Yield and Economics of Dual Purpose Barley as Influenced by Various Nitrogen Dose and Seed Rate

ABSTRACT

A field experiment was carried out 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. With four replications, experiment was laid out in split plot design. Based on the research investigation, it was found that nitrogen dose and seed rate both had significantly influenced the yield attributes and yield of dual purpose barley Among nitrogen doses, 90 kg/ha being at par with 75 kg/ha recorded significantly higher grain yield (4895 kg/ha), biological yield (12220 kg/ha) and green fodder yield (3706 kg/ha) which were 9.7, 12.0 and 15.1 percent higher than nitrogen dose of 60 kg/ha, respectively due to higher yield attributes *i.e*. number of effective tillers (85.08), number of grains per spike (44.15), number of spikelets per spike (23.10), spike length (7.47) and test weight (37.82) with nitrogen dose 90 kg/ha which were 8.5, 5.1, 7.9, 11.4 and 4.8 percent higher than nitrogen dose of 60 kg/ha, respectively. Among seed rates, 125.0 kg/ha closely followed by 112.5 kg/ha recorded significantly higher effective tillers (85.11), grain yield (4922 kg/ha), biological yield (12181 kg/ha), green fodder yield (3729 kg/ha) which were 8.0, 11.0, 11.8 and 16.7 per cent higher than seed rate of 87.5 kg/ha, respectively

Keywords:dual purpose barley, seed rate, nitrogen dose, green fodder yield, grain yield.

1. INTRODUCTION

Barley (*Hordeum vulgare* L.) is the one of the first domesticated cereal of world agriculture. It occupies fourth place among cereal crops after maize, wheat and rice in the world with a share of 7.0 per cent of the global cereal production.Barley is considered as poor man's crop that may thrive well in problematic soils and marginal land. It is not only useful for malting, feed and food purpose but also its β – glucanse is useful in lowering the risk of cardio- vascular diseases (Kharub*et al.*,2014). 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.Besides these conventional uses, it is an important industrial crop as it is used as raw material for beer, whiskey, baby foods, coca malt drinks, *ayurvedic* medicines and brewing industries.

The global production of barley is amounted to 142.37 million metric tons. In India barley was grown on 0.58 Mha area with production of 1.633 M tons yielding 28.37 q of grains per ha during 2018-19. The major barley producing states in India are Rajasthan, Uttar Pradesh, Madhya Pradesh and Haryana.In Haryana, area under barley crop was 14900 ha with production 57600 tonne and yield was 3866 kg/ha during 2018-19 (Anonymous, 2019).

In recent past, India has made an impressive progress in achieving self-sufficiency in food grain production by elevating productivity of several crops. Because of its low input requirements and tolerance to severe conditions such as drought, salinity, alkalinity, and marginal soils, barley is chosen over other crops for producing feed and fodder for animals(Singh *et al.,* 2016).Barley possesses very high regeneration capacity compared to other cereals after cutting up to attainment of jointing stage. Lodging close to harvest is usually a major problem in cereals under good nutrition and assured 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 lodging chances in barley. It will also help in mitigating the

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UNDER PEER REVIEW

fodder shortage. By taking one cutting during the active vegetative growth stage and then leaving the regenerated crop for grain production, barley's regeneration capacity may be put to use (Mishra andKumar, 2002). The animal husbandry occupies an important role in sustaining economic condition of farmers but and there is a big gap between demand and supply of forage particularly during winter season due to occurrence of less rainfall and slow plant growth during *Rabi* season in north-western part of India. Barley being a fast-growing crop with high biomass in early stages can be utilized as green fodder with very limited water supply or less rainfall in these areas. In drier parts of northern plains (Rajasthan, Madhya Pradesh, Southern Haryana, South-West Punjab and Western U. P.) during *Rabi*, farmers can grow dual purpose barley over other forage crops because of its dual utilization and less water requirement (Verma *et al.*, 2007). This suggests an ample scope for growing dual purpose barley for obtaining moderate yield of green fodder as well as grain from the same crop. Growing of dual purpose barley genotypes having a wider adaptability and responsive to inputs has opened a new avenue for exploiting higher grain fodder and subsequent grain yield potential (DWR, 2010). Therefore, barley can provide important nutrition to the livestock through its green fodder and grains harvested from regenerated crop.

