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RESPONSE OF NITROGEN LEVELS AND CUTTING MANAGEMENT ON GROWTH AND YIELD OF DUAL PURPOSE BARLEY

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ABSTRACT

During the 2020–21 *Rabi* season, a field experiment was carried out at the Agronomy Instructional Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat. The pH of the loamy sand soil in the experimental field was 7.58, with low levels of organic carbon and available nitrogen, medium levels of available phosphorus and high levels of available potassium. The experiment consisting of twelve treatment combinations comprised of three nitrogen levels *viz.*, 100 kg N/ha, 120 kg N/ha and 140 kg N/ha and four cutting management *viz.*, 45 DAS, 55 DAS and 65 DAS and no cutting (Only seed production) were laid out in randomized block design (factorial concept) with four replications. Fertilizing the dual purpose barley with 120 kg N/ha recorded significantly higher plant height, number of leaves, leaf length, dry leaf weight per plant, dry stem weight per plant, seed yield straw yield and seed equivalent yield at the time of harvesting. Fertilizing the dual purpose barley crop with 140 kg N/ha recorded numerically higher green forage yield and dry forage yield at time of green forage cutting. The results on plant height, number of leaves per plant, leaf length, dry leaf weight per plant, dry stem weight per plant, seed yield and straw yield significantly higher by no cutting treatment at the time of harvesting. Whereas, seed equivalent yield of barley was significantly higher with cutting at 55 DAS at harvesting time. Cutting of dual purpose barley at 65 DAS recorded numerically higher green forage yield and dry forage yield at the time of green forage cutting.

Key words : Barley, Nitrogen, Cutting, Fertilizer.

Introduction

Barley is a temperate and subtropical crop and is widely adapted to different climatic conditions. It is regarded as one of the crops that can withstand salt the best. Additionally, barley is regarded as a poor man's crop and is more tolerant of difficult soils and marginal terrain. 15% of the coarse grains consumed worldwide come from this region. Whole barley grain contains vitamins and minerals like calcium, magnesium, phosphorus, potassium, vitamin A, vitamin E and niacin.

In the world, about 70% of barley is used for animal feed, 20% for malting and 5% for direct food use. The green fodder of barley may be a viable source of income generation for farmers. It is an important industrial crop because it is used as raw material for beer, whisky and brewing industries. Barley is also used as green fodder, straw, hay or silage. The barley products like "sattu" (in summer because of its cooling effects on the human body) and Missi Roti have been traditionally used in India (Verma *et al.*, 2011).

Among the different agronomic practices, fertilizer and cutting management plays an important role for the production of barley for green forage as well as grain yield. In fertilizer management, nitrogen is the most common limiting nutrient for barley crop production and therefore, adoption of good nitrogen management strategies often results in large economic benefits to the farmers. Nitrogen is the key element in achieving consistently high yields in cereals. It is an essential element of all amino acids in plant structure, which are the building block of plant proteins. It is a constituent of physiologically important compounds like nucleotides, vitamins, enzymes, chlorophyll and hormones that promotes growth and development in crop plants (Kumar *et al*., 2001). Nitrogen also increases the meristematic activity, which is useful for absorption of nutrients and enhances the cell division, cell elongation and protein content through the improvement in synthesis of carbohydrates.

Cutting management is the one of the important factors to influence the growth, yield and quality of fodder crop. In general, the cutting management for dual purpose fodder crop, the stage of cutting is most important. Early cutting of barley forage crop will reduce the quality of forage and grain yield will be affected by late harvesting of forage. So, it is important to determine the right stage of cutting of barley to obtain the highest green fodder as well as grain yield from the crop. When crop grown as a green fodder plus grain crop, the first cut of barley at proper vegetative growth stage provides fresh and nutritious green fodder to animal at minimum cost. The ratoon is maintained for grain and harvest at crop maturity gives satisfactory grain yield and straw yield.

