International Journal of Agriculture and Plant Science
www.agriculturejournal.in
Online ISSN: 2664-7664, Print ISSN: 2664-7656
Received: 21-07-2025, Accepted: 21-08-2025, Published: 05-09-2025
Volume 7, Issue 5, 2025, Page No. 14-18

The effect of row spacing and nitrogen levels on growth and yield of barley (*Hordeum vulgare* L.)

Rahul Kumar Sharma, Mahipal Dudwal, Dr. Arjun Lal Choudhary
Department of Agriculture, Vivekananda Global University, Jaipur, Rajasthan, India

Abstract
A field during the *rabi* season of 2024-25 at the Agronomy Research Farm of Vivekananda Global University, Jaipur. The experiment consisted of four spacings (17.5, 20.5, 22.5, and 24.5 cm) in main plots and four nitrogen levels (75, 100, 125, and 150 kg N/ha) in subplots. The 16 treatment combinations were tested in a randomized block design with three replications. Based on research investigation, it was found that the application of row spacing significantly improved plant stand, yield attributes, and harvest index. However, row spacing of 17.5 cm was significantly superior to plant stand, growth parameters, and biological yield as compared to both 17.5 and 24.5 cm. Dry matter accumulation, number of tillers, all the yield attributes, grain yield, and biological yield increased significantly up to 125 kg N/ha. However, plant height and straw yield increased significantly up to 150 kg N/ha. At higher row spacing of 17.5 and 22.5 cm produced statistically similar yield, whereas at 17.5 cm row spacing produced significantly more grain yield than 22.5 and 24.5 cm.

Keywords: Row spacing, nitrogen, yield of barley

Introduction

Barley (*Hordeum vulgare* L.) is an ancient cereal grain, which upon domestication has evolved from largely a food grain to a feed and malting grain (Baik and Ullrich, 2008 [3]; Pourkheirandish and Komatsuda,2007) [20]. It is considered the fourth-largest cereal crop in the world, with a share of 7% of the global cereal production (Pal *et al.,* 2012) [17]. Barley can grow in a wider range of environments than any other cereal, including extremes of latitude, longitude, and high altitude (Vangool and Vernon, 2006) [30]. It is frequently described as the most cosmopolitan of the crops and is also considered as a poor man's crop because of its low input requirement and better adaptability to drought, salinity, alkalinity, and marginal lands (FAO, 2002) [7]. Barley has been cultivated in India since ancient times and is considered a sacred grain. In India, barley is cultivated on about 6.95 lakhs ha area with production of 17.43 lakhs tons and productivity of 2508 kg ha^{-1} (Anonymous, 2016). The major barley growing states in India are Rajasthan, Uttar Pradesh, Haryana, Punjab, Madhya Pradesh, Uttarakhand, Himachal Pradesh, Bihar, Jammu and Kashmir, West Bengal, Chhattisgarh, and Sikkim. Among states, Rajasthan occupied the highest area and production of barley, 3.67 lakhs ha and 10.17 lakhs tons respectively, followed by U.P. and Haryana. However, maximum productivity is recorded in Haryana (3642 kg ha^{-1}). In Punjab, barley production got a major boost up during 2012-13 and reached about 70,000 tons against the 47,000 tons in 2011-12 (http://www.moneycontrol.com, 2016).

In India, barley is cultivated in an area of 0.73mha with an annual production of 1.46 million tonnes of grain (Anonymous, 2016). It is cultivated mainly in the states of Uttar Pradesh, Rajasthan, Madhya Pradesh, Bihar, Haryana, and Punjab. In Rajasthan, the crop occupies an area of 1.91 lakh ha, producing 4.47 lakh tonnes with an average productivity of 2329 kg/ha. The average productivity of barley in the state is far behind the attainable yield of 40-50 q/ha, mainly because of inadequate and unbalanced supply of nutrients.

