International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(2): 1205-1215

Received: 02-01-2020
Accepted: 04-02-2020

Shipra Yadav
Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Rahul Kumar
Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Sanjay Singh Chauhan
Department of Agronomy, Narendra Deva University of Agriculture & Technology, (Kumarganj) Faizabad, Uttar Pradesh, India

Monu Kumar
Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Sandeep Kumar
Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Corresponding Author:
Shipra Yadav
Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Influence of different nitrogen levels on growth, productivity, profitability, nutrient content and protein yield of barley cultivars in Sodic soil of Uttar Pradesh

Shipra Yadav, Rahul Kumar, Sanjay Singh Chauhan, Monu Kumar and Sandeep Kumar

DOI: https://doi.org/10.22271/chemi.2020.v8.i2s.8930

Abstract
A field experiment was conducted at Main Experimental Station (MES), Narendra Deva University of Agriculture & Technology, (Kumarganj) Faizabad (U.P.) during *Rabi* season 2016-17 to study the performance of barley varieties under various nitrogen levels in sodic soil. The experiment was laid out in split plot design (SPD). Nitrogen levels (60, 75 and 90 kg N ha^{-1}) were kept in main-plots and varieties (RD-2907, RD-2552, NDB-1173 and RD-2794) in sub-plots with three replications on sodic soils having low organic carbon (0.38 g kg^{-1}), available nitrogen (185.0 kg ha^{-1}), phosphorus (15.25 kg ha^{-1}) and potassium (265 kg ha^{-1}). All the growth parameters, yield attributes and yield increased significantly with increasing levels of nitrogen up to 90 kg ha^{-1}. Maximum plant height, no. of tillers, dry matter accumulation, number of spike m^{-1}, spike length, number of grain spike^{-1}, 1000 grain weight, straw yield and grain yield were recorded under 90 kg N ha^{-1} then 75 and 60 kg N ha^{-1}, which was significantly higher. Variety RD-2907 recorded significantly higher Plant height, number of tillers, dry matter accumulation, LAI, yield attributes, grain and straw yields over variety RD-2794 and NDB-1173 while at par with RD-2552. Maximum protein content (10.54%) was recorded with the application of 90 kg N ha^{-1} which was at par with 75 kg N ha^{-1} and significantly higher than 60 kg N ha^{-1}. The varieties had no-significant effect on the protein content in grain. Maximum protein yield (278.51 kg ha^{-1}) was recorded with the application of 90 kg N ha^{-1} and the lowest protein yield was recorded with the application of 60 kg N ha^{-1}. The maximum net return (Rs. 45511 ha^{-1}) and B:C ratio (1.74) were obtained under variety RD-2552 at 90 kg N ha^{-1}.

Keywords: Barley cultivars, nitrogen levels, productivity.

Introduction
Barley (*Hordeum vulgare* L.) is one of the world's fourth most important cereals after wheat, rice and maize in the world. It is popularly known as "Jau". India ranks 7th in respect to total area and production. Barley is the major cereal in many dry areas of the world and is vital for the livelihoods of many farmers. Barley is an annual cereal crop and grown in environments ranging from the desert of the Middle East to the high elevation of Himalayas (Hayes *et al.*, 2003) [9]. In India, barley crop was grown over an area of seven lac hectare with a production of 1700 mt and productivity of 22.50 qha^{-1} during 2016-17 (Anonymous, 2017) [3]. Uttar Pradesh is one of the most important barley growing state of India. Barley is superior to wheat with respect to some minerals and fiber contents. It contains water soluble fiber (Betaglucons) and oil compound (tocotrinal) which one found effective in lowering the cholesterol level of blood. Being a good source of protein. This crop has industrial demand due to use of malt. It is used in different forms such as bread, porridge, soup and roasted grain and for preparing alcoholic and non-alcoholic drinks. Barley grain has good nutritive value, which contains about 11.5% protein, 74% carbohydrate, 1.3% fat, 3.9% crude fiber, 1.5% ash and 1.2% minerals. In addition, the energy rich drinks like bournvita, boost, horlics, maltava etc. are prepared by the malt extracts of barley.
This crop has wider adoptability and needs less water and it is more tolerant to salinity and other stress conditions. Therefore, it is of great significance in areas where successful wheat

crop cannot be grown due to unsuitable soil and insufficient irrigation. The preached grains of barley are consumed in many parts of Uttar Pradesh, Rajasthan and Haryana. Due to its perceived cooling effect on human system; it is preferred to wheat for consumption during summer. Consumption of barley is reported to reduce the cholesterol levels in liver and plasma by inhibiting the rate limiting hepatic enzyme β-hydroxy, β-methyl glutaryl Co-A reductase. It also stimulates fatty acid synthesis in liver. Straw is used for animal feed, thatching roofs and bedding. Barley is a fast growing, cool season, annual grain crop that could be used as forage as well as cover crop to improve soil fertility. Generally, barley crop is grown separately for seed production and fodder purpose because if the barley crop is harvested for green fodder at vegetative stage then opportunity for producing seed is eliminated. Therefore, it is necessary to develop strategies for obtaining moderate yield of green forage as well as seed from the same crop by adopting appropriate management practices. It will be helpful in alleviating the acute shortage of green fodder during the winter season and in obtaining the good seed yield from the barley crop. The crop is sown with minimal care and management under residual moisture. It has been observed by several workers that after one cut of barley for fodder and good seed yield can also be obtained. Barley is very sensitive to insufficient nitrogen and very responsive to nitrogen fertilization. The most important role of nitrogen in the plant is its presence in the structure of protein and nucleic acids, which are the most important building and formative substances from which the living material or protoplasm of every cell is made. In addition, nitrogen is also found in chlorophyll, coloring the green matter of plants. Excessive nitrogen causes excessive vegetative growth, resulting in greatly increased danger of lodging, delayed maturity and greater susceptibility to diseases and pests. Nitrogen application at proper dose has the most important effect in terms of increasing crop production. Farmers use nitrogen fertilizers indiscriminately without adequate information concerning actual soil requirements.

Nitrogen is a key factor in achieving an optimum yield in cereals and in their growing period requires lot amount of absorbed nitrogen. Proper dose of nitrogen increased leaf area, tillers formation, leaf area index and leaf area duration and which lead to greater production of dry matter and grain yield. Salinity stress affect plants nutrient uptake and metabolic activity in plant. However, salinity and alkalinity effects magnitude is depending upon plant species and level of salinity. Salinity and alkalinity stress adversely affect all stage of growth and development such as germination growth and vigor of seeding, vegetative growth, flowering and grain filling and ultimately causing diminished economic yield and also quality of products. For most of the crops, nitrogen must be applied in two or three split doses coinciding with the crop growth stages when its requirement is high.