Materials and Methods

Experimental site

The field experiment was laid out during *Rabi* season of 2020-21 at Agronomy Instructional Farm, Department of Agronomy, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha (Gujarat). Geographically, situated at 24^o 19' North latitude and 72^o 19' East longitude with an elevation of 154.52 meters above the mean sea level and represents the North Gujarat Agroclimatic region. The climate of this region is sub-tropical monsoon type and falls under semi-arid region. In general, monsoon is warm and moderately humid, winter is fairly cold and dry, while summer is largely hot and dry.

Physico-chemical properties of soil

The experimental field land was uniform, and it had a mild slope with effective drainage. It is appropriate for a wide range of crops grown in tropical and subtropical regions. The soil of the experimental plot has a loamy sandy texture. Initial soil analysis data showed that the experimental area had low organic carbon (0.24%), available nitrogen (162 kg/ha), medium phosphorus (38.2 kg/ha) and rich in potassium (287 kg/ha) in the experimental area. Very low EC (0.12 ds/m) indicates that the soil was free salinity hazard.

Experimental details

For experiment, the dual purpose barley variety RD 2552 was used. Barley variety RD 2552 belongs to the *Hordeum* genus and raw species, developed at Rajasthan Agricultural Research Institute (RARI), Jobner. The experiment was set up using a randomized block design (factorial concept) with four replications. Gross plot size is 5.0 m × 3.6 m and net plot size is 4.0 m × 2.4 m. The seed of dual purpose barley variety were drilled manually to a depth of 2-3 cm in the previously opened furrows at a distance of 30 cm apart between two rows and it was covered with the soil.

It included twelve treatment combinations with three nitrogen level *viz*., 100 kg N/ha, 120 kg N/ha and 140 kg N/ha and four cutting management *viz.*, 45 DAS, 55 DAS, 65 DAS, and no cutting (only seed production). The barley crop received a half-dose of nitrogen as a basal and the remaining half-dose as a top dressing in the form of urea and DAP are applied immediately after each cutting and in the absence of cutting at tillering stage of the barley. All plots received the same amount of 40 kg of phosphorus per hectare in the form of DAP. The Department of Agricultural Statistics at the C. P. College of Agriculture used computer software to analyses the data using the method outlined by Cochran and Cox (1967). The "F" test was used to compare the variances of the various sources of variation in the ANOVA with the value of Table F at the 5% level of significance, S.Em.±, critical differences and the coefficient of variation (C.V.%) were also calculated.

Biometric observations

Plant height (cm) and number of leaves per plant

The five previously labelled plants were measured in centimetres from the base to the tip of the flag leaf or ear head and their leaf counts at time of harvesting. Mean plant height and number of leaves per plant was determined by averaging the five plants.

Leaf length (cm)

From the base to the tip of the leaves, the length of each of the three developed leaves on each of the five previously tagged plants was measured. The length of leaves on each plant was determined by averaging five plants.

Dry leaf weight per plant (g)

From the ring line on both sides of each plot, a total of five plants were chosen at random to record the leaf weight per plant at harvest. Five plants that had previously been tagged were used to record the leaf weight of each plant at harvest time. After separating the leaf and stem portions, they were each given a separate brown paper bag and weighted using an electrical scale up to two decimals. The separated leaves were first allowed to dry in the sun and then dried in hot air oven at 60^0C till constant weight is obtained. After that, the weight of the dry leaves was recorded on an electronic balance up to two decimals. Dry leaf weight per plant was determined by averaging five plants.

Dry stem weight per plant (g)

The previously separated stem piece was first left to dry in the sun and then heated to 60^0C in a hot air oven until a consistent weight was achieved. Next, the electronic balance was used to record the dry stem weight up to two decimals. Dry stem weight per plant was determined by averaging the five plants.

Green forage yield (q/ha)

The net plot's plants were harvested with the plants remaining 2-3 cm above the ground and fresh weight of the harvested produce was recorded for each treatment separately at 45, 55 and 65 days after sowing and converted into hectare basis by multiplying with multiple factor.

Dry forage yield (q/ha)

A sample of thousand grammes of green plants was randomly weighed at 45, 55 and 65 days after sowing and stored in a brown paper bag. After that, samples were baked at 60 degrees Celsius and sun dried until a constant weight was achieved. After the sample was dried in the oven, its dry weight was measured using an electronic scale up to two decimals. This weight was then multiplied by a multiple the factor to get the sample's hectare base.

