditions and thus it varies from variety to variety.

The significant increase in yield attributes in variety RD 2552 and RD 2715 seems to be an account of overall

Table 1 : Growth parameters

Treatments	Plant height (cm)	Tillers 55 DAS (m^{-1} row)	DMA (g 0.25 m^{-1} row length)			Days to 50 % heading	Days to maturity	Plant height (cm) at harvest	Total tillers (m^{-1} row length) at harvest	DMA (g 0.25 m^{-1} row length)		
			20 DAS	40 DAS	55 DAS					30 days	60 days	At crop harvest
Varietetes												
RD 2715	78.25	94.84	7.90	39.53	56.55	87.16	124.00	88.36	100.84	43.90	68.03	105.93
RD 2035	72.61	85.63	7.00	33.27	52.45	85.11	123.00	84.29	91.63	40.65	63.33	98.65
RD 2552	77.55	93.56	7.63	36.61	54.65	87.96	124.83	89.43	99.56	44.73	68.08	107.45
S.E.±	1.40	2.22	0.10	1.03	0.72	0.33	0.44	1.32	2.22	0.98	1.34	1.96
C.D. (P=0.05)	4.21	6.65	0.29	3.08	2.17	0.98	1.33	3.97	6.65	2.95	4.03	5.87
Sowing dates												
15th November	80.62	103.37	8.60	40.58	57.68	86.89	124.00	91.28	109.37	48.08	70.30	111.00
25th November	76.19	91.22	7.45	37.10	53.90	86.67	123.83	87.26	97.22	41.00	65.90	103.95
05th December	71.61	79.44	6.50	31.75	52.10	86.67	124.00	83.54	85.44	40.20	63.23	97.08
S.E.±	1.40	2.22	0.10	1.03	0.72	0.33	0.44	1.32	2.22	0.98	1.34	1.96
C.D. (P=0.05)	4.21	6.65	0.29	3.08	2.17	NS	NS	3.97	6.65	2.95	4.03	5.87
Fertility levels												
60 kg N + 20 kg P_2O_5 ha^{-1}	74.09	86.57	7.45	33.65	51.80	86.81	123.96	85.12	92.57	40.38	64.03	101.25
75 kg N + 25 kg P_2O_5 ha^{-1}	78.18	96.12	7.58	39.30	57.33	86.67	123.93	89.60	102.12	45.83	68.93	106.75
S.E.±	1.01	1.37	0.03	0.57	0.34	0.09	0.20	0.98	1.37	0.7659	0.78	1.54
C.D. (P=0.05)	3.00	4.06	0.10	1.69	1.02	NS	NS	2.92	4.06	2.2756	2.32	4.59

NS=Non-significant

improvement in growth as evinced from higher production of dry matter as well as there was greater availability of growth inputs matching with formation and development of yield components. It is well established fact that number and growth of yield components is outcome of complementary interaction between vegetative and reproductive growths of a crop. The greater availability of photosynthates as evinced from higher biomass in variety RD 2552 and RD 2715 might have resulted in enhancing effective tillers m^{-1} row length. Besides this, greater availability of growth inputs seems to have promoted growth of ears of variety RD 2552 and RD 2715 as well as number of $grains^{-1}$ ear and consequently grain weight ear^{-1} compared to variety RD 2035. Test weight is significantly influenced by prevailing growing conditions and genetic potential of a variety. Conversely higher test weight of variety RD 2552 and RD 2715 seems to be an account of faster seed filling process. The regression and correlation studies also validated profound role of DMA at harvest on ear length, grains ear^{-1}, test weight and grain weight ear^{-1}. The results corroborate with finding of Karwsara *et al*. (1998), Sharma (2007) and Rawat (2011). The grain yield of barley is the sum total of different yield contributing factors controlled both genetically and agronomical manipulation. Since barley yield formation is a complex process and interaction governed by complimentary interaction between source (photosynthesis and availability of assimilates) and sink component (storage organs). In the present study, the higher yield of both dual purpose barley varieties RD 2552 and RD 2715 may be attributed to its higher biomass accumulation due to higher number of tillers, plant height and its proper partitioning as evident from equally higher harvest index and good yield attributes *i.e.* effective tillers, ear length, grains ear^{-1}, grains weight and test weight. Variety RD 2035 recorded lowest grain yield due to lower biomass accumulation after green fodder cutting as a result of least number of tillers, plant height, DMA and yield component *viz.*, effective tillers, grain ear^{-1}, grain weight ear and test weight. Similar results were reported by Dhaka *et al*. (2006), Shirpurkar *et al*. (2007) and Rawat (2011). A significant and positive correlation was also recorded in between grain yield and yield attributing characters *viz.*, effective tillers, test weight, ear length, grain ear, and grain weight ear. Further higher capability