It is an established fact that green fodder and grain yield potentials of dual purpose barley genotypes are realized to the fullest extent when they are grown under optimum agro-climatic conditions. Proper fertilization is considered to be 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 (Halvin*et al*., 2003). Insufficient nitrogen can reduce grain yield and quality below the acceptable level, whereas excess nitrogen usually produces undesirable high protein levels. The dual purpose barley may response to use of balanced dose of nitrogen fertilizer and its times of application is considered the most limiting factor for realizing higher yields (Yadav *et al.,* 2003).As the nitrogen play a vital role in plant nutrient, its application has resulted in significant increase in yield and yield components of all the crops. Increased nitrogen levels improved the number of effective tillers, spike length, number of grains per spike, test weight, and grain production per hectare of barley considerably (Naroliа*et al.,* 2009). Hence synchronizing N application to barley as per its requirement can be an important technology to obtain reasonable fodder and grain yield for dual purpose barley.

Optimum seed rate is considered to be one of the most important prerequisite for realizing higher green fodder as well as grain yields (Thomson *et al.*, 2009). 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. Additional applied seed rate produced the maximum forage dry matter and biological yield (Khalil *et al*., 2011).In some countries like Australia and USA, barley is commonly 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 green fodder yield and grain production in dual purpose barley.

2. MATERIAL AND METHODS

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A field experiment was carried out 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 major characteristics of climate in Hisar district are its extremes temperature,dryness and scanty rainfall. The average annual rainfall is

UNDER PEER REVIEW

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 laid 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. Each plot's harvested green fodder was weighed in situ and then converted to q/ha. The experimental data were analyzed by using OPSTAT software available on CCS Haryana Agricultural University home page (Sheoran*et al*., 1998).

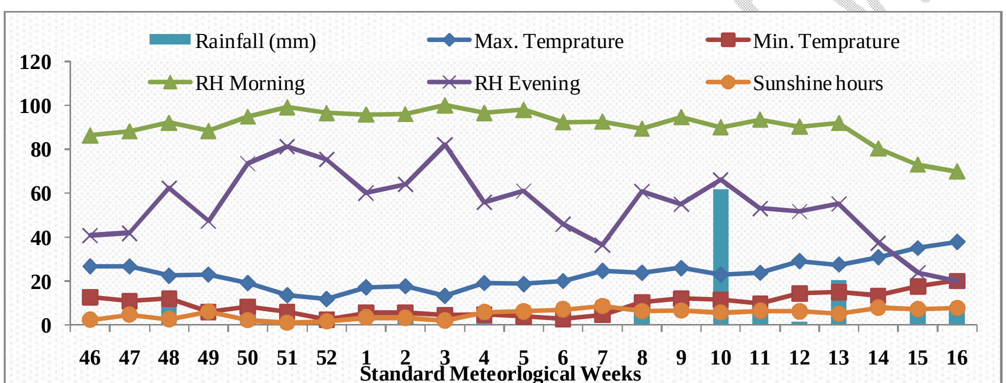

Fig 1 Mean weekly weather condition during cropping period

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3. RESULTS AND DISCUSSION

3.1 Yield attributes

The data on various yield attributes *viz*. effective tillers, spike length, number of grains per spike, number of spikelets per spike, test weight and as influenced by various seed rate and nitrogen levels are presented in (Table 1).

3.1.1 Effective tiller/mrl

The data pertaining Table 1showed that number of effective tillers were significantly affected by nitrogen dose and seed rate. Increasing nitrogen dose from 60 to 90 kg/ha progressively increased number of effective tillers but non-significant differences were recorded between 75-90 kg/ha. Nitrogen dose of 90 kg/ha recorded 1.4 and 8.5 percent higher effective tillers over 75 and 60 kg/ha nitrogen dose, respectively.It might be due to cumulative influence of growth and yield attributing characters owing to fertilization. Greater availability of metabolites (Photosynthates) and nutrients to developing reproductive structures seems to have resulted in increase in all the yield-attributing characters that ultimately

UNDER PREVIEW

improved the yield of the crop (Singh *et al.* 2010).

