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Original Research Article

Effect of Different Levels of Nitrogen on Productivity of Green Biomass of Sorghum [*Sorghum bicolor*(L.) Moench] under Temperate Conditions of Kashmir

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A B S T R A C T

The present investigation was carried out at experimental field at Faculty of Agriculture, Division of Agronomy, Wadura (SKUAST-K) during Khareif 2018, in split plot design with four levels of nitrogen application (90,120,150 and 180 kg N ha^{-1}) in sub plots with three replications and 12 treatment combinations. The soil of the experimental field was clay loam in texture, neutral in reaction, medium in organic matter, potassium (224 kg/ha), phosphorus (19.6 kg/ha) and low in nitrogen (240 kg/ha). Application of 180 kg N ha^{-1} significantly increased plant height, dry matter accumulation and leaf area index than other treatments of nitrogen application. Total green fodder as well as dry fodder yield and crude protein content (%) significantly improved by application of nitrogen up to 180 kgha-^{1}. However crude fibre content (%) decreased with increased levels of nitrogen. Highest net returns (Rs 60602 ha^{-1}) and B: C (1.70) was recorded with the application of 180 kg N ha^{-1}.

Keywords

Productivity, Dry matter, Crude protein, Leaf area index

Introduction

India is having the largest livestock population of 529.7 million heads, which is about 15 per cent of the world's livestock population. India supports 55, 16, 20 and 5 per cent of world's buffalo, cattle, goat and sheep population, respectively (Anonymous, 2014). But, the country has only 4.4 per cent (8.3 million hectare) of the cultivated area under fodder crops with an annual total forage production of 833 m t (390 m t green and 443 m t dry fodder). The annual forage requirement is 1594 m t (1025 m t green and 569 m t dry fodder) to support the existing livestock population (Source: Livestock census, Dept. of Animal Husbandry, Dairing & Fisheries, Ministry of Agri., GOI. 2012). Forages are the mainstay of animal wealth and their production is the backbone of livestock industry. The scarcity of green forages and grazing resources in India has made the livestock to suffer continuously with malnutrition resulting in their production potentiality at sub-optimum level as compared to many developed nations.

The present feed and fodder resources of the country can meet only 48 per cent of the requirement with a vast deficit of 61.1, 21.9 and 64 per cent green, dry fodder and concentrate feeds, respectively (Anonymous, 2014). Even though the farmers are rearing the livestock breeds with higher milk yield potential, they are suffering from deficit in green and dry fodder availability in the country. Because of ever growing demand for food, land area for fodder production is declining with consequent shortage of fodder supply. The problem is further aggravated by increased urbanization contributing to shrinking cultivable land area and preference of farmers to grow cash crops rather than fodder crops. To overcome this deficit, dairy farmers resort to the increased use of costly concentrate feeds which increases the cost of production. The only way to bridge the large gap between supply and demand of fodder is to maximize the fodder production per unit area per unit time within the existing farming systems and utilising marginal, sub marginal dry lands and problematic soils for developing feed and fodder resources. Simultaneous efforts in the genetic upgradation of the livestock as well as fodder resources with the identification and introduction of new high yielding nutritious fodder crops and identifying suitable agronomic practices are the need of the day. Fertilizer management is an important agronomic aspect which includes proper application of macro and micro nutrients to get maximum quality forage (Verma *et al.*, 2005). Nutrient rich fodder sorghum is more advantageous in many ways such as high yield in shorter period and continuous supply of green fodder for a longer period (Shinde *et al.,* 1987).Productivity of fodder sorghum is low in India because of insufficient supply or sub optimal use of nutrients, in general and nitrogen and zinc in particular. Nitrogen plays a vital role in growth, development and fodder quality as it is a principle constituent of protein. Timing and placement of N fertilizer have a major effect on the efficiency of N management system. Nitrogen should be applied to a crop at times that avoids periods of significant loss and provide adequate N when needed. For producing sorghum hybrids for forage, nitrogen should be applied in a split application with half of the nitrogen applied at planting and the remaining applied after the first cut (OMAF, 2002). In irrigated areas, Nitrogen fertilizer is the main factor affecting the dry matter production of sorghum cultivars; Nitrogen is highly soluble and leaches down in most of the soils (Rahman *et al.,* 2001).

