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Growth and Phenology of Dual Purpose Barley as Influenced by Nitrogen Dose and Seed Rate

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ABSTRACT: Animal husbandry occupies an important role and there is a big gap between demand and supply of forage. As the problem of the supply of feed and forage has become so serious due to the increasing number of animals and the limited land resources, and the expense of feeding makes up around 65-70% of all livestock production. So, keeping these things in view a field experiment was conducted during *Rabi* season 2019-20 at wheat and barley section research area of CCS Haryana Agricultural University, Hisar. The experiment was comprised of three nitrogen doses (N_1-60, N_2-75 and N_3- 90 kg N/ha) as main plot treatments and four seed rates (S_1- 87.5, S_2- 100, S_3- 112.5 and S_4-125.0 kg/ha) as sub plot treatments. Experiment was laid out in split plot design with four replications. The goal of this study was to look into how the nitrogen dose and seed rate affect growth of dual-purpose barley. Based on the research investigation, it was found that nitrogen dose and seed rate both had significantly influenced the growth of dual purpose barley. Among nitrogen doses, 90 kg/ha being at par with 75 kg/ha recorded significantly higher plant height, dry matter accumulation, crop growth rate and leaf area index (2.64) at all stages of crop growth than nitrogen dose of 60 kg/ha, respectively. Progressive increase in the days taken to booting, heading and maturity was recorded with increase in nitrogen doses from 60 to 90 kg/ha. Among seed rates, 125.0 kg/ha closely followed by 112.5 kg/ha recorded significantly higher plant height, dry matter accumulation, crop growth rate and leaf area index (2.85) at all stages of crop growth than seed rate of 87.5 kg/ha, respectively. Significant increase in plant population was recorded with increase in seed rate from 87.5 to 125.0 kg/ha.

Keywords: Dual purpose barley, seed rate, nitrogen dose, growth, phenology, leaf area index.

INTRODUCTION

Barley (*Hordeum vulgare* L.) is the one of the first domesticated cereal of world agriculture. It occupy fourth place among cereal crops after wheat, rice and maize in the world with a share of 7.0 per cent of the global cereal production. It is considered as poor man's crop and better adaptable to problematic soils and marginal land. It is a valuable crop because it is used for food, processed food and feed for livestock. Its straw is used for making hay and silage.

The global production volume of barley is amounted to 145.93 million metric tons. In India, barley was grown on 0.59 Mha area with production of 1.656 M tons yielding 29.20 q of grains per ha during 2020-21. The major barley producing states in India are Rajasthan, U.P., M.P. and Haryana (Anonymous, 2021).

Traditionally in India, barley is preferred over other crops to produce feed and fodder for livestock because of its low input requirement and better adaptability to harsh environments like salinity, alkalinity, drought and marginal lands (Singh *et al.*, 2016). Barley possesses good regeneration capacity compared to other cereals after cutting up to attainment of jointing stage. Lodging close to harvest is commonly a major problem in cereals under well nutrition and adequate water supply conditions, if winds blow after irrigation. Therefore, it is reasonable to assume that one cutting for green forage at active growth stage will reduce the probability of lodging in barley.

Dual-purpose management is the practise of cultivating cereals for both pasture and grain yields at the same season. Plants are grown for grain production but clipped at vegetative stage, then left to redevelop and produce grains (Bell *et al.*, 2015). The success of dual-purpose barley in marginal environments is subject to proper agronomic management practices along with proper fertilization. It is considered as one of the most important pre-requisite in this respect. Amongst nutrients, nitrogen plays an important role in synthesis of chlorophyll, amino acids and other organic compounds of physiological significance in plant system (Hajighasemi *et al.*, 2016).

The performance of dual purpose systems relies on the seeding rate since it regulates the intra- and interplant competition for light, water, and nutrients (Salama, 2019). It is suggested that a higher seed rate helps in increasing the crop stand, green forage biomass and stabilize grain yield of cereals in dual purpose systems (Ertekin, 2022). In some countries like Australia and USA, barley is usually grown for the dual purpose of producing forage and grain from the same crop, but in India, this kind of experience is still unexploited. So, there is a crucial need to determine the influence of nitrogen dose and seed rate for a balanced growth of dual purpose barley.