The growth characters of different varieties of barley varies from variety to variety due to genetic characteristics of varieties like higher growth in Lakhan variety of barley as compared to Vijaya, K-169, K- 125, and K-141 but the differences among cultivars were not significant with respect to dry matter accumulation. Barley cultivars are of different types that may affect their nitrogen uptake and utilization characteristics. Modern barley cultivars vary in height from semi dwarf to the tall types. The former generally produces more fertile tiller per plant, while the latter is superior in the number of kernels per ear. Nitrogen regime may affect these components differently. Information on the fertilizer rate and cultivar interactions may be important to improve nitrogen use efficiency associated with high yielding characteristics. Newly introduced variety may excel the out dated local variety in terms of increased yield per unit area. Similarly, nitrogen plays an important role among the environmental influences on crop production. Various researchers have reported that different barley genotypes showed differential response to nitrogen application. Nitrogen is commonly the most limiting nutrient for crop production in the major world's agricultural areas and therefore adoption of good N management strategies often results in large economic benefits to farmers. Among the plant nutrients, nitrogen plays a very important role in crop productivity (Zapata & Cleenput, 1986; Ahmad, 1999; Miao *et al.*, 2006; Oikeh *et al.*, 2007; Worku *et al.*, 2007) [27, 1, 10, 11, 26]. Nitrogen is the key element in achieving consistently high yields in cereals. Nitrogen is a constituent of many fundamental cell components such as nucleic acids, amino acids, enzymes, and photosynthetic pigments. The rate of uptake and partition of N is largely determined by supply and demand during various stages of plant growth. Soil N supply, for example must be high at tillering, stem elongation, booting, heading and grain filling requiring a greater amount of the development and growth of its reproductive organs and for an enhanced and high accumulation of proteins in the kernel. Nitrogen is considered one of the most important factors affecting crop morphology (Amanullah *et al.*, 2008a) [2], crop growth rate and grain yield (Amanullah *et al*., 2008b) in Northwest Pakistan. The amount of nitrogen that a barley crop needs to maximize yield and quality will depend on the seasonal conditions, soil type, and rotational history of the soil as well as the potential yield of the crop. Nitrogen is needed for early tiller development of barley to set up the crop for a high yield potential. Ayoub *et al*., (1994) [4] reported that spilt N application had little effect on yield, but decreased lodging and spike population with increased grain weight. Barley can replace wheat as the dominant crop due to its tolerance to drought and salinity. Barley is more productive under adverse environments than other cereals. The amount of nitrogen that a barley crop needs to maximize yield and quality will depend on the seasonal conditions, soil type, and rotational history of the soil as well as the potential yield of the crop. Nitrogen is needed for early tiller development of barley to set up the crop for a high yield potential. Increased grain yield with increase in nitrogen level. However, increasing N fertility beyond a certain limit induced lodging and ultimately decreased grain yield and its components. grain yield and quality of malt barley varieties is significantly influenced by rate of N fertilizer that means when assessing grain yield of cultivars in different rate of N fertilizer in different barely varieties. The main factors N and variety were significantly affected either on the yield parameters, but the interactions were less consistent. It is now well established that for most of the crops, nitrogen must be applied in two or three split doses coinciding with the crop growth stages when its requirement is high therefore, it is high time to assess the effect of optimum dose of nitrogen to increase the production of barley.

Keeping the above points in view, present study was conducted to work out the suitable dose of nitrogen for barley varieties under sodic soil condition and to find out the high yielding variety of barley for better performance and productivity in sodic soil of Uttar Pradesh.

Methods and Materials

The field experiment was conducted during Rabi season of 2016-17 at MES Farm, Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad which is situated 42 km away from Faizabad-Raibareli road. The experimental site falls under sub-tropical zone in Indo-Gangetic plains and lies between 26^{0}47´North latitude, 82^{0}12´East longitudes, at an altitude of about 113.0 meter from mean sea level and is subjected to extremes of weather conditions. The region received an average rainfall of about 1200 mm out of which about 80% is concentrated from mid-June to end of September. The winter months are very cold whereas summer months are hot and dry. Westerly hot winds are started from the April and remain continue till onset of monsoon. In order to determine the fertility status and soil class. Soil samples were taken randomly from different places of the experimental field with the help of soil auger to a depth of 0-15 cm. The collected soil samples were mixed together to make composite sample representing the fertility of the whole field. These samples were air dried and grind with the help of pestle mortar and packed in polythene bag and analysed for different soil parameters. The region enjoys sub-tropical climate with an average annual rainfall of around 1200 mm, which is mostly received from July to September with a few showers in winter. The total rainfall during course of experimentation was 17.5 mm. The winter months are cold and occasionally frost occurs during this period. The summer is very hot and dry western ally hot winds start from the month of April and continue till the onset of monsoon. Metrological conditions such as maximum and minimum temperature, distribution of rainfall, relative humidity and sunshine hours recorded during the crop period *i.e.* from November 2016 to April 2017 have been illustrated in Figure 1. During the crop season, the lowest temperature (4.9 ^{0}C) was recorded in the month of January and the maximum (39.0 ^{0}C) in the month of April. The highest mean relative humidity (88.2%) was recorded in the month of January.

The experiment was laid out in split plot design with three levels of nitrogen (60, 75 and 90 kg N ha^{-1}) and four barley varieties RD-2907, RD-2552, NDB-1173, RD-2794 with three replications. There were 12 treatment combinations comprised of 3 nitrogen levels and 4 varieties. The treatments were allocated to different plots at random in all the three replications using the random table. The nitrogen was applied as per treatment through urea, however, 30 kg P_2O_5 ha^{-1} through DAP and 20 kg K_2O ha^{-1} through MOP was applied at the time of sowing as a basal dose. The crop was harvested at proper stage of maturity as determined by visual observations on (16 April 2017). Half meter length on either end of each plot and 2 border rows from each side as border were first removed from the field to avoid error. The crop in net plot was harvested for calculation of yield data. Produce was tied in bundles and weighted for biomass yield. Threshing of produce of each net plot was done by using pull man's thresher. The data collected from the experiment were subjected to statistical analysis with the procedure of Split Plot Design as suggested by Cochran and Cox (1970).

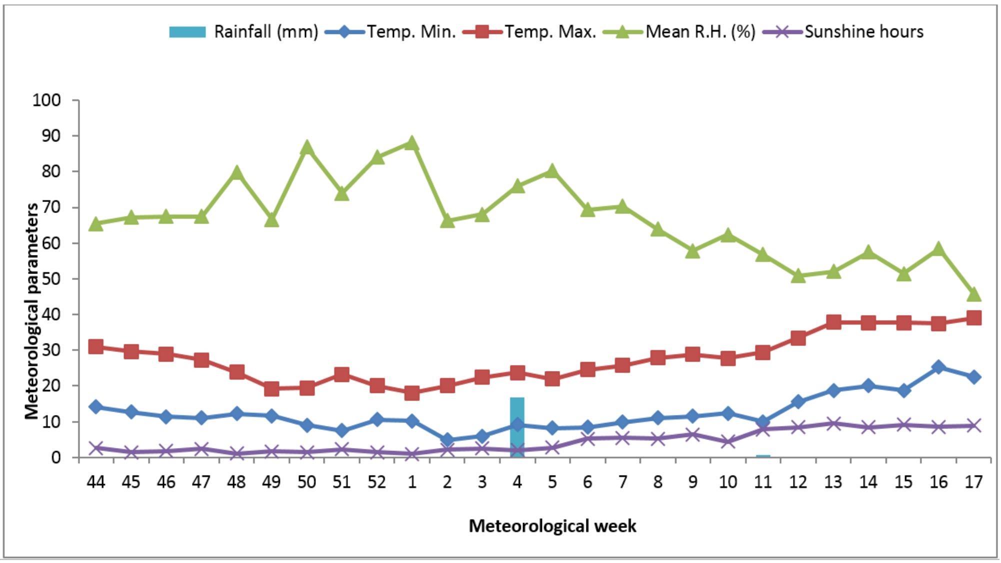

Fig 1: Mean weekly meteorological observations during crop season (Nonember, 2016 to April, 2017)