Seed yield (kg/ha)

Each net plot dried bundles were weighed to determine the biological yield, after which the seeds were cleaned and threshed. Following that, each net plot seed yield was measured and reported in kilogrammes. The seed production of the five previously tagged plants in each treatment was also added to the corresponding net plot yield and the factor was multiplied to convert the result into hectares.

Straw yield (kg/ha)

Straw yield was obtained by subtracting the seed yield of each net plot from their respective total dry matter (biological yield). The straw yield of previous tagged five plants also added in net plot and was converted into hectare basis by multiplying with multiple the factor.

Seed equivalent yield (kg/ha)

Seed equivalent yield of barley was calculated for each treatment on the basis of following formula

Seed equivalent yield (kg/ha)

$$= \frac{\left[\begin{pmatrix}\text{Green forage yield} \times \text{Price of green forage yield} \\ \text{(kg/ha)} \qquad\qquad \text{(Rs/kg)}\end{pmatrix} + \begin{pmatrix}\text{Straw yield} \times \text{Price of straw yield} \\ \text{(kg/ha)} \qquad\qquad \text{(Rs/kg)}\end{pmatrix}\right]}{\text{Price seed yield (Rs/kg)}}$$

+ Seed yield (kg/ha)

Economics

In order to evaluate the effectiveness of each individual treatment, the relative economics of each treatment was worked out in terms of net profit, so that the most effective and remunerative treatment could be found out.

Net realization (Rs/ha)

The gross realization in terms of rupees per hectare was worked out based on green forage yield, seed yield and straw yield of dual purpose barley for each treatment with the prevailing market prices. The total cost of cultivation of the dual purpose crop for each treatment was worked out by considering the expenses incurred for all cultural operations as well as cost of various inputs. The net realization was computed by subtracting the total cost of cultivation from gross realization per hectare for each treatment.

Benefit: Cost Ratio (BCR)

The benefit: cost ratio (B : C ratio) is the ratio of gross realization to total cost of cultivation and was calculated by using following formula

$$\text{Benefit : Cost Ratio (BCR)} = \frac{\text{Gross realization (` /ha)}}{\text{Total cost of cultivation (` /ha)}}$$

Results and Discussion

Plant height (cm)

When it came to harvesting time, various nitrogen level treatments had a significant impact on plant height. The application of 120 kg of nitrogen per hectare resulted in noticeably higher plant height (78.79 cm), although it was at par with the application of 140 kg of nitrogen per hectare. Due to increased meristematic activity brought on by the availability of nitrogen in sufficient quantities and at the proper times throughout the entire growth period of the crop, which in turn caused higher cell enlargement and cell elongation. The findings of Singh *et al.* (2003), Alam *et al.* (2007), Ferdous and Biswas (2007), and Meena *et al.* (2012), Singh *et al.* (2018) concur with those of the present study.

Plant height was significantly influenced by different cutting management. Significantly the highest plant height (82.31 cm) was recorded by no cutting treatment of dual purpose barley crop but it was statically at par with the 45 days after sowing cutting (77.82 cm) due to longer period of growth and development of dual purpose barley crop and better assimilation of photosynthates. The findings concur with those made by Ferdous and Biswas (2007), Hadi *et al.* (2012a), Karwasra *et al.* (2007) and Patel *et al.* (2011). The interaction effect of nitrogen levels and cutting management on plant height recorded at the time of harvesting was found non-significant.

Number of leaves per plant

In case of harvesting time, number of leaves per plant increased significantly up to 120 kg nitrogen per hectare. The same treatment recorded a significantly higher number of leaves per plant (11.70) at the time of harvesting, but it was at par with the application of 140 kg nitrogen per hectare due to the use of nitrogen, which has caused the barley crop to grow more favorably and at a higher plant height. The result of Hadi *et al.* (2012b) and Patel *et al.* (2020) showed that the application of 120 kg nitrogen per hectare recorded a significantly higher number of leaves per plant of barley crop.