MATERIAL AND METHODS

A field experiment was conducted during *Rabi* season 2019-20 at wheat and barley section research area of CCS Haryana Agricultural University, Hisar which is situated in the sub-tropical region at 29° 10' N latitude and 75° 46' E longitude with an elevation of 215.2 m above mean sea level in Haryana State of India. It lies on the outer margins of the south-west (SW) monsoon region. It has tropical monsoonal climate and is characterized as arid type of climate. The main characteristics of climate in Hisar district are its dryness, extremes temperature and scanty rainfall. The average annual rainfall is around 452 mm. The soil exhibits mixed pattern of Aeolian and Alluvial deposits. During crop growing season 133.5 mm rainfall was received. The mean weekly maximum and minimum temperature ranged between 11.9 to 38 ºC and 2.6 to 20 ºC, respectively. The mean weekly values of morning and evening relative humidity ranged between 70 to 100 and 20 to 82 per cent respectively, while sunshine ranged between 1.1 to 8.7 hrs during crop season. The experiment was comprised of three nitrogen doses (N_1-60, N_2-75 and N_3- 90 kg N/ha) as main plot treatments and four seed rates (S_1- 87.5, S_2- 100, S_3- 112.5 and S_4-125.0 kg/ha) as sub plot treatments. Experiment was carried out in split plot design with four replications. All the other standard agronomic practices for the cultivation of barley were followed uniformly in all the treatments. Plants of one meter row length from the second row on either side in each plot, representing the whole plot, were cut close to the ground at the time of observation to record dry matter accumulation per meter row length. Thereafter, these samples were dried in oven at 65ºC temperature till constant weight, after drying the samples were weighed for recording dry weight in grams per meter row length. Phenological studies were recorded by counting the number of days from sowing to the date when 50% emergence, heading, booting and physiological maturity in the plot. The CGR of a plant for a time ‘t’ is defined as the increase in dry weight of plant material from a unit area per unit of time. It was calculated with the following formula (Radford, 1967) from the crop dry matter recorded at periodic intervals.

$$CGR = \frac{(W_2 - W_1)}{t_2 - t_1} \text{ (g/m}^2\text{/day)}$$

Leaf area of plants in 0.25 m row length was multiplied by four to obtain total leaf area per meter row length. Average leaf area per unit area was used for computation of LAI, which is the ratio between the surface area of green leaves and the ground area covered.

$$\text{Total leaf area LAI} = \frac{\text{Leaf area}}{\text{Ground area}}$$

The experimental data were analyzed through OPSTAT software available on CCS Haryana Agricultural University home page (Sheoran *et al.*, 1998).

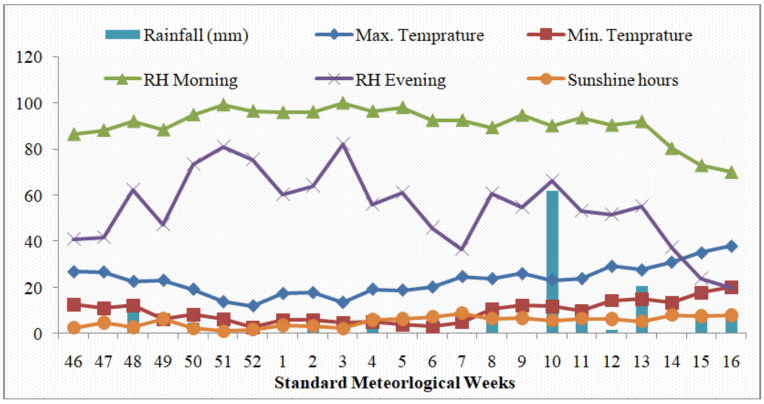

Fig. 1. Mean weekly weather condition during cropping period.