Table 2 : Yield attributes and yield

Treatments	Yield attributes					Yield (t ha^{-1})				Harvest index (%)
	Effective tillers m^{-1} row length	Ear length (cm)	Grains ear^{-1}	Grain weight ear^{-1} (g)	Test weight (g)	Green fodder	Grain	Straw	Biological	
Varietetes										
RD 2715	89.56	7.00	20.05	0.603	36.83	32.96	3.80	6.44	10.24	37.67
RD 2035	81.63	6.51	18.93	0.568	34.49	26.44	3.39	6.13	9.51	35.63
RD 2552	90.84	7.27	20.75	0.617	37.63	31.61	4.05	6.58	10.64	38.04
S.E.±	2.22	0.15	0.35	0.009	0.33	0.46	0.09	0.10	0.16	0.53
C.D. (P=0.05)	6.65	0.46	1.04	0.027	1.00	1.39	0.27	0.29	0.48	1.59
Sowing dates										
15^{th} November	99.37	7.55	21.06	0.644	38.15	31.84	4.22	7.15	11.36	37.18
25^{th} November	87.22	6.97	19.91	0.597	35.99	30.34	3.85	6.60	10.45	36.86
05^{th} December	75.44	6.26	18.76	0.547	34.82	28.83	3.18	5.41	8.58	37.29
S.E.±	2.22	0.15	0.35	0.009	0.33	0.46	0.09	0.10	0.16	0.53
C.D. (P=0.05)	6.65	0.46	1.04	0.027	1.00	1.39	0.27	0.29	0.48	NS
Fertility levels										
60 kg N + 20 kg P_2O_5 ha^{-1}	82.57	6.50	18.85	0.575	35.84	29.91	3.60	6.09	9.69	37.19
75 kg N + 25 kg P_2O_5 ha^{-1}	92.12	7.35	20.97	0.618	36.80	30.77	3.89	6.68	10.57	37.04
S.E.±	1.37	0.08	0.28	0.006	0.24	0.19	0.03	0.08	0.09	0.31
C.D. (P=0.05)	4.07	0.24	0.84	0.018	0.70	0.57	0.10	0.23	0.27	NS

NS=Non-significant

of dual purpose barley varieties RD 2552 and RD 2715 to produce straw yield seems to be primarily due to increase in morphological parameters (tillers m^{-1} row length) and stem thickness. A significant and positive correlation between straw yield and dry matter accumulation at harvest, showed dependence of straw yield on DMA at harvest. The biological yield is a function of grain and straw yields. Thus significant increase in biological yield of variety RD 2552 and RD 2715 could be ascribed to increase in grain and straw yield. These results are in close agreement with finding of Rawat (2011).

Effect of sowing dates :

Growth characters :

The results showed that amongst sowing time, the crop sown early *i.e.* on 15th November produced maximum plant height, total tiller m^{-1} row length and DMA at successive growth stages before and after green fodder cutting. At final harvest, the magnitude of increase in DMA 0.25 m^{-1} row length was 4.31 and 13.90 per cent over 25th November and 5th December sowings, respectively.