Number of effective tillers (mrl) progressively increased with the increase in seed rate from 87.5 kg/ha to 125.0 kg/ha. Number of effective tillers obtained with 125.0 kg/ha were found significantly higher over other seed rates except seed rate of 112.5 kg/ha. Number of effective tillers (85.08) recorded with seed rate of 125.0 kg/ha were significantly higher with a relative advantage of 8.0 and 3.6 per cent over seed rate of 87.5 and 100.0 kg/ha, respectively.

3.1.2 Number of grains per spike

A thorough examination of the data in table 1 revealedthat number of grains per spike was significantly affected by nitrogen dose. Increasing nitrogen dose from 60 to 90 kg/ha progressively increased number of grains per spike but non-significant differences were recorded between 75-90 kg/ha. Nitrogen dose of 90 kg/ha recorded 1.2 and 5.1 percent higher grains per spike over 75 and 60 kg/ha nitrogen dose, respectively. Increased yield attributes due to increasing level 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). While seed rate failed to produce significant variation in relation to number of grains per spike. Increasing seed ratesfrom 87.5 to 125.0 kg/ha progressively decreased number of grains per spike.

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3.1.3 No. of spikelets per spike

A close perusal of data in table 1 showed that number of spikelets per spike was significantly affected by nitrogen doses. Increasing nitrogen dose from 60 to 90 kg/ha progressively increased number of spikelets per spike but non-significant differences were recorded between 75-90 kg/ha. Nitrogen dose of 90 kg/ha recorded 1.2 and 7.9 per cent higher over 75 and 60 kg/ha nitrogen dose, respectively while seed rate failed to produce significant variation in relation to number of spikelets per spike. Increasing seed ratesfrom 87.5 to 125.0 kg/ha progressively decreased number of spikelet per spike.

3.1.4 Spike length

A delve to data given in table 1 presented that length of spike was significantly affected by nitrogen dose. Increasing nitrogen dose from 60 to 90 kg/ha progressively increased spike length but non-significant differences were recorded between 60-75 kg/ha and 75-90 kg/ha. Nitrogen dose of 90 kg/ha recorded 6.6 and 11.5 per cent higher spike length over 75 and 60 kg/ha nitrogen dose, respectively while seed rate failed to produce significant variation in relation to spike length. Increasing seed ratesfrom 87.5 to 125.0 kg/ha progressively decreased spike length. This might be due to length of spike is more of genetic in nature.

3.1.5 Test weight (g)

A delve to data given in table 1 presented that test weight was significantly affected by nitrogen

UNDER PEER REVIEW

dose. Increasing nitrogen dose from 60 to 90 kg/ha progressively increased test weight but non-significant differences were recorded between 60-75 kg/ha and 75-90 kg/ha. Nitrogen dose of 90 kg/ha recorded 1.7 and 4.8 per cent higher over 75 and 60 kg/ha nitrogen dose, respectively.

Test weight progressively decreased with the increase in seed rate from 87.5 kg/ha to 125.0 kg/ha. Test weight obtained with 87.5 kg/ha was found significantly higher over seed rate of 125.0 kg/ha. Test weight (37.71) recorded with seed rate of 87.5 kg/ha was significantly higher with a relative advantage of 4.4 per cent over seed rate of 125.0 kg/ha.

3.2 Yield studies

A delve to data exhibited in table 2showing yield studies *i.e.* biological yield, grain yield, green fodder yield, straw yield and harvest index at various nitrogen doses and seed rates in dual purpose barley.