The barley crop growing without cutting recorded significantly the higher number of leaves per plant (12.07), but it remained at par with 45 days after sowing cutting. due to more height of the plant and more growth period in no cutting treatment. Because the plant is taller and has more time to grow without cutting, there may be more leaves on each plant. According to Hadi *et al*. (2012a), growing barley crop without cutting resulted in a higher number of leaves per plant of barley. The interaction effect of nitrogen levels and cutting management did not exert any significant effects on number of leaves per plant of dual purpose barley at harvesting time.

Leaf length (cm)

The leaf length data presented in Table 1 shows that significantly higher leaf length (17.65 cm) was observed when applying 120 kg nitrogen/ha, but it was remained at par with the application of 140 kg nitrogen/ha at the time of harvesting. The increase in leaf length was due to continuous supply and availability of nitrogen to the crop enhances the meristematic activities of plant cells leading to higher cell enlargement and cell elongation which might be turned into better vegetative growth leading to the higher leaf length of dual purpose barley crop. The result of Patel *et al*. (2020) showed that the application of 120 kg nitrogen per hectare recorded significantly higher leaf length of barley crop.

At the time of harvest, a significantly higher leaf length (17.99 cm) was observed by no cutting. The longer cutting intervals may have given the barley plant more time to grow, resulting in higher plant height and a greater number of leaves per plant, which in turn contributed to the longer leaf length of the barley crop. The interaction effects of nitrogen levels and cutting management on leaf length of dual purpose barley was found non-significant at the time of harvesting.

Dry leaf weight per plant (g)

Perusal of data presented in Table 1 revealed that crop fertilized with 120 kg nitrogen per hectare registered significantly higher dry leaf weight per plant (0.92 g), but it remained at par with 140 kg nitrogen per hectare. The increase in the leafy portion brought on by the nitrogen application may have increased photosynthetic activity and led to the production of additional photosynthates, increasing the amount of dry leaf mass per plant of the barley crop.

The data embodied in Table 1 indicated that the no cutting the barley crop recorded significantly the higher dry leaf weight per plant (0.93 g), but it was at par with cutting at 45 days after sowing. The remarkable increase in dry leaf weight per plant without cutting might be attributed due to the favorable effect on plant height and number of leaves per plant which ultimately leads to higher dry leaf weight per plant. The interaction effect of nitrogen levels and cutting management on dry leaf weight per plant of dual purpose barley was found non-significant at the time of harvesting.

Dry stem weight per plant (g)

According to the findings presented in Table 1, the application of 120 kg of nitrogen per hectare resulted in significantly higher dry stem weight per plant (3.70 g), but it was statistically equivalent to the application of 140 kg of nitrogen per hectare at the time of harvest. A higher nitrogen dose was applied, which promoted more growth and development and as a result, increased dry stem weight per plant.

When dual purpose barley was grown without cutting, the dry stem weight per plant was much greater (3.74 g), but it was still comparable to cutting at 45 days after planting when the crop was harvested. Due to different cutting management, the dry stem weight per plant followed the same pattern as the dry leaf weight per plant. The interaction effect of nitrogen levels and cutting management on dry stem weight per plant of dual purpose barley was found non-significant.

Green forage yield (q/ha)

The information in Table 1 showed that the yield of green fodder linearly increased as the nitrogen levels increased. However, by applying 120 and 140 kg of nitrogen per hectare at the time of green forage cutting, quantitatively equivalent green forage yield (213 q/ha) was observed. The increase in leaf fraction due to nitrogen application can eventually lead to an increase in photosynthetic activities and also production of more photosynthetic substances. This readily available feed for growing parts may have contributed to improved growth parameters and yield attributes.

As a result, nitrogen yielded a better response to forage yield of a multi-purpose crop. Cutting green forage at 65 days after sowing resulted in a numerically greater green forage production (259 q/ha), which was followed by cutting at 55 DAS (211 q/ha). This could eventually lead to increased photosynthetic activity and induce more photosynthesis, which would increase the green forage yield of barley.