RESULTS AND DISCUSSION

A. Effect of nitrogen dose on plant population

An inquisition to data showed in Table 1 strutted that nitrogen doses failed to produce significant variation in relation to plant population at 15 DAS. However, numerical variation was recorded among different nitrogen doses with higher plant population recorded with 90 kg N/ha (31.31) while minimum plant population recorded with 60 kg N/ha (29.50).

B. Effect of seed rate on plant population

The data pertaining to Table 1 and showed the progressive significant increase in plant population per meter row length at 15 DAS with increase in seed rate from 87.5 to 125.0 kg/ha. The plant stand with seed rate of 125.0 kg/ha was found significantly higher over other seed rates. Seed rate of 125.0 kg/ha recorded 41.1, 21.2 and 10.6 per cent higher over 87.5, 100.0, and 112.5 kg/ha seed rates, respectively. Increase in plant stand with increasing seed rate up to certain level was also reported by Kharub *et al.* (2013) in dual purpose barley.

C. Effect of nitrogen dose on plant height (cm)

The plant height recorded at green fodder cut, 20, 40 DAC and at maturity is presented in Table 2. Plant height increased with the advancement of crop growth up to maturity irrespective of nitrogen dose and seed rate, but maximum increase in plant height was observed between 20-40 days after fodder cut. Plant height was significantly affected by nitrogen dose and seed rate at all stages of observation. At all stages of crop development, plant height increased significantly with each rise in nitrogen dose up to 75 kg N/ha, however non-significant increase in plant height was observed between 75-90 kg/ha nitrogen dose at all stages of observations. Plant height (cm) recorded at cut (31.85), 20 DAC (46.90), 40 DAC (108.50), and maturity (117.41) with nitrogen dose 90 kg/ha was significantly higher over 60 kg/ha with a percentage increase of 16.8, 9.7, 4.1 and 2.4, respectively. At green fodder cut plant height with 90 kg N/ha was found significantly higher over other nitrogen doses. This might be due to the better nutrient availability at higher dose of nitrogen which resulted in greater cell division and cell elongation which ultimately resulted in higher photosynthetic activities and produced more photosynthates and these readily supplied food to the growing parts and improved the growth characters like plant height, leaf area index and dry matter accumulation. Similar results have also been reported by Meena *et al.* (2011).

D. Effect of seed rate on plant height (cm)

A probe to data presented in Table 2 unveiled that the plant height significantly increased with the increase in seed rate from 87.5 kg/ha to 112.5 kg/ha at all the stages of crop growth. Plant height obtained with 100, 112.5 and 125.0 kg/ha seed rate were found statistically at par at all stages of observations but significantly higher than seed rate of 87.5 kg/ha. Plant height (cm) recorded at green fodder cut (31.9), 20 DAC (46.8), 40 DAC (108.8) and maturity (118.4) with seed rate of 125.0 kg/ha was significantly higher over 87.5 kg/ha with a percentage increase of 19.5, 10.5, 5.1 and 4.8, respectively. The improvement in plant height with increased seed rate seems to be the resultant of mutual shading due to over-crowding of plants. This is a "cooperative interaction" where in smaller plants tends to catch up with the taller ones by mean of it and compete more on even terms.

E. Effect of nitrogen dose on dry matter accumulation (g/mrl)

The data on dry matter accumulation (Table 3) revealed that irrespective of nitrogen dose and seed rate, dry matter accumulation (g/mrl) was increased up to maturity but maximum increase in dry matter accumulation was observed between 40 DAC to maturity. Dry matter accumulation was significantly affected by nitrogen dose and seed rate at all stages of observation. At all stages of crop development, dry matter accumulation increased significantly with each rise in nitrogen dose up to 75 kg N/ha, however non-significant increase in dry matter accumulation was observed between 75-90 kg/ha nitrogen dose at all stages of observations. Dry matter accumulation (g/mrl) recorded at cut (16.59), 20 DAC (32.78), 40 DAC (81.06) and maturity (161.45) with nitrogen dose 90 kg/ha was significantly higher over 60 kg/ha with a percentage increase of 15.2, 14.9, 5.5 and 20.7, respectively. Thus, better and higher availability of nutrients right from sowing caused vigorous growth of individual plant as reflected through increased dry matter at successive growth stages after green fodder cutting.