Results and Discussion

Growth parameters of Barley

In general, formation of tillers was very rapid from 30 to 60 DAS whereas the maximum number of tillers was recorded at 90 DAS and thereafter, there was gradual reduction in number of tillers. The number of tillers was influenced significantly by the rate of nitrogen at all the growth stages of crop except at 30 DAS. The maximum number of tillers m^{-1} was obtained with 90 kg N ha^{-1} which was at par with 75 kg N ha^{-1} and significantly superior over lower dose of nitrogen at all the growth stages of crop. Among the varieties the maximum no of tillers m^{-1} was recorded in variety RD-2907 which was at par with variety RD-2552 and significantly superior to RD-2794 and NDB-1173 at 60, 90 DAS and at harvest stages. At 30 DAS result was found non-significant. The number of tillers m^{-1} row length was influenced significantly by rates of nitrogen at all the stages of crop growth except 30 DAS. Maximum numbers of tillers were recorded under 90 kg N ha^{-1} at 90 days after sowing. This may be due to least plant competition for nutrient caused by sufficient supply of nitrogen which increased the better absorption of nutrients from the soil. Reduction in number of tillers after 90 days of sowing may be due to moratility of tillers. Similar results were reported by Sardana and Guoping (2005) [19] and Hooda and Singh (1979) [7]. The variety had the profound effect on number of tillers. At all stages of the crop growth except 30 DAS the number of tillers m^{-1} row length, was recorded significantly higher in variety RD-2709 while was equal comparable to RD-2552. Similar results were reported by Saini and Thakur (1999) [18].

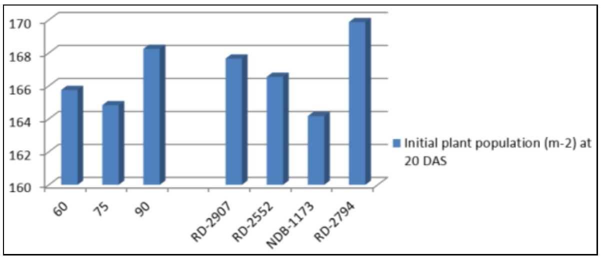

Fig 2: Initial plant population (m^{-2}) at 20 DAS

Plant height increased with advancement of the age. Data revealed that the rate of growth was rather slow during the initial stage up to 30 DAS thereafter, a rapid increase in growth was observed till 90 DAS, referring to its grand growth period. Plant height increased successively till the harvest stage but the increase was rather slow after 90 DAS. Plant height increased with increasing nitrogen levels. The maximum plant height was recorded with the application of 90 kg N ha^{-1} which was at par with 75 kg N ha^{-1} and significantly superior to rest of the lower level of nitrogen at all the growth stages of crop except 30 DAS. Among the varieties the maximum plant height was found in variety RD-2907, which was at par with variety NDB-1173 and significantly superior to RD-2794 and RD-2552 at 60,90 DAS and at harvest stages but did not significant impact at 30 DAS. The leaf area index during initial stage was rather slow and thereafter, increased rapidly between 30 to 60 DAS and then declined thereafter indicating grand growth period line between 60 to 90 DAS of the crop. There was rapid increased in height of plant from 30 to 90 days after sowing thereafter, increased in height was rather slow. Maximum plant height was recorded under 90 kg N ha^{-1} at all the crop growth stages, which was mainly due to more availability of nitrogen. Higher nitrogen levels resulted in higher nitrogen uptake, which could ultimately result in to increased protein synthesis, cell division, cell elongation and finally expressed morphologically on increased in height of the plant. Similar findings were reported by Raghuvanshi *et al.* (1987) [14], Saini and Thakur (1999) [18]. The plant height was affected significantly due to variety at all stages of growth. The height was recorded significantly higher in RD-2907 as compared to rest of the varieties. The taller plant associated with RD-2907 variety which might be due to varietal genetic characteristics and also due to proper availability of nitrogen throughout the crop growth coinciding with the germination, tillering and ear initiation stages. The results are in close proximity to those of Rawat (2011) [17].

Table 1: Effect of nitrogen levels and varieties on growth parameters of barley crop.

Treatments	**Growth Parameters**			
	Plant height (cm)	**Number of tillers (m^{-1})**	**Leaf area index**	**Dry matter accumulation (g m^{-1})**
(A) Nitrogen levels (kg N ha^{-1})				
60	76.85	73.54	4.03	148.49
75	80.49	77.08	4.40	169.27
90	83.71	80.99	4.55	178.67
SEm ±	1.22	1.22	0.070	0.88
$CD_{(P=0.05)}$	4.92	4.93	0.282	3.58
(B) Varieties				
RD-2907	83.55	80.39	4.51	183.11
RD-2552	77.95	78.00	4.37	180.70
NDB-1173	81.15	74.82	4.19	137.30
RD-2794	78.75	75.61	4.24	160.79
SEm ±	1.39	1.30	0.07	1.09
$CD_{(P=0.05)}$	4.17	3.91	0.22	3.29

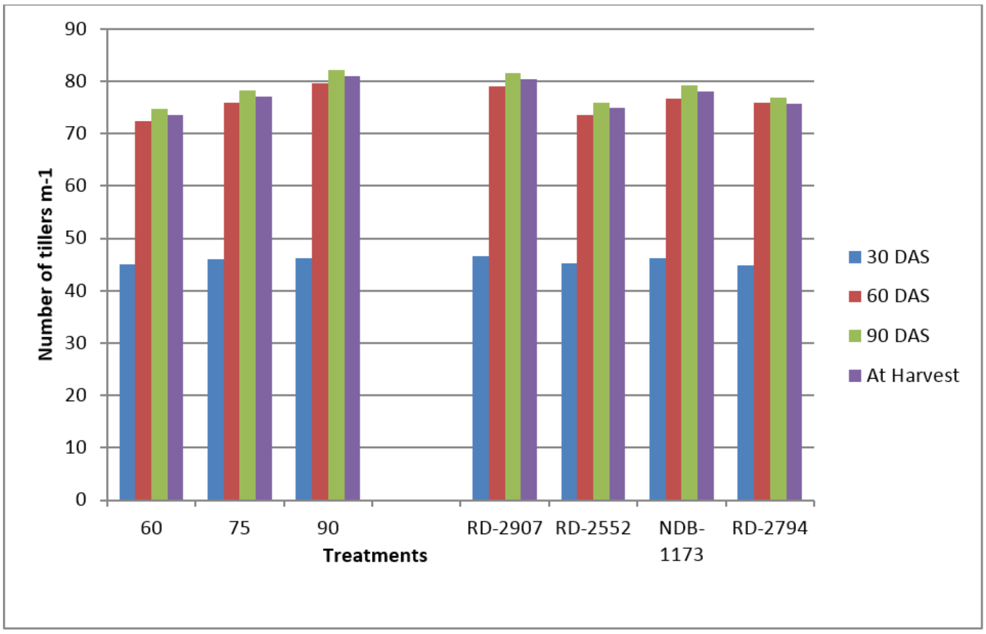

Fig 3: Effect of different treatment on number of tillers at various growth stages of crop