Material and methods

In Rajasthan, barley is grown both conserved moisture under tankbed situation and as an irrigated crop on light-textured marginal soils. The production of barley is low due to inadequate availability of nutrients and water scarcity at the Agronomy farm, Vivekananda Global University, Jagatpura, Jaipur, during *the rabi* season of the year 2024-25. The experiment was laid out at the Agronomy Farm, Vivekananda Global University, Jaipur, during the *rabi* season of 2022-23. Jaipur is situated at 26^0 5" North latitude and 75^0 28" East longitude at an altitude of 427 meters above mean sea level. In Rajasthan, this region falls under Agro-climatic zone-IIIA (Semi-Arid Eastern Plains). The climate of this region is typically semi-arid, characterized by extreme temperatures during both summers and winters. During summers, the temperature may go as high as 48 °C, while in winters, it may fall as low as -1.0°C. Frost is not uncommon during winter. The average annual rainfall of this tract ranges between 400 to 500 mm, most of which is contributed by the S-W monsoon during July and August. There is hardly any rain during winter and summer. The maximum and minimum temperatures during the crop season ranged between 37.9 ^{0}C to 17.3 ^{0}C and 21.5 ^{0}C to 0.3 ^{0}C, respectively. A total of 94.5 mm of rainfall was recorded during the cropping season. The relative humidity fluctuated between 34 to 69 per cent, while the average sunshine hours ranged between 4.1 to 9.7 hrs/day.

Results

Row spacing also had a significant effect on plant height at all stages of crop growth. The plant height increased consistently with each level of the decrease in row spacing from 17.5 cm to 20.5 cm, 22.5 cm, and then to 24.5 cm at all plant growth stages. The maximum plant height of 20.6, 53.3, and 109.4 cm was recorded with row spacing of 24.5 cm at 30, 60, 90, 120 DAS, and at maturity, respectively, followed by 20cm (19.5, 52.4, 101.7, 107.0, and 108.0 cm, respectively) and minimum at row spacing of 17.5cm (19.1, 50.0 and106.7cm, respectively).

The plant height was significantly increased with each increase in nitrogen levels up to 150 kgN/ha at all the stages of crop growth. The maximum plant height was recorded with 150 kg N/ha (21.5 cm), 60 (55.3 cm), and at harvest (112.0cm), followed by nitrogen levels of 125 and 100 kg N/ha, and minimum with 75 kgN/ha.

Table 1: Effect of row spacing and nitrogen levels on plant height (cm)

Treatments	Plantheight(cm)		
	30 DAS	60 DAS	Atharvest
Rowspacing(cm)			
17.5 cm	19.1	50.0	106.7
20.5 cm	19.2	52.3	106.9
22.5 cm	19.5	52.4	108.0
24.5 cm	20.6	53.3	109.4
SEm±	0.2	0.3	0.4
CDat5%	0.6	1.0	1.3
Nitrogenlevel(kg/ha)			
75	17.7	49.5	104.4
100	19.4	52.4	106.9
125	20.6	53.6	109.0
150	21.5	55.3	112.0
SEm±	0.2	0.3	0.4
CDat5%	0.6	1.0	1.3

Dry matter accumulation (g/m^{-2})

The rate of dry matter accumulation was slow up to the initial 30 days and highest between 30 to 60 DAS, and thereafter the increase was at a decreasing rate up to harvest.

Table 2: Effect of row spacing and nitrogen levels on dry matter accumulation (g m^{-2})

Treatments	Dry matter accumulation(gm^{-2})		
	30 DAS	60 DAS	At maturity
Row spacing(cm)			
17.5 cm	48.2	233.4	1445.2
20.5 cm	46	222.8	1380.9
22.5 cm	45.7	220.8	1369.6
24.5 cm	44.8	216.9	1345.4
SEm±	0.3	2.2	9.3
CDat5%	1.0	6.8	29.2
Nitrogen level(kg/ha)			
75	42.8	206.8	1281.2
100	46.2	222.2	1387.3
125	47.9	233.2	1434.0
150	48.6	235.3	1459.4
SEm±	0.3	2.4	10.3
CDat5%	0.9	6.8	29.4