F. Effect of seed rate on dry matter accumulation (g/mrl)

A delve to data given in Table 3 exhibited that dry matter accumulation significantly increased with the increase in seed rate from 87.5 kg/ha to 100.0 kg/ha at all the stages of crop growth. Dry matter accumulation obtained with 100, 112.5 and 125.0 kg/ha seed rate were found statistically at par at all stages of observations but significantly higher than seed rate of 87.5 kg/ha. Dry matter accumulation (g/mrl) recorded at cut (16.68), 20 DAC (33.05), 40 DAC (81.41) and maturity (159.56) with seed rate of 125.0 kg/ha was significantly higher over 87.5 kg/ha with a relative advantage of 21.9, 21.1, 9.7 and 19.7 per cent, respectively. Dry matter accumulation is one of the most important parameters of growth, which is cumulative product of plant height and leaf area index. This increase in plant height with increase in seed rate was due to the reason that there was more number of plants per unit area that caused more competition for light which results into higher plant height. Similar results were also previously reported in barley by Dahiya (2016).

G. Effect of nitrogen dose on crop growth rate (CGR)

Irrespective of nitrogen dose and seed rate, crop growth rate (g/m^2/day) was increased up to maturity but maximum increase in CGR in dual purpose barley was recorded between 40 DAC to maturity period followed by 20 DAC-40 DAC intervals. It's obvious from the data contained in Table 4 showed that increasing level of nitrogen doses from 60 to 90 kg/ha has significantly increased the CGR at all stages of observation except green fodder cut to 40 DAC stages. Nitrogen dose @ 90 kg/ha closely followed by 75 kg/ha recorded higher CGR values of 1.42, 3.41, 7.98 and 15.06 g/m^2/day, respectively at sowing-green fodder cut, green fodder cut-20 DAC, 20 DAC-40 DAC and 40 DAC-maturity stage. Application of 90 kg N/ha recorded significantly higher CGR as compared to 60 kg N/ha with a percentage increase of 20.3 and 47.9 during sowing-fodder cut and 40 DAC-maturity stage, respectively.

H. Effect of seed rate on crop growth rate (CGR)

The data in Table 4 revealed that increasing seed rate from 87.5 to 125.0 kg/ha failed to produce significant variation in relation to crop growth rate (CGR) at various growth stages except green fodder cut to 40 DAC period. Increasing seed rate showed the increased rate of CGR at all the stages of observations. Among the seed rates, CGR recorded with 125.0 kg/ha seed rate was found significantly higher over other seed rates except 112.5 kg/ha during sowing-fodder cut stage and 40 DAC-maturity stages. CGR recorded with seed rate of 125.0 kg/ha during sowing-fodder cut stage (1.49) and 40 DAC-maturity (15.99) was 36.7 and 89.6 percent higher, respectively over seed rate of 87.5 kg/ha while it was 17.3 and 27.0 per cent higher over 100.0 kg/ha.

I. Effect of nitrogen dose on leaf area index (LAI)

A disquisition to data given in Table 5 exhibited that leaf area index was significantly affected by nitrogen dose and seed rate at anthesis. Increasing nitrogen dose from 60 to 90 kg/ha progressively increased LAI but non-significant differences were recorded between 60-75 kg/ha and 75-90 kg/ha. Leaf area index (2.64) recorded at anthesis with nitrogen dose 90 kg/ha was significantly higher over 60 kg/ha with a percentage increase of 10.5. The larger canopy development under the additional application of nitrogen could be reasoned for increased interception, absorption and utilization of radiant energy which in turn increased overall growth, photosynthesis, plant height LAI, CGR and finally dry matter meter row length Narolia (2009).