In general, overall improvement in growth and vigour of the crop sown on 15th November could be ascribed to favorable internal environment of the plants as well as external environment (atmospheric conditions) to which it was exposed during its life cycle. Under the present study, significant improvement in accumulation of biomass and nutrients amply suggests prevalence of congenial internal environment of plants for its growth and development under 15th November sown crop. Beside this, the crop sown during this period was also exposed to optimum environmental (climatic variables) and soil moisture conditions required for its proper growth. Mavi (1986) stated that plants can realize its genetic programmed phasic development under certain ranges of environmental factors. Significant increase in total tillers m^{-1} row length under early sowing over late sowing before and after fodder cutting also substantiate that under 15th November sowing, the availability of favourable environmental conditions (external and internal) led to better growth of each components. Further, the estimates of nutrient uptake also revealed improvement in endogenous nutrient status of plants under 15th November sown crop. Thus increased availability of nutrients seems to have promoted vegetative growth by way of active cell elongation, thereby, improving morphological parameters (plant height, tillers $plant^{-1}$ etc.). Improvement in these parameters under 15th November sowing might have helped in rapid initiation of leaves, while on the other hand higher nutrient uptake seems to have provided adequate supply of nutrients thereby helped in vigorous growth of plants. The reduction in morphological parameters under 25th November and 5th December sowing was due to the crop experienced low temperature at the time of tiller initiations and increased temperature at time of tiller survival during later stage of growth. The above results are in close agreement with the findings of Zhao *et al*. (1985) who reported that growth period was shortened with delayed sowing. Kozlowsaka (1993) indicated that delay in sowing increased the percentage of short tillers in the stand. The results are in the close conformity with finding of Sirohi (2001); Sharma (2007) and Chakrawarty and Kushwaha (2007).

The significant increase in DMA at successive growth stages seems to be on account of larger canopy development due to production of higher number of tillers and plant height before and after green fodder cutting under early sown crop *i.e.* 15th November. These might have increased interception, absorption and utilization of radiant energy as well as larger duration available for the growth and development of the crop. The significant reduction in DMA could be ascribed to significant reduction in total tillers and plant height under delayed sowing. The correlation analysis also validated dependence of final DMA on total tillers and plant height before and after green fodder cuttings. The significantly higher DMA with early sowing was in close conformity with the finding of Ghosh *et al.* (2000); Sirohi (2001); Mishra *et al.* (2003); McKenzie *et al.* (2005); Guixia *et al.* (2010) and Singh *et al.* (2013).

Yield attribute and yield :

Data on yield attributes of the crop under the influence of sowing time revealed that various yield attributes *viz*., effective tillers, ear length grains ear^{-1}, grain weight ear^{-1} and test weight were significantly improved under 15th November sowing compared to successive delay in sowing by 10 days *i.e.* on 25th November and 5th December. The crop sown on 15th November produced higher fodder, grain, straw and biological yield by 4.94, 9.61, 8.33, 8.71 and 10.44, 32.70, 32.16, 32.40 per cent over 25th November and 5th December sowings, respectively.

The marked improvement in various yield attributes of the crop seems to be on account of increased capacity of the early sown crop to exploit environmental resources (above and below ground) for yield synthesis. Besides, adequate supply of growth inputs (metabolites and nutrients), the congenial climatic conditions seems to have helped the plant to exploit their potential for reproductive growth. The production of higher amount of photosynthates in early sown crop (15th November) might be due to longer duration (flowering and maturity) which helped the plant to develop the larger sink in order to accumulate synthesized photosynthates. Thus resulted increased growth and development of each yield component. Reduction in ear length under late sown condition might be due to fact that there would have been low temperature in the beginning but after February onward the temperature starts rising very fast and the plant do not get significant favorable environment to express their full potentiality. Further high temperature during the later part of the reproductive stages in 25th November and 5th December sowing caused forced maturity of the crop resulting in development of grains which were small, shriveled and of low weight as evident from its low test weight. The significant positive correlations between DMA at harvest and yield attributes also suggests positive interrelationship between these parameters and DMA at harvest. These results are close conformity the observation of Singh *et al.* (2013).

Thus, as a consequence of favorable climatic conditions, improvement in growth and yield attributing characters, the crop sown early produced significantly higher yield. The regression analysis indicate that a unit increase in effective tillers m^{-1} row, ear length, grains ear^{-1}, test weight and grain weight ear^{-1} increased the grain yield by 0.030, 0.457, 0.204, 0.122 and 11.24 t ha^{-1}, respectively. The significant increase in fodder yield under early sowing (15th November) seems to be due to their direct effect in improving DMA m^{-1} row while indirect effect might be on account of increased morphological parameters *i.e.* tiller m^{-1} row and plant height. Further, biological yield is a function of grain and straw yield. While increased grain and straw yield under 15th November sowing resulted in production of higher biological yield. Such observations were also reported by Sirohi (2001); Mani *et al.* (2006) and Chakrawarty and Kushbwaha (2007) who reported that dual purpose barley sown early gave significantly higher grain and straw yield compared to crop sown late *i.e.* beyond 25th November.