3.2.1 Biological yield (kg/ha)

The perusal of data in table 2 revealed that progressive significant increase in biological yield with increase in nitrogen dose from 60 to 90 kg/ha was recorded. Biological yield with nitrogen dose of 90 kg/ha was found significantly higher over other nitrogen doses. Nitrogen dose of 90 kg/ha recorded 3.8 and 12.0 per cent higher over 75 and 60 kg/ha nitrogen dose, respectively.Biological yield is a function of grain and straw yield representing reproductive and vegetative growth of the crop. The profound influence of nitrogen dose on both of these characters mediated *via* increased photosynthetic efficiency and nutrient accumulation might have ultimately led to production of higher biological yield under its application. The results of present investigation indicated higher production of dual purpose barley under influence of higher fertility levels. These findings are similar to those of Sharma and Verma (2010).

The biological yield progressively increased with the increase in seed rate from 87.5 kg/ha to 125.0 kg/ha. Among the seed rates, biological yield obtained with 125.0 kg/ha was found significantly higher over other seed rates except 112.5 kg/ha. Biological yield (12181 kg/ha) recorded with seed rate of 125.0 kg/ha was significantly higher with a relative advantage of 11.8 and 5.3 per cent over seed rate of 87.5 and 100.0 kg/ha, respectively.

3.2.2 Grain yield (kg/ha)

A disquisition to data given in table 2 exhibited that grain yield was significantly affected by nitrogen doses. Increasing nitrogen dose from 60 to 90 kg/ha progressively increased grain yield but non-significant differences were recorded between 75- 90 kg/ha. Nitrogen dose of 90 kg/ha recorded 1.2 and 7.9 percent higher grain yield over 75 and 60 kg/ha nitrogen dose, respectively.It has been well emphasized that N fertilization play vital role in improving three major aspects of yield determination *i.e.*, formation of vegetative structure for nutrient absorption, photosynthesis and strong sink strength through development of reproductive structure and production of assimilates to fill economically enhanced sink

UNDER PEER REVIEW

(source strength). Thus, cumulative influence of N application seems to have maintained balanced source sink through improving both the events of crop development (vegetative and generative), ultimately resulted in increased grain yield per hectare. These results are in close conformity with the findings of Shaktawat and Shekhawat (2010) and Meena *et al.* (2012).

Grain yield progressively increased with the increase in seed rate from 87.5 kg/ha to 125.0 kg/ha(figure1). Biological yield obtained with 125.0 kg/ha was found significantly higher over other seed rates except seed rate of 112.5 kg/ha. Grain yield (4895 kg/ha) recorded with seed rate of 125.0 kg/ha was significantly higher with a relative advantage of 11.0 and 4.8 per cent over seed rate of 87.5 and 100.0 kg/ha, respectively. Higher grain yield was recorded with seed rate 125.0 kg/ha this was due to higher number of effective tillers recorded with seed rate of 125.0 kg/ha which were significantly higher with a relative advantage of 8.0 and 3.6 per cent over seed rate of 87.5 and 100.0 kg/ha, respectively. Results are close conformity with findings of Singh *et al.* (2009)

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3.2.3 Green fodder yield (kg/ha)

A disquisition to data given in table 2 exhibited that green fodder yield was significantly affected by nitrogen doses. Increasing nitrogen dose from 60 to 90 kg/ha progressively increased green fodder yield but non-significant differences were recorded between 75-90 kg/ha. Nitrogen dose of 90 kg/ha recorded 3.3 and 15.1 per cent higher over 75 and 60 kg/ha nitrogen dose, respectively.The increase in green fodder yields were due to taller plants having more effective tillers due to increased nitrogen uptake.This might be due to N plays important role for providing nutrient to the plants during vegetative stage. These improvement in availability of nutrients also increased the supplyof metabolites that's synchronized to demand for overall improvement anddevelopment of vegetative structure.

Green fodder yield progressively increased with the increase in seed rate from 87.5 kg/ha to 125.0 kg/ha. Green fodder yield obtained with 125.0 kg/ha was found significantly higher over other seed rates except seed rate of 112.5 kg/ha. Green fodder yield (3729 kg/ha) recorded with seed rate of 125.0 kg/ha was significantly higher with a relative advantage of 16.6 and 7.1 per cent over seed rate of 87.5 and 100.0 kg/ha, respectively.