The dry matter accumulation significantly increased with the decrease in row
spacing at all the growth stages. The differences in dry matter accumulation under different spacing increased with the advancement of crop growth. The maximum dry matter accumulation was recorded with row spacing of 24.5 cm as compared to 22.5 cm row spacing and minimum with spacing of 17.5 cm at 30, 60 DAS, and at harvest. The increase in dry matter accumulation with 17.5 cm row spacing was 7.59, 7.61, and 7.42%over24.5cm and 5.47, 5.71, 5.52 % over 22.5 cm and 4.78, 4.76, 4.66% over 20.5 cm row spacing at 30, 60 DAS, and at harvest stages, respectively.

The dry matter accumulation m^{-2}increased significantly with the increase in nitrogen levels up to 125 kg N/ha. However, the maximum dry matter accumulation m^{-2} was recorded with 150 kg N/ha, which was statistically at par with 125 kg N/ha but significantly higher than 100 and 75 kgN/ha at all the stages of crop growth. Atharvest, the increase in dry matter was 8.3, 11.9, and 13.9 % with 100, 125, and 150 kg N/ha over 75 kg N/ha, respectively.

Number of tillers m^{-2}

The data pertaining to the number of tillers m^{-2} at different stages of crop growth are presented in Table 3. The number of tillers increased slightly up to 60 DAS and thereafter marginally decreased at harvest.

Table 3: Effect of row spacing and nitrogen levels on the number of tillers/m^2

Treatments	Number of tillers/m^2			Test weight(g)
	30 DAS	60 DAS	At harvest	
Row spacing(cm)				
17.5 cm	795.5	831.1	818.2	39.0
20.5 cm	740.2	774.7	762.9	40.8
22.5 cm	727.9	762.5	751.3	41.4
24.5 cm	672.9	701.7	690.8	41.9
SEm±	4.3	4.9	5.4	1.0
CDat5%	13.4	15.6	17.0	NS
Nitrogen level(kg/ha)				
75	694.8	729.6	717.4	40.4
100	727.3	758.5	747.1	41.0
125	749.9	782.5	770.8	41.8
150	756.2	789.9	778.5	40.9
SEm±	3.1	4.0	4.3	1.0
CDat5%	8.8	11.6	12.3	NS

Among different row spacing treatments, significantly higher numbers of tillers m^{-2} were recorded with row spacing of 24.5 cm as compared to 22.5, 20.5, and 17.5 cm (672.9) row spacing. The later two row spacings were also differed significantly with respect to the number of tillers m^{-2}. Row spacing of 17.5 cm had 18.22, 9.29, 7.47 per cent, 18.44, 9.00, 7.28, and 18.44, 8.90, and 7.25 per cent over 17.5 cm, 20.5 cm, 22.5 cm more tillers over 24.5 cm over spacing, at 30,60 DAS and at harvest, respectively.

The number of tillers m^{-2}increased with the increase in nitrogen levels up to 150 kg N/ha. The maximum number of tillers m^{-2} (756.2, 789.9, and 778.5) was recorded with 150 kg N/ha, which was statistically at par with 125 kg N/ha (749.9, 782.5, and 770.4) but both were significantly higher than 100 and 75 kg N/ha at 30, 60 DAS, and at harvest, respectively.

Test weight (g)

Harvest index was also not significantly influenced by various nitrogen levels; however, it was numerically maximum at 125 kg N/ha, followed by 75, 100, and 125 kg N/ha.

Grain yield (q/ha)

The grain yield of barley was significantly influenced by row spacing (Table 4. The highest grain yield (34.16 q/ha) was obtained with row spacing of 17.5 cm, which was significantly higher (6.45%) over the treatment where row spacing was 24.5 cm (32.09 q/ha) but was statistically at par with row spacing of 20.5 cm (33.52 q/ha). Also, 17.5 cm

row spacing produced significantly higher grain yield than 20.5 cm row spacing.
The data in Table 4 revealed that among different nitrogen levels, 150 kg N/ha and 125 kg N/ha in barley recorded almost similar grain yield (35.02 and 34.97 q/ha, respectively), and both these treatments produced significantly higher grain yield than 100 and 75 kg N/ha (32.74 and30.28q/30.28 q/ha, respectively). The increase in grain yield was 8.1, 15.5, and 15.7%with 75,90 and 105 kgN/ha over 60kgN/ha, respectively.