Effect of fertility levels :

Growth characters :

Application of 75 kg N + 25 kg P_2O_5 ha^{-1} to dual purpose barley crop significantly improved plant height, total tiller m^{-1} row and dry matter at accumulation at successive growth stages before, at and after green foddder cutting over application of 60 kg N + 20 kg P_2O_5 ha^{-1}. At harvest the magnitude of increse in DMA was 5.43 per cent. Amongst mineral nutrients, N and P are considered to be most important for exploiting genetic potential of crop through growth and development Halvin *et al.* (2003). Nitrogen is considered to be essential for synthesis of chlorophyll, which is of great physiological significance in plant system, whereas, P is involved in root growth. It also plays an active role in formation of high energy phosphate which are unstable in water and act as carrier for vital reactions like oxidation of sugars through enhancing enzymatic activities and in initial reaction for photosynthesis etc. Similar results have also been reported by Halvin *et al.* (2003) and Meena *et al.* (2011).

Under present investigation, the preponderant effect of application of 75 kg N + 25 kg P_2O_5 ha^{-1} on various growth parameters of the barley crop before and after harvesting of green fodder appears to be on account of enrichment of soil with both of these nutrients to the level of sufficiency. The significant improvement in nutrient status of plant parts (green fodder, grain and straw) resulted in better availability of nutrient for growth and development of the plant right from early stage, as nutrient in harvestable plant part are mostly translocated from vegetative to reproductive parts. Thus better nutritional environment in plant under the influence of application of higher fertility levels *i.e.*75 kg N + 25 kg P_2O_5 ha^{-1} to barley crop might have enhanced meristematic activities in plant thereby increased division, enlargement and elongation of cells resulting in higher plant height. The larger canopy development on account of higher number of total tillers m^{-1} row length and plant height under application of 75 kg N + 25 kg P_2O_5 ha^{-1} might have increased interception, absorption and utilization of radiant energy resulting in higher photosythesis and finally accumulation of dry matter 0.25 m^{-1} row length at successive growth stages before and after green fodder cutting. The significant positive correlation between dry matter accumulation at green fodder cutting and plant height and number of tillers m^{-1} row length also validated above findings. Further, regression analysis also indicated strong dependence of dry matter accumulation on plant height and tillers mrow length as a unit increase in plant height and number of tillers increase DMA by 0.270 and 0.062 g 0.25 m^{-1} row length. Similarly, after green fodder cutting aforesaid correlation again validated strong positive relationship between DMA at harvest and plant height and total tillers m^{-1} row length at harvest. The regression analysis also indicated strong dependence of dry matter on these growth parameters. The observed relationship is in close agreement with finding of Kumawat and Jat (2005); John *et al*. (2008); Narolia (2009) and Rawat (2011).

Yield attributes and yield :

Results presented in Table 2 revealed that application of higher fertility level *i.e.* 75 kg N + 25 kg P_2O_5 $ha^{-1}$to barley crop resulted significant improvement in yield attributes *viz.*, effective tillers, ear length, grains ear^{-1}, test weight and grain weight ear^{-1} over application of lower fertility level *i.e.* 60 kg N + 20 kg P_2O_5 ha^{-1}. The significant improvement in aforesaid yield attributes led to highest green fodder, grain and straw yield of 30.77, 3.89 and 6.68 t ha^{-1} under application of 75 kg N + 25 kg P_2O_5 ha^{-1} as to compared 29.91, 3.60 and 6.09 t ha^{-1} under 60 kg N + 20 kg P_2O_5 ha^{-1}, respectively.

The additional supply of 25 per cent nitrogen and phosphorus to barley crop resulted enrichment of soil with these nutrient to the level of sufficiency. Thus better and higher availability of these nutrients right from sowing caused vigorous growth of individual plant as reflected through increased plant height and dry matter at successive growth stages after green fodder cutting.

Furthermore, in preceding text, it was well emphasized that N and P fertilization play vital role in improving nutritional status of plant in both vegetative and reproductive part. These improvements suggest greater availability of metabolites and nutrients synchronized to demand for growth and development of each reproductive structure. Thus higher availability of both these inputs as evinced from N and P content in grain and straw, plant height and dry matter accumulation demonstrate reduced competition of these between developing structure, consequently improving functional activity of each reproductive structure. The positive interrelationship between test weight and nutrient content of grain N and P further affirms role of N and P fertilization in improving individual seed weight by virtue of increasing nutritional conditions. Further, the regression analysis also substantiated strong dependence of number of effective tillers, ear length, number of grains ear^{-1}, test weight and grain weight ear^{-1} on dry matter accumulation at harvest. A unit increase in dry matter increased number of effective tillers m^{-1} row length, ear length, number of grains ear^{-1}, test weight and grain weight ear^{-1} by 0.05, 0.46, 0.20, 0.12 g and 0.24 g, respectively. Positive response of barley crop to N and P fertilization is in close agreement with the findings of Bisht (2009), Shaktawat and Shekhawat (2010), Rawat (2011) and Meena *et al.* (2012).