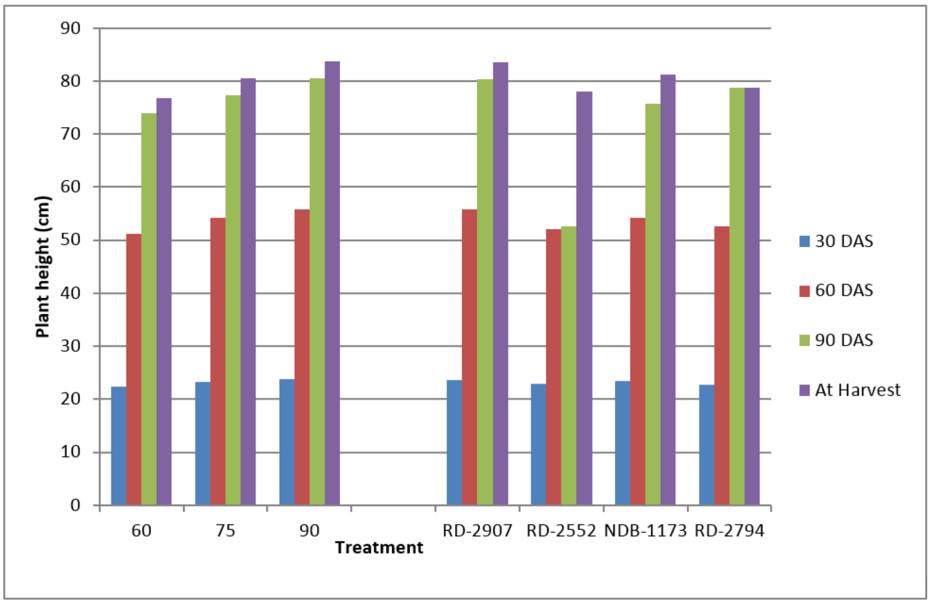

Fig 4: Effect of different treatment on plant height at various growth stages of crop

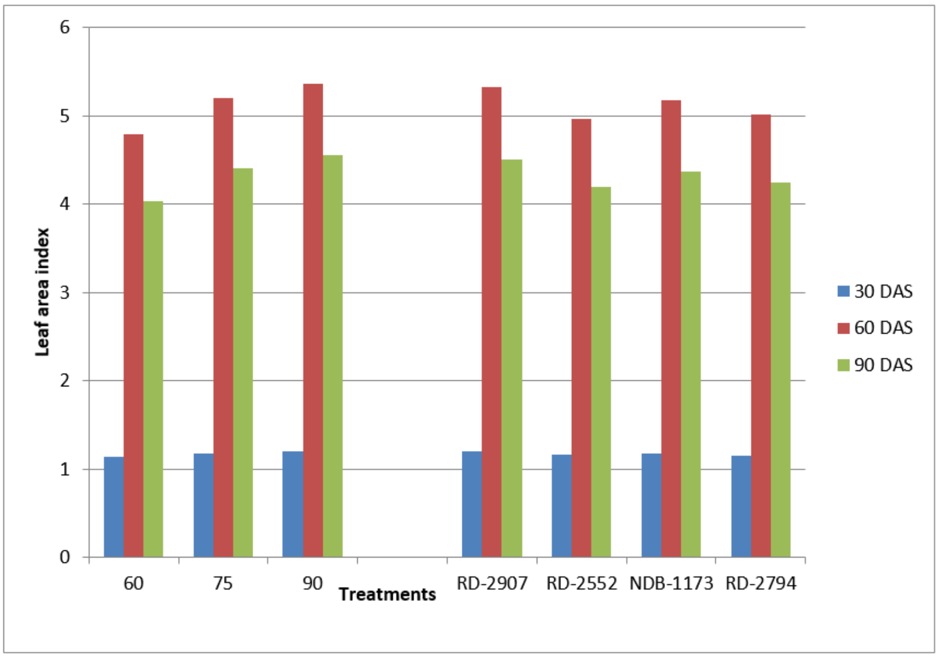

Fig 5: Effect of different treatments on leaf area index at various growth stages of barley crop

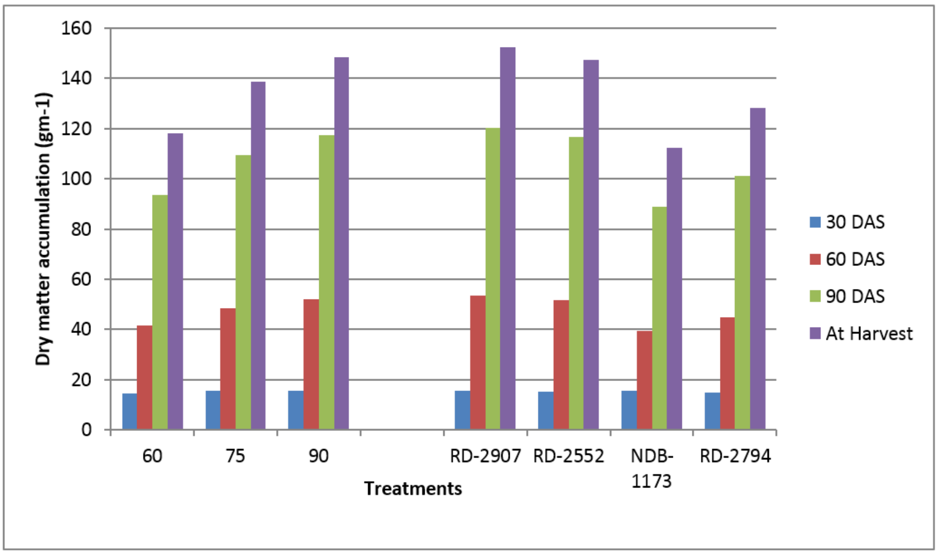

Fig 6: Effect of different treatments on dry matter accumulation at various growth stages of crop

It is quite evident from the data that increasing nitrogen supply successively increased the leaf area index and it was significantly affected due to different levels of nitrogen at 60 and 90 DAS. Maximum LAI recorded at 90 kg N ha^{-1} which was significantly superior to 60 kg N ha^{-1} and at par with 75 kg N ha^{-1} at 60 and 90 DAS. The varieties had significant effect on the leaf area index at all the successive stages of crop growth except at 30 DAS, the difference in leaf area index at 30 days was found non-significant. It was recorded maximum under the variety RD-2907 which was at par with RD-2552 and significantly higher over RD-2794 and NDB-1173 respectively at 60 and 90 DAS. The dry matter accumulation as affected by different barley varieties under different nitrogen levels. In general, dry matter accumulation increased with the advancement in crop age. The rate of increase in the dry matter production was very slow in the initial stage, up to 30 days. It was found faster from 30 days to maturity of the crops. The dry matter yield increased with increasing rates of nitrogen at all the stages, except at 30 DAS. The maximum dry matter accumulation was recorded under 90 kg N ha^{-1} which was at par with 75 kg N ha^{-1} and significantly superior to 60 kg N ha^{-1} at all stages except at 30 DAS. Leaf area index was affected significantly due to different nitrogen levels and varieties at all the stages of crop growth except at 30th day stage. Initially leaf area index (LAI) increased very slowly up to 30th day stage of crop growth and after that ushered in a rapid expansion up to 60th day stage. After that declining trend in LAI was observed. Slow increased in LAI at initial stage was due to less time available for growth and development of the plant. Rapid increase up to 60 DAS was possibly because of increased rate of light interception, high photosynthetic activities and increased absorption of nutrient from the soil. The reduction in LAI at 90 DAS might be due to increased senescence. The leaf area index increased with increasing the nitrogen levels and was recorded maximum under 90 kg Nha^{-1} at all the crop growth stages, except 30th day stage. This may be due to increased rate of light interception, high photosynthetic activities and increased absorption of nutrients from the soil. Meena *et al.* (2012) [9]. Leaf area index was affected significantly at all stages of crop growth due to variety except 30th day stage. It was recorded significantly higher in RD-2907 variety as compared to other but at par with RD-2552 varieties. It might be due to genetic characters. Similar findings were reported by Rawat (2011) [17] and Singh *et al.* (2013) [22]. Among the varieties maximum dry matter accumulation was recorded in RD-2907 which was at par with variety RD-2552 and significantly superior to rest of the varieties at 60, 90 DAS and at harvest stages but it was non-significant at 30 DAS. The different nitrogen levels had significant effect on the dry matter accumulation at all the successive stages of the plant growth, except 30 DAS. Maximum dry matter accumulation was recorded under 90 kg N ha^{-1} at all stages. This might be due to higher collective contribution of various growth characters like plant height, number of shoots, leaf area index and yield of vegetative part. Similar findings were reported by Singh *et al.* (2013) [22] and Singh *et al.* (2012) [22]. Dry matter accumulation of barley was affected significantly due to different variety at all the stages of the crop growth, it increased successively till the harvest. The rate of increase in dry matter production was slow during initial stage due to slow crop growth but it increased rapidly at later stages up to harvest due to bright sunshine, high photosynthetic activities. Maximum dry matter accumulation recorded in RD-2907 which was at par with RD-2552 and significantly higher than other varieties. It might be due to the genetic characteristics of the variety for more assimilation and utilization of period. As the result of this more drymatter accumulation in roots, stem, leaves and grains which favored to increase the dry weight under this treatment. Similar results were reported by Rawat (2011) [17].