Straw yield (q/ha)
The straw yield was increased significantly with decreasing row spacing. Highest straw yield (76.80 q/ha) was recorded in the treatment with row spacing of 17.5 cm and minimum straw yield (72.74 q/ha), which was closely followed by spacing of 20.5 cm (75.33 q/ha) and both these treatments recorded significantly higher straw yield than spacing of 22.5 cm (74.00 q/ha). Row spacing of 17.5 cm and 20.5 cm gave 5.58 and 3.56 % more straw yield than 22.5 cm row spacing, respectively.
The straw yield of barley increased significantly with each increase in nitrogen levels up to 150 kg N/ha. The increase in straw yield was 8.5, 12.5, and 16.3 % with 100, 125, and 150 kg N/ha over the 75 kg N/ha level (Fig. 4.6).

Biological yield (q/ha)
The highest biological yield was recorded with 17.5 cm of row spacing (110.96 q/ha), which was significantly higher than both 20.5cmrowspacing (108.85 q/ha) and 22.5 cm, 24.4cm row spacing, with the lowest biological yield of 106.12, 104.83 q/ha. Row spacing of 20.5 cm was also significantly superior to 24.5 cm in respect of biological yield. The per cent increase in biological yield was 5.58 and 3.56 % with 17.5 and 20.5 cm row spacing, as, compared to 24.5cm row spacing, respectively.
The biological yield of barley varied significantly among different nitrogen levels. The highest biological yield (114.77q/ha) was recorded with 150 kgN/ha, which was at par with 125 kg N/ha (112.12 q/ha) but was significantly higher than 100 and 75 kg N/ha. The percent increase in biological yield was 8.4,13.4, and 16.8 with 100,125, and 150kgN/ha over 75 kgN/ha, respectively (Fig. 4.6).

Harvest index (%)
The data in Table 4 revealed that different row spacing did not affect the harvest index of barley significantly.
Harvest index was also not significantly influenced by various nitrogen levels; however, it was numerically maximum at 125kg N/ha, followed by 75, 100, and 125 kg N/ha.

Table 4.6 Effect of row spacing and nitrogen levels on yields and harvest index

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Biological yield (q/ha)	Harvest index (%)
Row spacing(cm)				
17.5 cm	34.16	76.8	110.96	30.79
20.5 cm	33.52	75.33	108.85	30.79
22.5 cm	32.12	74	106.12	30.27
24.5 cm	32.09	72.74	104.83	30.61
SEm±	0.28	0.56	0.61	0.251
CDat5%	0.89	1.75	1.91	NS
Nitrogen level(kg/ha)				
75	30.28	68.56	98.84	30.64
100	32.74	74.37	107.11	30.60
125	34.98	77.15	112.12	31.21
150	35.02	79.75	114.77	30.55
SEm±	0.40	0.77	0.85	0.404
CDat5%	1.26	2.48	2.70	NS