Significant increase in green fodder yield due to application of 75 kg N + 25 kg P_2O_5 ha^{-1} could be ascribed to the fact that green fodder yield of crop is a function of several growth components. The positive correlation between number of tillers m^{-1} row length, plant height and dry matter accumulation also substantiated dependence of green fodder yield on these components. Further a unit increase in aforesaid components increased the green fodder yield to the magnitude of 0.095, 0.479 and 1.294 t ha^{-1}.

It has been well emphasized that N and P fertilization play vital role in improving three major aspects of yield determination *i.e.*, formation of vegetative structure for nutrient absorption, photosynthesis and strong sink strength through development of reproductive structure and production of assimilates to fill economically improved sink (source strength). Thus, cumulative influence of N and P application seems to have maintained balanced source sink through improving both the events of crop development (vegetative and generative), ultimately resulted in increased grain yield ha^{-1}. The increase in grain yield under additional N and P fertilization might be on account of positive interrelationship between grain yield and various yield attributes *i.e.* effective tillers m^{-1} row length, ear length, grain ear^{-1} (r =0.503**) and test weight. A unit increase in aforesaid yield attributes increased grain yield to the tune of 0.30, 0.457, 0.204 and 0.122 t ha^{-1}, respectively. The finding of this investigation fall in line with those observed by Shaktawat and Shekhawat (2010) and Meena *et al.* (2012).

The significant increase in straw yield with additional N and P fertilization seems to be due to its direct effect in improving biomass $plant^{-1}$ at successive growth stages as well as in plant part at harvest of the crop, while the indirect effect might be on account of increase in various morphological parameters *viz.*, plant height and number of tillers. Further, biological yield is a function of grain and straw yield representing reproductive and vegetative growth of the crop. The profound influence of N and P fertilization on both of these characters mediated via increased photosynthetic efficiency and nutrient accumulation might have ultimately led to production of higher biological yield under its application. The results of present investigation indicated higher production of dual purpose barley under influence of higher fertility levels. These results are in close conformity with the findings of Sharma and Verma (2010) and Rawat (2011).

REFERENCES

Bisht, J.K. (2009). Effect of different cropping sequences and fertility levels on the winter dual purpose food and fodder crops. *Archives Agron. & Soil Sci.,* **55** : 515-524.

Chakrawarty, V.K. and Kushwaha, K.P. (2007). Performance of barley (*Hordeum vulgare*) varieties under sowing dates and nitrogen levels in Bundelkhand. *Prog. Res.,* **2** : 163-164.

Dhaka, A.K., Bangarwa, A.S., Pannu, R.K., Malik, R.K. and Garg, R. (2006). Phenological development, yield and yield attributes of different wheat genotypes as influenced by sowing time and irrigation levels. *Agric. Sci. Digest,* **26**: 174-177.

Ghosh, D.C., Nandi, P. and De, B. (2000). Phenological development and productivity of wheat (*Triticum aestivum*) at different dates of sowing. *Indian J. Agric. Sci.,* **70**: 393-395.

Guixia, Zhao Guang, C., Xu, K., Xuhong, C., Yang, Y., Ma, S., Ming, F. and Fengjiao, X. (2010). Effect of sowing date and density on grain yield and nutrition quality and physiological index of wheat. *Chinese J.Triticeae Crops,* **30**: 687-692.

Havlin, J.L., Beaton, J.D., Tisdale, S.L. and Nelson, W.L. (2003). Soil fertility and fertilizer. 4th Ed., Pearson Education Pvt. Ltd. Indian Branch, 482 FIE.

John, T., Donovan, O., Georage, W.C., Clayton, A., Grant, K., Neil, H.T., Kelly, T. and Newton, Z.L. (2008). Effect of nitrogen rate and placement and seeding rate on barley productivity and wild oat fecundity in a zero tillage system. *Crop Sci.,* **48**: 1569-1574.