3.2.4 Straw yield (kg/ha)

The perusal of data in table 2 revealed that progressive significant increase in straw yield with increase in nitrogen dose from 60 to 90 kg/ha. Straw yield with nitrogen dose of 90 kg/ha was found significantly higher over other nitrogen doses. Nitrogen dose of 90 kg/ha recorded 4.9 and 13.7 per cent higher over 75 and 60 kg/ha nitrogen dose, respectively.The significant increase in straw yield with additional N fertilization seems to be dueto its direct effect in improving biomass per plantat successive growth stages as well as in plant part at harvest of the crop,while the indirect effect might be on account of increase invarious morphological parameters *viz.*, plant height andnumber of tillers.

UNDER PEER REVIEW

Straw yield progressively increased with the increase in seed rate from 87.5 kg/ha to 125.0 kg/ha. Straw yield obtained with 125.0 kg/ha was found significantly higher over other seed rates except seed rate of 112.5 kg/ha. Straw yield (7259 kg) recorded with seed rate of 125.0 kg/ha was significantly higher with a relative advantage of 12.42 and 5.6 per cent over seed rate of 87.5 and 100.0 kg/ha, respectively.

3.3.5 Harvest index

Data mentioned in table 2 reflects that nitrogen dose and seed rate failed to produce significant variation in relation to harvest index. Increasing nitrogen dose and seed rate from 60 to 90 kg/ha and 87.5 to 125.0 kg/ha, respectively showed the progressive decreasing trend of harvest index. However, numerical variation was recorded among different nitrogen dose and seed rate for harvest index. Higher harvest index (40.96) and (40.79) was recorded with nitrogen dose 60 kg/ha and seed rate 87.5 kg/ha, respectively, while minimum harvest index (40.05) and (40.43) recorded with nitrogen dose 90 kg/ha and seed rate 125.0 kg/ha, respectively.Nitrogen dose and seed rate of 60 kg/ha and 87.5 kg/ha recorded 0.5 and 2.3 and 0.5, 0.8 and 0.9 per cent higher over 75 and 90 kg/ha nitrogen dose and 100, 112.5 and 125.0 kg/ha seed rates, respectively.

3.3 Economics

The data pertaining to cost of cultivation, gross returns, net returns and B:C is given as under various seed rate and nitrogen dose are presented in Table 3.

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Data given in Tables (3) revealed that increasing nitrogen dose and seed rates from 60 to 90 kg/ha and 87.5 to 125.0 kg/ha, respectively increased cost of cultivation, gross returns, net returns and B: C ratio progressively. Among different nitrogen doses, maximum cost of cultivation (₹63,848), gross returns (₹1,00,437), net returns (₹36,589) and B:C ratio (1.57) recorded with nitrogen dose 90 kg/ha, which was 1.4, 13.1, 41.7 and 11.3 per cent, respectively higher over 60 kg/ha.These results are in conformity with those of Singh *et al.* (2013) who reported that the higher net profit was obtained with higher dose of nitrogen in dual purpose barley over lower doses.

Among different seed rates, maximum cost of cultivation (₹64503), gross returns (₹99,439), net returns (₹34,937) and B:C ratio (1.54) recorded with seed rate 125.0 kg/ha which was 3.5, 10.3,25.4 and 6.2 per cent higher over 87.5 kg/ha, respectively. These findings are confirmed by Stougaard and Xue, (2005).

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CONCLUSION

Based on field research experiment, it is concluded that increasing nitrogen dose from 60 to 90 kg/ha progressively increased plant population, phenology, yield attributesand yield of dual purpose barley. Among nitrogen doses, 90 kg/ha being at par with 75 kg/ha recorded significantly higher grain yield (4895 kg/ha), biological yield (12220 kg/ha), green fodder yield (3706 kg/ha) which were 9.7, 12.0, 15.1percent higher than nitrogen dose of 60 kg/ha, respectively due to higher yield attributes *i.e.* number