Dry forage yield (q/ha)

The data overview in Table 1 shows that dry forage yield increases linearly with increasing nitrogen levels. A numerically higher value of dry forage yield (54 q/ha) was observed when 140 kg nitrogen per hectare was applied and followed by 120 kg nitrogen per hectare (53 q/ha) application. Dry forage yield followed a similar trend observed in green forage yield due to nitrogen use. Nitrogen is widely used in the synthesis of proteins, chlorophyll molecules and carbohydrates, ultimately producing more green and dry feed yields.

The data overview in Table 1 shows that dry forage yield increases linearly with late forage cutting. Quantitative higher dry forage yield (72 q/ha) was recorded 65 days after sowing the cut and then 55 DAS cuttings (55 q/ha). This may be due to the higher forage yield in 65 DAS treatment, so the dry forage yield was naturally higher within 65 days after sowing the cutting compared to 45 days after sowing the cutting.

Seed yield (kg/ha)

Seed yield data affected by different nitrogen levels and cutting management of dual-purpose barley at harvest are presented in Table 1. The application of 120 kg nitrogen per hectare resulted in a significantly higher seed yield (2983 kg/ha), while it was at par with 140 kg of nitrogen per hectare. The quick growth of dark green foliage, which may absorb and use more light energy during photosynthesis to produce more carbohydrates, may be the reason nitrogen levels are having a positive impact. The present findings are in accordance with the findings of Arora and Singh (2004), Alazmani (2015), Verma *et al.* (2016b), Zebarth *et al.* (2009), Neetarani *et al.* (2018) and Singh *et al.* (2018).

Without cutting, the dual-purpose barley produced a significantly highest seed production (4037 kg/ha). The reduction in grain yield at 65 DAS cuttings could be attributed to the shortened vegetative and reproductive periods by delaying green forage cutting. Thus, shortening the seed filling time may have led to the forced maturation of the barley crop, resulting in the production of more shrunken seeds and thus a significant reduction in grain yield in the 65 DAS cutting treatment. According to Kaur *et al.* (2009), Kharub *et al.* (2013), Singh *et al.* (2014), and Lal and Saini (2017), the current results are in agreement with those of those authors. The interaction effect of nitrogen levels and cutting management did not exert any significant effect on seed yield of dual purpose barley.

Straw yield (kg/ha)

Table 1 details the data on straw yield as influenced by various nitrogen levels and cutting management of dual purpose barley at harvest. The barley crop applied with 120 kg nitrogen/ha resulted in significantly higher straw yields (4692 kg/ha) but it was at par with 140 kg nitrogen/ha. This means that higher plant height, higher number of leaves per plant, higher dry leaf weight per plant and higher dry stem weight per plant results in higher straw yields per hectare. The studies of Roy and Singh (2006), Alazmani (2015), Varma *et al.* (2016), Zebarth *et al.* (2009), Neetarani *et al.* (2018) and Singh *et al.* (2018) also revealed similar trends.

Significantly, no cutting treatment had the highest straw yield (5351 kg/ha). The reduced straw production with delay in cutting may be caused by a shorter vegetative and reproductive time. The studies of Kaur *et al.* (2009), Singh *et al.* (2014), Lal and Saini (2017), and Uppal and Dhillon (2019) all revealed comparable trends. The interaction effect of nitrogen levels and cutting management did not exert any significant effect on straw

Table 1 : Growth and yield parameter of dual purpose barley as influenced by nitrogen levels and cutting management.