The data recorded on 50% spike emergence as affected by different barley varieties under various nitrogen levels, was found non-significant. The data indicate that the maximum spike emergence was recorded (101.25) with the application of 90 kg N ha^{-1} followed by 75 and 60 kg nitrogen levels. Varieties also had non-significant effect on 50 % spike emergence. The data pertaining to days to maturity indicated that different nitrogen levels and varieties did not show significant variation in among themselves at maturity. When enhance the dose of nitrogen delayed the maturity of barley crop. The maximum days taken (132.32) were recorded with the application of 90 kg N ha^{-1} while at 75 kg N ha^{-1} (130.27) days and at 60 kg N ha^{-1} (127.95) days taken up to maturity. Among the varieties there are non-significant variation was recorded for maturity.

Table 2: 50% spike emergence and days to maturity as influenced by nitrogen and varieties of barley.

Treatments	50% spike emergence	Days taken to maturity
(A) Nitrogen levels (kg ha^{-1})		
60	96.62	127.95
75	98.90	130.27
90	101.25	132.32
SEm±	1.53	2.01
CD (P=0.05)	*NS*	*NS*
(B) Varieties		
RD-2907	98.00	129.40
RD-2552	99.73	130.90
NDB-1173	100.96	132.10
RD-2794	97.00	128.33
SEm±	1.69	2.19
CD (P=0.05)	*NS*	*NS*

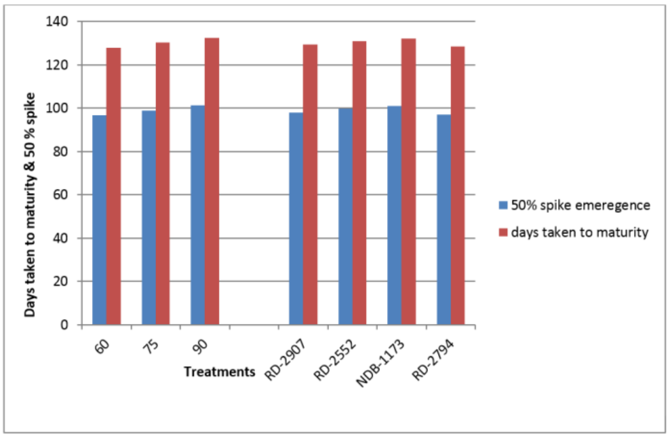

Fig 7: Effect on different treatments on days taken to maturity & 50% spike emergence of crop

Yield attributes of Barley

The number of spikes m^{-1} were significantly affected by various nitrogen levels. Maximum number of spikes m^{-1} were recorded with 90 kg N ha^{-1} which was significantly higher than rest of the treatments. Varieties had non-significant on number of spikes m^{-1}. The maximum number of spikes m^{-1} in RD-2552 and minimum in NDB-1173. Nitrogen levels had significant effect on length of spike and maximum spike length (8.61cm) was recorded with the application of 90 kg N ha^{-1}, which was at par with 75 kg N ha^{-1} and significantly superior to 60 kg N ha^{-1}. The data further revealed that the length of spike (cm) was significantly affected due to varieties of barley. The maximum spike length (8.96) was noted in variety (RD-2907), which was significantly superior to RD-2552, NDB-1173 and RD-2794. Data indicated that nitrogen levels and varieties had significant effect on number of grains spike^{-1}. The maximum number of grains spike^{-1} (53.00) was recorded with 90 kg N ha^{-1}, which was significantly higher than 75 and 60 kg N ha^{-1}. Among the varieties, the maximum number of grains spike^{-1} (52.55) was obtained in variety RD-2907 which was at par with RD-2552 (50.33) and significantly superior over NDB-1173 and RD-2794. Nitrogen levels and varieties had significant effect on test weight. The maximum 1000-grain weight (41.24 g) was recorded with the application of 90 kg N ha^{-1} which was significantly higher than 75 and 60 kg N ha^{-1}. Among the varieties maximum 1000 grain weight (40.55) was obtained in variety (RD-2907), which was at par with RD-2552 and RD-2794 while significantly higher to NDB-1173 barley variety.

The data revealed that increasing levels of nitrogen has positive correlation with yield and yield attributes *viz.*, length of spike, number of spikes (m^{-1}), number of grains spike^{-1}, test weight, grain yield and straw yield, which led to increase in yield can be discussed in the light of fact that availability of nitrogen in higher amount resulted in higher dry weight which ultimately increased the yield attributes and yield. The number of grains spike^{-1} was affected by various nitrogen levels, the maximum number of grains spike^{-1} was recorded under 90 kg N ha^{-1} in comparison to lower nitrogen levels. The number of grains spike^{-1} determined primarily by the amount of nutrient absorbed and secondary by the amount of carbohydrate produced at the time of spikelets differentiation. The carbohydrates production has positive correlation with levels of nitrogen. Hence, under present study increase in the number of grains spike^{-1} might be due to better assimilation of carbohydrate in spike. Maximum length of spike, number of spikes m^{-1} and test weight were recorded with 90 kg N ha^{-1} sowing its significantly superiority to rest of the treatment. The lowest value of yield attributing characters was obtained under lowest nitrogen level because plants were subjected to utilize the least amount of available nitrogen which resulted into reduced translocation of photosynthates from source to sink and thus led to poor growth of various yield attributing characters. Similar findings were reported by Devaraja and Hegde (2006) [5], Zeidan (2007) [28] in case of spike length and number of grain spike^{-1} Singh *et al.* (2012) [22], Sharma and Verma (2010) [21] in case of test weight. The yield contributing characters are the resultant of vegetative growth of the plant. All the yield attributes *viz.* length of spike, number of spikes (m^{-1}), number of grains spike^{-1}, test weight, grain yield and straw yield were affected significantly due to different varieties. Highest value of all the yield attributes were recorded under RD-2907 was at par with RD-2552 variety and significantly better than other varieties. Similar results were obtained by Singh *et al.* (2013) [22].

Table 3: Yield attributing characters were influenced by different nitrogen levels and varieties of barley crop.