J. Effect of seed rate on leaf area index (LAI)

A perusal of data presented in table5 depicted that leaf area index progressively increased with the increase in seed rate from 87.5 kg/ha to 125.0 kg/ha. Leaf area index obtained with 125.0 kg/ha was found significantly higher over other seed rates except seed rate of 112.5 kg/ha. Non-significant variation regarding LAI was observed between 87.5-100.0 kg/ha and 100-112.5. Leaf area index (2.85) recorded with seed rate of 125.0 kg/ha was significantly higher over 87.5 and 100.0 kg/ha with a percent increase of 22.0 and 25.0, respectively. Improvement in LAI might be on account of increased number of plants meter row length andincreasing the capture of solar radiation within the canopy. The results are in accordance with findings of Dahiya (2016).

K. Effect of nitrogen dose on phenology

The data pertaining to days taken for different phenological stages *i.e.*, emergence, booting, heading and physiological maturity under different treatments are presented in (Table 6). Days taken to all pheno phases observed were significantly affected by nitrogen doses except days taken to emergence. Progressive increase in the days taken to booting, heading and maturity was recorded with increase in nitrogen doses from 60 to 90 kg/ha. Maximum number of days taken to booting (88.31), heading (107.75) and maturity (130.81) recorded with nitrogen dose of 90 kg/ha closely followed by 75 kg/ha were 2.7, 2.9 and 2.9 per cent significantly higher than nitrogen dose of 60 kg/ha. This might be due to the enhanced effect of N fertilizer on vegetative growth which ultimately delayed maturity of the crop. This result was in agreement with that of Abdur and Khan (2008) on barley who found extended maturity of 121 days for 90 kg N/ha as compared to 116 days for the control (without nitrogen). Similar results were recorded by Ejigu *et al.* (2015).

L. Effect of seed rate on phenology

Increase in seed rate from 87.5 to 125.0 kg/ha did not affect significantly the days taken to different pheno phases for dual purpose barley.

Table 1: Effect of nitrogen dose and seed rate on plant population (per mrl) at 15 DAS of dual purpose barley.

Treatments	Plant population (15 DAS)
Nitrogen dose	
N_1- 60 kg/ha	29.50
N_2- 75 kg/ha	30.62
N_3- 90kg/ha	31.31
SEm ±	0.61
CD at 5%	**NS**
Seed rate	
S_1-87.5 kg/ha	25.33
S_2-100.0 kg/ha	29.50
S_3-112.5 kg/ha	32.33
S_4-125.0 kg/ha	35.75
SEm ±	0.46
CD at 5%	**1.49**

Table 2: Effect of different nitrogen dose and seed rate on plant height (cm) of dual purpose barley.

Treatment	Plant height (cm)			
	At cut	20 DAC	40 DAC	Maturity
Nitrogen dose				
N_1- 60 kg/ha	27.25	42.75	104.20	114.60
N_2- 75 kg/ha	30.32	45.96	107.22	116.47
N_3- 90 kg/ha	31.85	46.90	108.50	117.41
SEm ±	0.41	0.35	0.35	0.69
CD at 5%	**1.20**	**1.04**	**1.03**	**2.03**
Seed rate				
S_1- 87.5 kg/ha	26.68	42.36	103.50	112.97
S_2-100.0 kg/ha	29.75	45.36	106.25	115.62
S_3-112.5kg/ha	30.91	46.25	108.02	117.61
S_4-125.0kg/ha	31.88	46.83	108.80	118.43
SEm ±	0.78	0.44	0.75	0.92
CD at 5%	**2.53**	**1.44**	**2.44**	**2.99**

Table 3: Effect of nitrogen dose and seed rate on dry matter accumulation (g/mrl) of dual purpose barley.