Discussion
Plant stands m^{-2} at 15 DAS and plant height at all crop growth stages, increased consistently with each level of the decrease in row spacing from 24.5 cm to 22.5 cm, 20.5 and then to 17.5cm. Dry matter accumulation increased with the decrease in row spacing. The maximum dry matter accumulation was recorded at a spacing of 17 cm, and minimum where the minimum was kept 24.5 cm. This was due to the fact that narrow row spacing caused higher leaf photosynthesis and suppressed weed growth as compared to wider row spacing, as observed by Dwyer *et al.* (1991) [5]. The results of the present study are in conformation with the results of Tollenaar and Auguilera (1992) [29], Iqbal *et al.* (2012) [11, 12], and Egly and Guffy (1997) [6]. The number of tillers m^{-2} increased significantly with decreasing row spacing from 24.5 cm to 17.5 cm, and the maximum number of tillers $m^{-2}$was recorded with 17.5 cm spacing. Increase in number of tillers m^{-2} with decreasing row spacing was also reported by Ottman (1998) [16] and Shah (2000).
The plant height increased significantly with each increasing nitrogen level from 75 to 150 kg N/ha at all the stages of plant growth. It may be because nitrogen plays an important role in cell division and cell elongation, and thus growth of the plant. Increased plant height with the increasing level of nitrogen was also reported in barley by Meena *et al.* (2012) [11], Singh *et al.* (2013) [25, 26, 27]. Shafi*et al.* (2011) [23] in their experiment on barley found maximum plant height at 100 kg N ha^{-1}, followed by 80 kg N ha^{-1}. The dry matter accumulation m^{-2}, number of tillers $m^{-2,}$ increased significantly with the increase in nitrogen level up to 100 kg N/ha, as compared to 75 and 100 kg N/ha. However, further increase in nitrogen level to 125 kg N/hadid not significantly improve values of these parameters as compared to 100 kg N/ha but was significantly superior to 100 and 75 kg N/ha at all the stages of crop growth. The improvement in these growth parameters due to increased nitrogen application may be due to the fact that nitrogen helped in cell division and cell elongation, leading to an increased number of lateral (side) tillers, which results in higher dry matter production and higher leaf area per unitland area. Increase in drymatterwiththeincreasinglevelofnitrogenwasalsoreportedn

barley by Alam *et al.* (2005) [1], Natr (1997) [12] and Sonmez (2000) [28], Sandhu (2006) [22], and Singh *et al.* (2013) [25, 26, 27].

Yield is expected as the cumulative function of the factors that contribute to it. Economic yield of the crop depends on the source-sink relationship and on different components of the sink self, *viz.*, grain yield (q/ha), biological yield (q/ha), straw yield (q/ha), and harvest index (%). The source components may be the number of leaves, tillers, and dry matter of the plants before anthesis. As the main component of growth, the number of effective tillers at maturity decides the grain yield. Perusal of the results revealed that the maximum number of effective tillers m^{-2} at maturity (Table 4.5 was recorded with row spacing. The number of effective tillers m^{-2} increased significantly with the increase in and with the decrease in spacing from 24.5 to 17.5 cm. The results of the present study were supported by Ottman (1998) [16], Ijaz *et al.* (2002), Baloch *et al.* (2010) [4], and Iqbal *et al.* (2012) [11, 12].

The number of grains per spike and the number of effective tillers m-2 at maturity were recorded as maximum with the row spacing of 17.5 cm, which was significantly higher than 24.5 cm row spacing, but 17.5cm spacing was statistically at par with 20.5 cm row spacing with respect to the number of grains per spike. The two-row spacing, *viz*.,22.5 and 24.5cm, was statistically at par concerning the number of grains per spike but significant with respect to the number of tillers m^{-2}.

The grain, straw, and biological yield were increased significantly with decreasing row spacing. Highest grain, straw and biological yield were recorded in the treatment withrow spacing of 17.5 cm which were closely followed by spacing of 20.5 cm except in case of biological yield in which row spacing of 17.5 and 20.5 cm differed significantly with each other and both these treatments recorded higher grain, straw, and biological yield than spacing of 22.5 cm. The higher yields under narrow spacing of 17.5 cm are mainly attributed to better growth and yield parameters. Similar results were reported by Paynter (2010) [19] and Papworth (2010) [18]. However, Donovan *et al.* (2011) reported that in barley and oat, row spacing had little or no effect on seed yield. The interaction between row spacing was also found to be positively significant for grain yield. Row spacing of 22.5 and 17.5 cm yielded at par, whereas at 87.5 kg/ha, row spacing of 17.5 cm recorded significantly more grain yield. These results indicate that intra-row placement of seed in two-row barley is less desirable than inter-row placement.