Karwsara, R.S., Gupta, S.N. and Kadian, R.S. (1998). Response of barley (*Hordeum vulgare* L.) varieties to nitrogen under rainfed conditions of Rohtak. *Crop Res.,* **15** : 31-33

Kozlowsaka, P.Z. (1993). Changes in structure and architecture of plant canopy of two and six-rowed spring barley cultivars as influenced by sowing dates. *Pamietnik Pulawski*. No. **102** : 53-54.

Kumawat, P.D. and Jat, N.L. (2005). Effect of organic manure and nitrogen fertilization on productivity of barley (*Hordeum vulgare* L.). *Indian J. Agron.,* **50** : 200-202.

Mani, J.K., Singh R., Singh, D., Pannu, R.K. and Singh, K. (2006). Effect of sowing dates and row spacing on yield and yield attributes of barley. *Haryana J. Agron.,* **22**: 129-131.

Mavi, H.S. (1986). Introduction to Agrometerology. Oxford and IHB Publication Company Bombay.

McKenzie, R.H., Middleton, A.B. and Bremer, E. (2005). Fertilization, seeding date, and seeding rate for malting barley yield and quality in southern Alberta. *Canadian J. Plant Sci.,* **85**: 603-614.

Meena, L.R., Mann, J.S., Jat, H.S., Chand, R. and Karim, S.A. (2011). Response of multi-cut fodder barley (*Hordeum vulgare* L.) to varying levels and N application under semi-arid condition of Rajasthan. *Indian J. Agron.,* **81**: 344-7.

Meena, L.R., Mann, J.S. and Meena, S.L. (2012). Effect of levels and mode nitrogen application on dual purpose barley (*Hordeum vulgare* L.) under semi-arid condition. *Indian J. Agron.,* **57** : 168-170.

Mishra, V., Misra, R.D., Singh, M. and Verma, R.S. (2003). Dry-matter accumulation at pre- and post-anthesis and yield of wheat (*Triticum aestivum*) as affected by temperature stress and variety. *Indian J. Agron.,* **48**: 277-281.

Narolia, G.P. (2009). Response of malt barley (*Hordeum vulgare* L.) to levels and scheduling of nitrogen application under varying growing environments. Ph.D. Thesis, Department of Agronomy, SKRAU, Bikaner.

Rawat, D.S. (2011). Performance of dual purpose barley (*Hordeum vulgare* L.) varieties under varying seed rates and fertility management. M.Sc. (Ag.) Thesis, Department of Agronomy, MPUAT, Udaipur**.**

Shaktawat, R.P.S. and Shekhawat, P.S. (2010). Soil fertility status as affected with and farmyard manure in *Kharif* crops and fertilizer levels in barley (*Hordeum vulgare* L.). *Indian J. Agric. Sci.,* **80** : 791-794.

Sharma, N.K. (2007). Effect of sowing time and cutting management on fodder yield of barley. *Range Mgmt. & Agroforestry,* **28** : 334-335.

Shirpurkar, G.N., Kashid, N.V. and Pisal, A.A. (2007). Effect of different sowing dates and varieties on yield and yield attributes of wheat. *Agric. Sci. Digest,* **27**: 68-70.

Singh, M., Niwas, R., Bishnoi, O.P. and Sharma, K. (2003). Phenology of wheat cultivars in relation to thermal indices under different management practices. *Haryana Agric. Univ. J. Res.,* **33** : 23-28.

Sirohi, A. (2001). Effect of sowing dates and fertility levels on productivity of different varieties of barley (*Hordeum vulgare* L.). M.Sc. (Ag.) Thesis, Department of Agronomy, MPUAT, Udaipur.

Verma, R.P.S. and Sarkar, B. (2010). Diversity for malting quality in barley (*Hordeum vulgare* L.) varieties released in India. *Indian J. Agric. Sci.,* **80**: 493-500.

Yadav, B.N. (2001). Performance of barley (*Hordeum vulgare* L.) varieties under varying fertilizer levels and microbial inoculation. M.Sc. (Ag.) Thesis, Department of Agronomy, MPUAT, Udaipur

Zaho, L.G., Lu, M.Q. and Li, G.M. (1985). Influence of sowing dates on growth and development of barley cv. Zhepi. *Zhejian Agric. Sci.,* **5** : 217-221.