Treatments	Dry matter accumulation (g/mrl).			
	At cut	20 DAC	40 DAC	Maturity
Nitrogen dose				
N_1- 60 kg/ha	14.40	28.52	76.84	133.75
N_2- 75 kg/ha	15.45	31.28	79.28	150.14
N_3- 90 kg/ha	16.59	32.78	81.06	161.45
SEm ±	0.54	0.68	0.71	5.19
CD at 5%	**1.60**	**2.00**	**2.10**	**15.24**
Seed rate				
S_1- 87.5 kg/ha	13.68	27.29	74.21	133.29
S_2-100.0 kg/ha	15.42	30.78	78.52	146.80
S_3-112.5kg/ha	16.14	32.30	80.44	154.19
S_4-125.0 kg/ha	16.68	33.05	81.41	159.56
SEm ±	0.50	0.67	0.61	4.16
CD at 5%	**1.64**	**2.19**	**1.97**	**13.49**

Table 4: Effect of nitrogen dose and seed rate on crop growth rate (g/m^2/day) of dual purpose barley.

Treatments	Crop growth rate (g/m^2/day)			
	Green fodder cut	Green fodder cut - 20 DAC	20 - 40 DAC	40 DAC- Maturity
Nitrogen dose				
N_1- 60 kg/ha	1.18	3.18	7.60	10.18
N_2- 75 kg/ha	1.33	3.33	7.84	13.03
N_3- 90 kg/ha	1.42	3.41	7.98	15.06
SEm ±	0.03	0.18	0.20	1.24
CD at 5%	**0.10**	**NS**	**NS**	**3.66**
Seed rate				
S_1-87.5 kg/ha	1.09	3.21	7.91	8.43
S_2-100.0 kg/ha	1.27	3.35	7.84	12.59
S_3-112.5 kg/ha	1.39	3.32	7.76	14.02
S_4-125.0 kg/ha	1.49	3.35	7.70	15.99
SEm ±	0.05	0.18	0.23	0.88
CD at 5%	**0.15**	**NS**	**NS**	**2.87**

Table 5: Effect of nitrogen dose and seed rate on Leaf area index (LAI) of dual purpose barley.

Treatments	Leaf area index (LAI) at anthesis.
Nitrogen dose	
N_1- 60 kg/ha	2.39
N_2- 75 kg/ha	2.56
N_3- 90 kg/ha	2.64
SEm ±	0.06
CD at 5%	**0.19**
Seed rate (kg/ha)	
S_1-87.5 kg/ha	2.28
S_2-100.0 kg/ha	2.34
S_3-112.5 kg/ha	2.64
S_4-125.0 kg/ha	2.85
SEm ±	0.08
CD at 5%	**0.26**

Table 6: Effect of different nitrogen dose and seed rate on phenology of dual purpose barley.

Treatment	Phenological studies			
	Days to emergence	Days to booting	Days to heading	Days to maturity
Nitrogen dose				
N_1- 60 kg/ha	9.87	85.93	104.68	127.08
N_2- 75 kg/ha	10.25	87.56	106.06	129.87
N_3- 90 kg/ha	9.87	88.31	107.75	130.81
SEm ±	0.12	0.38	0.43	0.50
CD at 5%	**NS**	**1.12**	**1.28**	**1.45**
Seed rate				
S_1- 87 kg/ha	9.83	86.91	106.00	129.67
S_2-100.0 kg/ha	10.08	87.33	106.75	130.00
S_3- 112.5 kg/ha	10.08	87.41	107.16	128.75
S_4-125.0 kg/ha	10.00	87.41	107.41	129.83
SEm ±	0.22	0.54	0.56	0.57
CD at 5%	**NS**	**NS**	**NS**	**NS**

CONCLUSIONS

Based on field research experiment, it is concluded that increasing nitrogen dose from 60 to 90 kg/ha progressively increased growth of dual purpose barley but delayed maturity. Among seed rates, 125.0 kg/ha closely followed by 112.5 kg/ha recorded significantly higher plant populations, plant height, dry matter accumulation, crop growth rate and leaf area index at all stages of crop growth than seed rate of 87.5 kg/ha, respectively. So, to obtain higher growth for dual purpose barley (green fodder cut at 55 DAS and left after that for grain production), variety BH 946 should be sown using optimum seed rate of 125.0 kg/ha and nitrogen dose of 90 kg/ha.

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Conflict of Interest. None.

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