The effective tillers m-2 increased significantly with increasing nitrogen up to 125 kgN/ha, and thereafter the yield attributes increased marginally up to 150 kg N/ha except 1000-grain weight, which decreased with 150 kg/ha. Increased yield attributes due to increasing levels of N were due to better growth parameters with the increasing level of N. These findings substantiate the results of O'Donovan *et al*. (2011), Singh *et al*. (2013) [25, 26, 27].

The grain and biological yield of barley increased significantly up to 125 kg N/ha. Whereas the straw yield was recorded significantly higher, up to 150 kg N/ha. Application of 100,75 and 100 kgN/ha increased grain yield by 8.1, 15.5, and 15.7 percent, straw yield by 8.5, 12.5, and 16.3 percent, and biological yield by 8.4, 13.4, and 16.8 percent, respectively, over the 60 kg N/ha level. The grain yield increase with increasing nitrogen levels was mainly due to more number of effective tillers m^{-2} at higher nitrogen levels and also due to a higher number of tillers per plant at higher nitrogen levels, i.e, at 125 and 150 kg N/ha. The higher straw and biological yields under higher doses of nitrogen were mainly attributed to better plant growth owing to increased N levels. The results of the present experiment were in unison with those obtained in barley by Rashid *et al*. (2010) [10], Sharma andVerma (2010) [24], and Singh *et al*. (2013) [25, 26, 27]. Interaction between spacing and nitrogen levels was also found positively positive for straw and biological yield. The results revealed that at higher spacing, the straw and biological yield increased up to the highest dose of N, i.e, 150 kg N/ha. This is mainly due to the fact that an increased plant population requires an additional dose of nitrogen for better plant growth.

Conclusion

Based on a one-year study, it can be concluded that, application of four-row barley spacing was found to be optimum in terms of growth, yield attributes (except 1000 grain weight), and yield as well as protein yield, malt yield, and economic returns. Among row spacing, 17.5 cm and 20.5 cm were at par and were significantly better as compared to 24.5 cm in terms of yield and economic returns. Among nitrogen levels, application of 125 kg N was found optimum in respect of growth, yield, quality, nutrient uptake, and economic returns of the four-rowed barley variety RD-5225.

References

1. Alam MZ, Haider SA, Paul NK. Effects of sowing time and nitrogen fertilizer on barley (Hordeum vulgare). Bangladesh Journal of Botany,2005:34(1):27–30.
2. Anonymous. World barley acreage and production from 2008/2009 to 2014/2015. Statista, 2014 http://www.statista.com/statistics.
3. Baik BK, Ullrich SE. Barley for food: Characteristics, improvement, and renewed interest. Journal of Cereal Science,2008:48:233–242.
4. Baloch MS, Shah ITH, Nadim MA, Khan MI, Khakwani AA. Effect of seeding density and planting time on growth and yield attributes of wheat. The Journal of Animal & Plant Sciences,2010:20(4):239–240.
5. Dwyer LM, Tollenaar M, Stewart DW. Changes in plant density dependence of leaf photosynthesis of maize (Zea mays) hybrids, 1959 to 1988. Canadian Journal of Plant Science,1991:71:1–11.
6. Egly DB, Guffy RD. Factors associated with reduced yields of delayed planting of soybean. Agronomy Journal,1997:159:176–185.
7. FAO. Food barley improvement. Food and Agriculture Organization of the United Nations, 2002 http://www.fao.org/ag/AGP/AGPC/doc/field/other/act.htm.
8. Khan IA, Bakht J, Shah WA, Khan N, Ullah I. Effect of seed rate on the yield and yield components of wheat under irrigated conditions of Peshawar. Asian Journal of Plant Science,2002:1:513–515.
9. Iqbal N, Akbar N, Ali M, Sattar M, Ali L. Effect of seed rate and row spacing on yield and yield components of wheat (Triticum aestivum). Journal of Agricultural Research,2012:48(2):588–591.