Treatments	Plant height (cm)	Number of leaves per plant	Leaf length (cm)	Dry leaf weight per plant (g)	Dry stem weight per plant (g)	Green forage yield(q/ha)	Dry forage yield(q/ha)	Seed yield (kg/ha)	Straw yield (kg/ha)	Seed equivalent yield (kg/ha)
	At harvest					At the time of green forage cutting		At harvest		
Nitrogen levels (N)										
N_1 **:** 100 kg/ha	70.77	10.25	15.29	0.72	3.18	189	51	2493	4061	4881
N_2 **:**120 kg/ha	78.79	11.70	17.65	0.92	3.70	213	53	2983	4692	5687
N_3 **:** 140 kg/ha	75.98	11.15	17.01	0.85	3.52	213	54	2936	4467	5605
S.Em.±	1.50	0.30	0.56	0.03	0.09	-	-	78	106	82
C.D. at 5%	4.31	0.87	1.62	0.08	0.26	-	-	224	304	236
Cutting management (C)										
C_1 **:** 45 DAS	77.82	11.25	17.22	0.86	3.51	145	31	2962	4335	5430
C_2 **:** 55 DAS	72.77	10.75	16.09	0.79	3.38	211	55	2755	4019	5949
C_3 **:** 65 DAS	67.80	10.07	15.30	0.75	3.24	259	72	1462	3922	5203
C_4 **:** No cutting (Only Seed production)	82.31	12.07	17.99	0.93	3.74	-	-	4037	5351	4981
S.Em.±	1.73	0.35	0.65	0.03	0.11	-	-	90	122	95
C.D. at 5%	4.98	1.00	1.87	0.09	0.31	-	-	258	351	272
Interaction (N × C)										
S.Em.±	3.00	0.60	1.13	0.06	0.18	-	-	155	211	164
C.D. at 5%	NS	NS	NS	NS	NS	-	-	NS	NS	NS
C.V.(%)	7.97	10.96	13.56	13.62	10.62	-	-	11.1	9.6	6.1

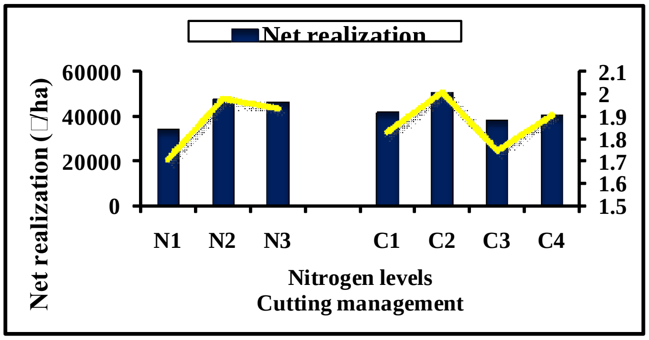

Fig. 1 : Economics of dual purpose barley as influenced by nitrogen levels and cutting management.

yield of dual purpose barley.

Seed equivalent yield (kg/ha)

Table 1 provides information on the seed equivalent yield of barley as influenced by various nitrogen levels and cutting management of dual purpose barley. Although, the seed equivalent yield of the barley crop was significantly higher when 120 kg of nitrogen per hectare was applied (5687 kg/ha), it was at par with 140 kg of nitrogen per hectare. Due to higher green forage yield (Table 1), seed yield (Table 1) and straw yield (Table 1) after the treatment of 120 kg nitrogen per hectare, the dual purpose barley seed equivalent yield increased. Findings from Yadav *et al*. (2003) and Singh *et al*. (2009) also noted similar results.

Significantly, cutting 55 days after sowing produced the maximum seed equivalent yield of the barley crop (5949 kg/ha). With no cutting treatment applied to the dual purpose barley, a decreased seed equivalent yield of 4981 kg/ha of barley was reported. This may be because higher green forage yield (Table 1), seed yield (Table 1) and straw yield (Table 1), which led to a higher seed equivalent yield of the dual-purpose barley crop. The interaction effect of nitrogen levels and cutting management did not exert any significant effect on seed equivalent yield of dual purpose barley.

Economic

Dual purpose barley crop recorded maximum gross realization (96679 ` /ha), net realization (47778 ` /ha) and benefit: cost ratio (1.98) by application of 120 kg nitrogen per hectare. The gross realizations, net realizations and benefit : cost ratio derived from different cutting (Fig. 1) indicated that cutting at 55 days after sowing gave the highest gross realization (101133 ` /ha), net realization (50701 ` /ha) and benefit : cost ratio (2.01).

Conclusion

In light of the results obtained from this investigation, the dual purpose barley crop should be fertilized with 120 kg nitrogen per hectare (50% N basal and 50% N just after each cutting) and cutting the barley crop at 55 days after sowing was obtained higher seed equivalent yield, net realizations and benefit: cost ratio.

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