Treatments	Number of spike (m^{-1})	Length of spike (cm)	Number of grains spike^{-1}	Test weight (g)
(A) Nitrogen levels (kg ha^{-1})				
60	52.75	7.94	46.50	38.89
75	55.63	8.31	50.08	39.59
90	57.91	8.61	53.00	41.24
SEm±	0.24	0.09	0.43	0.17
CD (P=0.05)	0.99	0.39	1.75	0.71
(B) Varieties				
RD-2907	56.22	8.96	52.55	40.55
RD-2552	56.31	8.05	50.33	40.55
NDB-1173	54.02	8.06	48.66	38.08
RD-2794	55.17	8.08	47.88	40.45
SEm±	0.71	0.18	0.93	0.34
CD (P=0.05)	*NS*	0.56	2.80	1.02

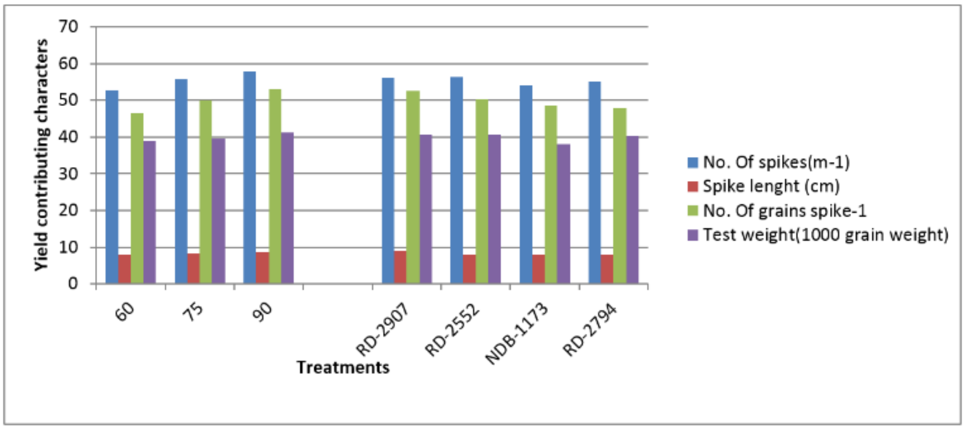

Fig 8: Effect of different treatments on yield contributing characters of barley

Yield of Barley

Grain yield (q ha^{-1})

Grain yield was significantly influenced by nitrogen levels and varieties. Grain yield increased successively with increase in successive nitrogen levels in the range of 60 kg N ha^{-1} to 90 kg N ha^{-1}. The significantly maximum grain yield was obtained with the supply of 90 kg N ha^{-1} as compared to supply of 60 and 75 kg N ha^{-1}. Among the varieties maximum grain yield (28.38 q ha^{-1}) was obtained in variety RD-2907 which was at par with in RD-2552(27.88 q ha^{-1}) and significantly higher over rest of the varieties. Different nitrogen levels and varieties had influence on grain yield. The yield was recorded significantly higher under 90 kg N ha^{-1} as compared to other treatments. This might be due to adequate nitrogen availability which contributed to increase dry matter accumulation. Productivity of a crop is collectively determined by vigour of the vegetative growth, development as well as yield attributes which is the result of better translocation of photosynthates from source (leaves and stem) to sink (grains). Better vegetative growth coupled with high yield attributes resulted into higher grain yield in 90 kg N ha^{-1}. Reduced nitrogen supply as in case of rest of the treatment, recorded lowest yield due to both poor growth and yield attributes. Similar findings were reported by Mal *et al*. (2014) [8]. The grain yield of barley was significantly influenced by varieties. Highest yield was obtained under RD-2907 was at par with RD-2552 and significantly higher than other varieties. The increase in grain yield under this variety was mainly due to improvement in yield attributing characters and growth of crops which might be due to the genetic characteristics of the variety. The grain yield as the result of growth and development through efficient assimilation and utilization of available nitrogen by the growing plants during the entire grand growth period. Growth in vegetative phase and development in reproductive phase determines the yield. Similar findings were reported by Ram and Dhaliwal (2012) [16].

Straw yield (q ha^{-1})

The straw yield (q ha^{-1}) increased with increasing the nitrogen levels in the range of 60 kg N ha^{-1} to 90 kg N ha^{-1}. Straw yield was recorded significantly higher (45.77 q ha^{-1}) with the application of 90 kg N ha^{-1}as compared rest of the nitrogen levels. Among varieties maximum straw yield (45.80 q ha^{-1}) was obtained in variety (RD-2907), which was at par with RD-2552 (45.39 q ha^{-1}), and significantly superior to NDB-1173 and RD-2794. Straw yield was influenced significantly by levels of nitrogen and different varieties. Maximum straw yield was recorded under 90 kg N ha^{-1}. This may be probably due to higher density of tiller and increased rate of dry matter production. Similar findings were reported by Rashimi (2012). Straw yield was noted higher under RD-2907 which was mainly due to more dry matter accumulation per unit area as a result of better performance of vegetative growth caused due to efficient assimilation and absorption of nitrogen from the soil during entire period of growth. Similar finding was reported by Sharma (2007) [20].

Biological yield

The data pertaining to biological yield, indicated that nitrogen levels and varieties influence biological yield significantly. The maximum biological yield (73.68 q ha^{-1}) was recorded at 90 kg N ha^{-1}, which was significantly superior over 60 kg N ha^{-1} and 75 kg N ha^{-1}. Maximum biological yield (74.18q ha^{-1}) was obtained in variety (RD-2907), which was at par with RD-2552(73.27qha^{-1}) and significantly maximum to NDB-1173 and RD-2794.

Harvest index (%)

The data pertaining to harvest index, clearly indicate that harvest index did not influenced significantly by different nitrogen levels and varieties of barley crop. However, the performance was better in RD-2907 due to the genetic characteristics of variety.

Table 4: Grain, straw and biological yield and Harvest index were influenced by nitrogen levels and varieties of barley crop.

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)
(A) Nitrogen levels (kg ha^{-1})				
60	22.54	35.97	58.51	38.60
75	25.95	42.71	68.67	37.81
90	27.90	45.77	73.68	37.83
SEm±	0.28	0.41	0.64	0.24
CD (P=0.05)	1.13	1.67	2.59	*NS*
(B) Varieties				
RD-2907	28.38	45.80	74.18	38.37
RD-2552	27.88	45.39	73.27	38.08
NDB-1173	21.33	34.90	56.24	37.96
RD-2794	24.27	39.85	64.12	37.90
SEm±	0.87	1.68	2.53	0.35
CD (P=0.05)	2.63	5.05	7.59	*NS*

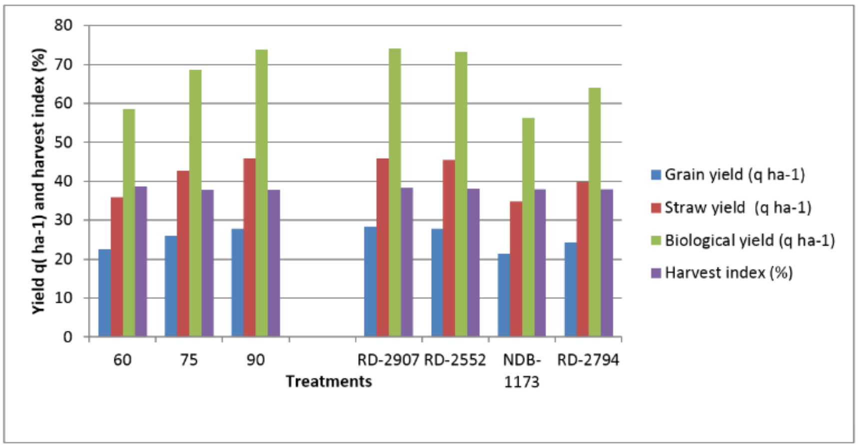

Fig 9: Effect of different treatments on grain and straw yield and harvest index

Nutrient content and uptake

Nitrogen content (%) in grain and straw

The nitrogen content in grain increased with increasing rate of nitrogen. Maximum nitrogen content (1.68) in grain determined with applied 90 kg N ha^{-1} which was at par with (1.65) the supply of 75 kg N ha^{-1} and significantly superior to (1.62) 60 kg N ha^{-1}. No significant different was noticed on nitrogen content in grain due to different varieties of barley crop. Data revealed that the nitrogen content in straw increased with increasing rates of nitrogen levels. Maximum nitrogen content (0.54%) was recorded with 90 kg N ha^{-1} and at par with 75 kg N ha^{-1} (0.53) which was significantly higher over the application of 60 kg N ha^{-1}. Among varieties, maximum nitrogen content (0.55) in straw was recorded in variety RD-2907 which was at par with RD-2552 (0.54%) and significantly maximum over rest of the varieties.