UNDER PEER REVIEW

of effective tillers (85.08), number of grains per spike (44.15), number of spikelets per spike (23.10), spike length (7.47) and test weight (37.82) with nitrogen dose 90 kg/ha which were 8.5, 5.1, 7.9, 11.4 and 4.8 percent higher than nitrogen dose of 60 kg/ha, respectively. Increase in number of 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 effective tillers (85.11), grain yield (4922 kg/ha), biological yield (12181 kg/ha), green fodder yield (3729 kg/ha) which were 8.0, 11.0, 11.8 and16.7 per cent higher than seed rate of 87.5 kg/ha, respectively.So, to obtain higher yield and economic returns 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.

Table 1:Effect of different nitrogen dose and seed rate on yield attributes of dual-purposebarley

Comment [HT11]: Attached the figure (chart) of yield attributes of barley

Treatments	**Yield attributes**				
Nitrogen dose	**No. of effective tiller/mrl**	**No. of grain per spike**	**No. of spikelet per spike**	**Spike length (cm)**	**Test Weight (g)**
Nitrogen dose					
N_1- 60 kg/ha	78.42	42.01	21.41	6.70	36.09
N_2- 75 kg/ha	83.92	43.62	22.77	7.14	37.19
N_3- 90 kg/ha	85.08	44.15	23.10	7.47	37.82
SEm ±	0.57	0.44	0.43	0.18	0.40
CD at 5%	**1.71**	**1.33**	**1.29**	**0.55**	**1.20**
Seed rate					
S_1 -87.5 kg/ha	78.78	43.89	22.85	7.24	37.71
S_2-100.0 kg/ha	82.11	43.67	22.45	7.12	37.45
S_3-112.5 kg/ha	84.27	42.90	22.32	7.08	36.70
S_4-125.0 kg/ha	85.11	42.59	22.01	7.00	36.13
SEm ±	0.67	0.51	0.40	0.28	0.29
CD at 5%	**2.38**	**NS**	**NS**	**NS**	**1.02**

Table 2: Effect of different nitrogen dose and seed rate on yield ofdual-purposebarley

Comment [HT12]: Attached the figure (chart) of yield of barley

Treatments	**Yield (kg/ha)**				
	Biological yield	**Grain yield**	**Green fodder Yield**	**Straw yield**	**Harvest Index**
Nitrogen dose					
N_1- 60 kg/ha	10907	4463	3221	6444	40.96
N_2- 75 kg/ha	11773	4788	3586	6985	40.70
N_3- 90 kg/ha	12220	4895	3706	7325	40.05
SEm ±	108	69	54	99	0.54

UNDER PEER REVIEW

CD at 5%	**328**	**210**	**164**	**299**	**NS**
Seed rate					
S_1-87.5 kg/ha	10892	4435	3197	6457	40.79
S_2-100.0 kg/ha	11571	4696	3482	6875	40.59
S_3-112.5 kg/ha	11890	4810	3610	7085	40.48
S_4-125.0 kg/ha	12181	4922	3729	7259	40.43
SEm ±	122	57	67	97	0.38
CD at 5%	**429**	**201**	**238**	**335**	**NS**

Table 3: Effect of nitrogen dose and seed rate on economics (₹ ha^{-1}) on dual-purpose barley

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Treatment	**Economics (₹ ha^{-1})**			
Nitrogen dose	**Cost of cultivation**	**Gross return**	**Net return**	**B:C Ratio**
N_1- 60 kg/ha	62968	88787	25819	1.41
N_2- 75 kg/ha	63408	97602	34194	1.54
N_3- 90 kg/ha	63848	100437	36589	1.57
Seed rate				
S_1-87.5 kg/ha	62315	90166	27851	1.45
S_2-100.0 kg/ha	63043	95456	32412	1.51
S_3-112.5 kg/ha	63773	97374	33601	1.53
S_4-125.0 kg/ha	64503	99439	34937	1.54

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Comment [HT14]: Year of reference can't matched from above.

Comment [HT15]: Year of reference shouldn't be matched from above

Comment [HT16]: Add few more references if possible (approx. 30)

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