10. Iqbal N, Akbar N, Ali M, Sattar M, Ali L. Effect of seed rate and row spacing on yield and yield components of wheat (Triticum aestivum). Journal of Agricultural Research,2012:48(2):588–591.
11. Meena LR, Mann JS, Meena SL. Effect of levels and mode of nitrogen application on dual-purpose barley (Hordeum vulgare) under semi-arid conditions. Indian Journal of Agronomy,2012:57(2):168–170.
12. Natr L. The effect of nitrogen on dry matter allocation in young spring barley plants (Hordeum vulgare). Sciatica Agriculturae Biochemical,1997:28(1):7–16.
13. O'Donovan JT, Turkington TK, Edney MJ, Juskiw PE, McKenzie RH, Harker KN, *et al*. Effect of seeding date and seeding rate on malting barley production in western Canada. Canadian Journal of Plant Science,2012:92:321–330.
14. O'Donovan J, Kabeta YA, Grant C, MacLeod AL, Edney M, Izydorczyk M, *et al*. Relative responses of new malting barley cultivars to increasing nitrogen rates in western Canada. Canadian Journal of Plant Science,2015:95:424–432.
15. Otteson BN, Mergoum M, Ransom JK. Seeding rate and nitrogen management effects on spring wheat yield and yield components. Agronomy Journal,2007:99:1615–1621.
16. Ottman MJ. Row spacing and direction effects on yield, water use, tillering, and light interception of one-irrigation barley. Forage and Grain Agriculture Report, 1998 College of Agriculture, the University of Arizona, Tucson, Arizona, http://ag.arizona.edu/pubs/crops/az1059/az105915.html.
17. Pal D, Kumar S, Verma RPS. Pusa Losar (BHS380) – the first dual-purpose barley variety for the northern hills of India. Indian Journal of Agricultural Sciences,2012:82:164–165.
18. Papworth L. Guy Lafond, Agriculture and Agri-Food Canada. Agricultural Information Centre, Government of Alberta, 2010.
19. Paynter BH. Wide row spacing and rigid ryegrass (Lolium rigidum) competition can decrease barley yield. Weed Technology,2010:24(3):310–318.
20. Pourkheirandish M, Komatsuda T. The importance of barley genetics and demonstration in global perspectives. Annals of Botany,2007:100:999–1008.
21. Rashid A, Khan RU. Response of barley to sowing date and fertilizer application under rainfed conditions. World Journal of Agricultural Sciences,2010:6:480–484.
22. Sandhu A. Effect of irrigation and nitrogen levels on the yield and quality of two-row malt barley. M.Sc. Thesis, Punjab Agricultural University, Ludhiana, India, 2006.
23. Shafi M, Bakht J, Jalal F, Khan MA, Khattak SG. Effect of nitrogen application on yield and yield components of barley (Hordeum vulgare). Pakistan Journal of Botany,2011:43(3):1471–1475.
24. Sharma RK, Verma RPS. Effect of irrigation, nitrogen, and varieties on the productivity and grain malting quality in barley. Cereal Research Communications,2010:38(3):419–428.
25. Singh J, Mahal SS, Singh A. Productivity and quality of malt barley (Hordeum vulgare) as affected by sowing date, rate, and stage of nitrogen application. Indian Journal of Agronomy,2013:58:72–80.
26. Singh J, Mahal SS, Singh A. Productivity and quality of malt barley (Hordeum vulgare) as affected by sowing date, rate, and stage of nitrogen application. Indian Journal of Agronomy,2013:58:72–80.
27. Singh J, Mahal SS, Singh A. Productivity and quality of malt barley (Hordeum vulgare) as affected by sowing date, rate, and stage of nitrogen application. Indian Journal of Agronomy,2013:58:72–80.
28. Sonmez F. Effect of seed size and nitrogen fertilizer on root and shoot growth in the early development stage of barley. Turkish Journal of Agriculture & Forestry,2000:24(6):669–675.
29. Tollenaar M, Auguilera A. Ear and kernel formation in maize hybrids representing three decades of yield improvement. Crop Science,1992:32:432–438.
30. Vangool D, Vernon L. Potential impacts of climate change on agricultural land use suitability: Barley. Department of Agriculture, Western Australia, 2006. Report No:302.