Table 5: Nitrogen content in grain and straw as influenced by different nitrogen levels and varieties of barley crop.

Treatments	N content in grain (%)	N content in straw (%)
(A) Nitrogen levels (kg ha^{-1})		
60	1.62	0.52
75	1.65	0.53
90	1.68	0.54
SEm±	0.01	0.004
CD (P=0.05)	0.04	0.01
(B) Varieties		
RD-2907	1.70	0.55
RD-2552	1.66	0.54
NDB-1173	1.65	0.52
RD-2794	1.60	0.51
SEm±	0.02	0.008
CD (P=0.05)	NS	0.02

Nitrogen uptake by grain and straw (kg ha^{-1})

It is clear from the data that nitrogen uptake by grain increased significantly with the enhanced the dose of N levels. It was recorded maximum (47.13 kg ha^{-1}) under the application of 90 kg N ha^{-1} which was significantly higher than 75 kg (42.96 kg ha^{-1}) and 60 kg N ha^{-1} (36.61 kg ha^{-1}). Among varieties maximum nitrogen uptake (48.31 kg ha^{-1}) by the grain was recorded in RD-2907, which was at par with the variety of RD-2552 (46.32) and significantly superior over the varieties of RD-2794 and NDB-1173. Data pertaining to nitrogen uptake by straw, indicate that nitrogen levels and varieties had significant effect on nitrogen uptake straw. The data revealed that nitrogen uptake by straw increased significantly with the increase in N levels. Maximum nitrogen uptake by straw was recorded (24.80 kg ha^{-1}) under the supply of 90 kg N ha^{-1} which was significantly higher than 75 and 60 kg N ha^{-1}. Among the varieties of barley, maximum nitrogen uptake (25.25 kg ha^{-1}) by straw was recorded in variety (RD-2907) which was at par with (24.52) RD-2552 and significantly superior to RD-2794 and NDB-1173. Nitrogen uptake by crop was affected significantly due to nitrogen levels it was recorded maximum under 90 kg N ha-^{1}. This might be due to better root establishment which resulted in better translocation of absorbed nutrient from soil and its transport to the plant and seed which may cause higher plant growth and grains and straw yields and ultimately increased the uptake of nitrogen. The lowest uptake of nitrogen recorded in minimum dose of nitrogen application was due to poor root growth, nitrogen mobilization, grain and straw yields. Similar results were reported by Meena *et al.* (2012) [9]. Among the varieties it was recorded significantly higher under RD-2907 variety as compared to rest of varieties. Plant under RD-2907 variety trapped adequate amount of nitrogen from the soil through effective root zone leading to increased nitrogen content in grain and straw and recorded maximum yield. Maximum uptake in variety RD-2552 might be due to higher nitrogen content and yield.

Table 6: Nitrogen uptake by grain and straw and total nitrogen uptake as influenced by different nitrogen levels and varieties of barley crop.

Treatments	Nitrogen uptake by grain (kg ha^{-1})	Nitrogen uptake by straw (kg ha^{-1})	Total nitrogen uptake (kg ha^{-1})
(A) Nitrogen levels (kg ha^{-1})			
60	36.66	18.77	55.43
75	42.96	22.67	65.64
90	47.13	24.80	71.94
SEm±	0.43	0.26	0.65
CD (P=0.05)	1.76	1.05	2.64
(B) Varieties			
RD-2907	48.31	25.25	73.57
RD-2552	46.32	24.52	70.85
NDB-1173	35.21	18.16	53.38
RD-2794	39.15	20.39	59.55
SEm±	1.49	0.94	2.42
CD (P=0.05)	4.48	2.84	7.25

Protein Content in Barley Grain (%)

Data pertaining to protein content in grain as influenced by different nitrogen levels and varieties of barley crop indicated that the protein content in grain increased with increasing rates of nitrogen. Maximum protein content (10.54%) was recorded with the application of 90 kg N ha^{-1} which was at par with 75 kg N ha^{-1} and significantly higher than 60 kg N ha^{-1}. The varieties had no-significant effect on the protein content in grain. An inspection of data presented in Table 7 revealed that the protein content increased in grain with increasing nitrogen levels. Villers *et al.* (1988) [25] reported that nitrogen application increased total nitrogen, free amino nitrogen and alfa and beta amylase activities in barley grain. Protein content of grain increased due to increase in nitrogen content of grain. This was due to well established fact that nitrogen in the structural constituent of protein structure in living cells. Thus, the maximum protein content was recorded at 90 kg N ha^{-1}. Similar findings were reported by Paramjit *et al.* (2001) and Singh and Singh (1991) [24]. Varieties did not show significant effect on nitrogen and protein content. However, higher nitrogen and protein content was recorded in RD-2907 variety.

Protein Yield of Barley (Kg ha^{-1})

Data pertaining to protein yield as influenced by different nitrogen levels and varieties of barley crop indicated that the protein yield increased with increasing rates of nitrogen. Maximum protein yield (278.51 kg ha^{-1}) was recorded with the application of 90 kg N ha^{-1} and the lowest protein yield was recorded with the application of 60 kg N ha^{-1}. The varieties had significant effect on the protein yield. The highest protein yield was recorded under the variety 'RD-2907' and lowest in case of 'NDB-1173'. Protein yield increased due to increase in nitrogen and protein content of grain. This was due to well established fact that nitrogen in the structural constituent of protein structure in living cells. Similar findings were reported by Paramjit *et al.* (2001) and Singh and Singh (1991) [24].

Table 7: Protein content in grain and protein yield of barley as influenced by different nitrogen levels and varieties.

Treatments	Protein Content in grain (%)	Protein Yield (Kg ha^{-1})
(A) Nitrogen levels (kg ha^{-1})		
60	10.14	228.61
75	10.33	258.11
90	10.54	278.51
SEm±	0.07	9.86
CD (P=0.05)	0.28	*NS*
(B) Varieties		
RD-2907	10.62	280.00
RD-2552	10.37	279.92
NDB-1173	10.31	220.62
RD-2794	10.06	239.76
SEm±	0.13	10.01
CD (P=0.05)	*NS*	29.98

Profitability of Barley

The highest gross return of Rs. 71666 ha^{-1} was obtained from 90 kg N ha^{-1} with variety RD-2907 followed by Rs. 70918 ha^{-1} 90 kg N ha^{-1} with RD-2552. The lowest gross return (Rs. 50399 ha^{-1}) was obtained under 60 kg N ha^{-1} with variety NDB-1173 due to lowest yield. Maximum cost of cultivation (Rs. 26155 ha^{-1}) was recorded under dose of 90 kg N ha^{-1} followed by (Rs. 25928 ha^{-1}) in 75 kg N ha^{-1} and the lowest was with 60 kg N ha^{-1}. Highest net return of Rs. 45511ha^{-1} was obtained from 90 kg N ha^{-1} with variety RD-2907 followed by Rs. 44763 ha^{-1} 90 kg N ha^{-1} with RD-2552. The lowest net return of Rs. 24699 ha^{-1} was recorded in 60 kg N ha^{-1} due to lowest gross return. Higher benefit-cost ratio (1.74) was obtained under the treatment combination of 90 kg N ha^{-1} with RD-2907 followed by (1.71) in 90 kg N ha^{-1} with RD-2552. The lowest benefit-cost ratio (0.96) was observed with the treatment 60 kg N ha^{-1}, NDB-1173. Almost similar finding reported by Puniya *et al.* (2015) [13].

Table 8: Economic analysis of various nitrogen levels and varieties of barley crop

Treatment combination	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C (ratio)
60 kg, RD2907	25700	62481	36781	1.43
60 kg, RD-2552	25700	61733	36033	1.40
60 kg, NDB-1173	25700	50399	24699	0.96
60 kg, RD-2794	25700	55559	29859	1.16
75 kg, RD2907	25928	68538	42610	1.64
75 kg, RD-2552	25928	67790	41862	1.61
75 kg, NDB-1173	25928	56455	30527	1.17
75 kg, RD-2794	25928	61615	35687	1.37
90 kg, RD-2907	26155	71666	45511	1.74
90 kg, RD-2552	26155	70918	44763	1.71
90 kg, NDB-1173	26155	59584	33429	1.27
90 kg, RD-2794	26155	64744	38589	1.47

Conclusion

The findings of the present experiment show that the 90 kg N ha^{-1} was the most suitable dose of nitrogen for barley under sodic soil of Eastern Uttar Pradesh. Application of 90 kg N ha^{-1} gave the highest protein content in barley grain and protein yield. Among the varieties RD-2907 was found the most suitable cultivar for barley production in sodic soil of Eastern Uttar Pradesh, this cultivar also gave highest protein content and protein yield. On the basis of economic analysis, it may be concluded that a dose of 90 kg N ha^{-1} with RD-2907 cultivar, was remunerative, which gave the highest net return (45511 ha^{-1}) and B:C ratio (1.74). The farmers of Eastern Uttar Pradesh can be advised to grow RD-2907 cultivar of barley with the application of 90 kg N ha^{-1} to achieve good productivity and profitability of barley crop.

References

1. Ahmad N. Fertilizer scenario in Pakistan: policies and development. In: Proc. Conference on Agriculture Fertilizer Use by 2010. NFDC, Publication 2/99. Islamabad, 1999.
2. Amanullah, Khattak RA, Khalil SK. Effects of plant density and N on phenology and yield of cereal. Plant. Nut. J. 2008a; 32:246-260.
3. Anonymous. Agriculture statistics at a glance, Department of Agriculture and Co-operation, Ministry of Agriculture, Government of India, New Delhi, 2017.
4. Ayoub M, Guertin S, Lussier S, Smith DL. Timing and levels of nitrogen fertility effects on spring wheat. Crop Sci. 1994; 34:748-750.
5. Devaraja M, Hegde R. Yield attributes of malt barley (*Hordeum vulgare* L.) as influenced by nitrogen, phosphorus, potassium and their correlation and regression with yield. Agric. Sci. Digest. 2006; 26(1):48-50.
6. Hayes PM, Castro A, Cedillo LM, Corey A, Henson C *et al*. Genetic diversity for quantitatively inherited agronomic and malting quality traits. Elsevier science publishers, Amsterdam, 2003.
7. Hooda RS, Singh HB. Effect of levels of nitrogen and phosphorus on different varieties of barley. First National Symposium on Barley, held at I.A.R.I. Regional Station, Karnal, Feb. 1979, 24-27, 50.
8. Mal T, Phogat SB, Kumar S, Singh B. Effect of nitrogen on yield and quality of barley (*Hordeum vulgare*) genotypes. India J Agron. 2014; 59(1):171-174.
9. Meena LR, Mann JS, Meena SL. Effect of levels and mode of nitrogen application on dual purpose barley (*Hordeum vulgare*) under semi-arid condition. Indian. J Agron. 2012; 57(2):168-170.
10. Miao Y, Mulla DJ, Robert CP, Hernandez JA. Within field variation in corn yield and grain quality responses to nitrogen fertilization and hybrid selection. Agron. J. 2006; 98:129-140.
11. Oikeh SO, Chude VO, Kling GJ, Horst WJ. Comparative productivity of nitrogen-use efficient and nitrogen inefficient maize cultivars and traditional grain sorghum in the moist Savanna of West Africa. African J Agri. Res. 2007; 2:112-118.
12. Paramjeet, Singh VP, Roy DK. Effect of different levels of nitrogen and irrigation on growth, yield and quality of malt barley (*Hordeum vulgare* L.). Res. crops. 2001; 2(2):120-122.
13. Puniya MM, Yadav SS, Shivran AC. Productivity, profitability and nitrogen-use efficiency of barley (*Hordeum vulgare*) as influenced by weed management and nitrogen fertilization under hot semi-arid ecologies of Rajasthan. Indian Journal of Agronomy. 2015; 60(4):564-569.
14. Raghuvanshi RKS, Puradkar VK, Gupta RK, Sharma OP. Response of Barley varieties to nitrogen application in a sodic clay soil. Ind. J of Agron. 1987; 32(4):428-431.
15. Rahimi A. Effect of planting date and nitrogen on yield and yield components of dry land barley (*Hordeum vulgare* L.) grown in Boyerahmad Region of Iran. Research on Crops. 2012; 13(3):840-845.

16. Ram H, Dhaliwal SS. Effect of varieties and integrated nutrient management techniques on growth, productivity, quality and economics of barley (*Hordeum vulgare* L.). International Journal of Agricultural Science. 2012; 8(1):91-97.
17. Rawat DS. 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, 2011.
18. Saini JP, Thakur SR. Response of barley (*Hordeum vulgare)* varieties to nitrogen under dry temperate condition. Indian. J of Agron. 1999; 44(1):123-125.
19. Sardana, Virender, Zhang, Guo-Ping. Effect of time of nitrogen application on the growth and yield of two barley (*Hordeum vulgare* L.) cultivars. *Cereal Res. Commun.* 2005; 33(4):785-791.
20. Sharma NK. Effect of sowing time and cutting management on fodder yield of barley. Range Management & Agroforestry. 2007; 28:334-335.
21. Sharma RK, Verma RPS. Effect of irrigation, nitrogen and varieties on the productivity and grain malting quality on barley. *Cereal Res. Communications* 2010; 38(3):419-428.
22. Singh D, Singh DR, Nepalia V, Kumari A. Annals of Agriculture Research. 2013; 34(3):325-229.
23. Singh J, Mahal SS, Manhas SS. Effect of sowing methods, nitrogen levels and irrigation scheduling on yield and quality of malt barley (*Hordeum vulgare* L.). Indian J Agron. 2012; 57(3):259-264.
24. Singh JP, Singh V. Response of hulled and hull-less barley to varying levels of nitrogen and phosphorus. Indian J Agron. 1991; 36:104-107.
25. Villers OTDE, Morre PLJ, Laubscger EW. Effect of time and rate of N application on the malting quality of barley. South Africa J Plant and Soil. 1988; 5(3):134-136.
26. Worku M, Friesen BE, Diallob OA, Horst WJ. Nitrogen uptake and utilization in contrasting nitrogen efficient tropical maize hybrids. Crop Sci. 2007; 47:519-528.
27. Zapata F, Cleenput OV. Recovery of N15 labelled fertilizer by sugar beet spring wheat and winter sugar beet cropping sequences. *Fert. Res.* 1986; 8:269-178.
28. Zeidan MS. Response of some Barley cultivars to nitrogen sources and rates grown in alkaline sandy soil. Res. J Agriculture. Biol. Science. 2007; 3(6):934-938.