Materials and Methods

The investigation was conducted at the experimental farm of Division of Agronomy at Wadura campus of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, Sopore during Khareif 2018, that lies at 34º17' N latitude and 74º33' E longitude at 1524 meter above mean sea level. The experimental site was well drained and had uniform topography. Climatically the experimental site is in mid to high altitude temperate zone characterized by hot summers and very cold winters. The total precipitation is 339.5 mm (average over past twenty years) and more than 80% of precipitation is received from western disturbances. The maximum and minimum temperatures were 28.6^{o}C and 14.4^{o}C, respectively. The total numbers of sunshine hours recorded during the crop growth period were 122.5 and the mean maximum and minimum relative humidity were 80.45 % and 55.9 %, respectively during the crop growth period. The treatments comprised of three sowing dates (11th June, 26th June and 10th July) and four nitrogen levels (90, 120, 150, 180 kg ha^{-1}). MP Chari variety was used as the test variety. The experiment was laid out in split plot design with three replications and 12 treatment combination. Main plots were assigned to nitrogen fertilizer levels of 90(N1), 120 (N2), 150 (N3) and 180 (N4) kg per hectare while the planting dates of T1 (June, 11th), T2 (June 26th) and T3 (July 10th) were allocated to subplots. Seeds were sown by hand on the rows with 10 cm intervals. The sowing density was considered 170,000 plants per ha. Sowing depth was 2-3 cm with 2-3 seed in each hole to guarantee the expected plant population. Recommended package of practices were adopted to raise a healthy crop. Plant height was measured from the base of the plant to the tip of the longest leaf stretched at 20 days interval from randomly labelled five plants in each net plot area and expressed in cm. Leaf area was recorded by destructive samples at 20 days interval, using Li-COR model, LT-300 portable leaf area meter with transparent conveyor belt and electronic digital display. Fordry matter accumulation Five plants were randomly selected from penultimate rows of each plot at 20 days interval from sowing date to harvest. These plants were cut from ground level and sun dried for 2-3 days. These samples were chopped into small pieces after sun drying, mixed homogenously and dried in hot air oven at 60^0C temperature till constant weight. The dry weight of plant samples was recorded as g plant^{-1}.The plants from the net plot area, including the tagged plants were harvested to the ground level at 90 per cent moisture, cut in to bits of one meter length and the weight of the green fodder was recorded and expressed in q ha^{-1} for recording of green fodder yield. The green fodder was sun dried on the threshing floor for 7 days and later dry fodder yield was recorded at 15 per cent moisture and the weights were expressed as dry fodder yield in q ha^{-1}.Protein content of fodder was determined by multiplying respective nitrogen concentration with a factor 6.25. Crude fibre was estimated by treating the sample with 1.25% H_2SO_4 and 1.25% NaOH and the residue left was ashed in muffle furnace at 550-600 ^{0}C. The loss due to ashing was considered as crude fibre, and was expressed in percentage.

Results and Discussion

Growth parameters

Plant height

Plant height is an important growth component for obtaining higher yield in fodder sorghum. The highest plant height was recorded by applying 180 kg N ha^{-1}, whereas lowest height was recorded at 90 kg N ha^{-1}. The significant gain in height was due to the faster growth accelerated by cell division and cell enlargement in specialized meristematic tissue, this finding is supported by Gardner *et al.,* 1988 who reported that Apical meristem generates new cells in the tip of the roots or shoots, resulting in increased height or length. Sufficiency of nitrogen in the crop plants resulted in full nutrients activity in growing points which might have resulted in taller plants. Increase in the plant height might be due to cell elongation, cell enlargement and more chlorophyll synthesis, in the presence of sufficient nitrogen at higher levels resulting in better plant growth and ultimately resulted in higher herbage yield of fodder sorghum (Singh and Gill, 1976). The role of nitrogen in increasing the vegetative growth in terms of taller plants was better noticed by several researchers like Patel *et al.,* (1993), Verma *et al.,*(2005).

Leaf Area Index

Leaf area index of fodder sorghum was significantly influenced by different nitrogen levels and dates of sowing. Among the different nitrogen levels studied, the highest LAI was recorded with the application of 180 kg N ha^{-1} (N_4), which was significantly superior to the rest of the nitrogen levels applied. The lowest LAI was recorded with the application of 90 kg ha^{-1} (N_1). In fact, increase in leaf area index with nitrogen fertilization could be attributed to the fact that more protein synthesis at higher nitrogen rates induced vegetative growth which resulted in increase of photosynthetic surface that stimulated more leaf length, width and leaf blade size. There was slight decrease in LAI at 60 DAS because the lower leaves were masked by upper leaves that resulted in senescence of lower leaves. These findings are in conformity with the results of Lemocof and Loomis (1994), Verma *et al.,* (2005) and Osman *et al.,* (2010)

Dry matter accumulation

Dry matter accumulation is the most important yield attributing character in fodder sorghum as the entire plant excluding root system is usable as fodder. High dry matter accumulation is always associated with higher yields. Dry matter is the expression of different morphological components like stem, number of leaves and number of tillers etc. Data pertaining to the dry matter accumulation in fodder sorghum revealed that the dry matter accumulation of fodder sorghum was influenced by increased N.

With increasing levels of N there was a gradual and significant increase in the dry matter content. The highest was registered by the treatment that received 180 kg N ha^{-1} and the lowest was recorded when 90 kg N ha^{-1} was applied.

The significant increase in dry matter accumulation with increase in fertilizer nitrogen might be due to the taller plants, higher number of leaves plant^{-1}. At higher level of nitrogen that provided larger photosynthetic surface area to intercept more radiant energy which might have resulted in more dry matter accumulation. Further, nitrogen is an integral part of protoplasm, amino acids, amides, nucleotides and nucleoproteins which are essential for cell division, expansion and thereby higher growth. On the other hand, it was also reported that nitrogen deficiency hinders growth process resulting in stunted growth, chlorosis and reduced dry matter accumulation. Similar favourable impact of N levels on dry matter accumulation was also reported by Gardner *et al.,* (1988). Pelletier *et al.,* (1976) and Jung *et al.,* (1984) also reported that increasing nitrogen fertilization increased dry matter yield.

Yield

Green fodder yield

Nitrogen is one of the most important nutrients limiting sorghum yields in various parts of India, as majority of the sorghum growing soils are deficient in nitrogen (Lomte, 1997). Nitrogen is an integral part of chlorophyll and also an essential component of amino acids and related proteins which are critical not only as building blocks for plant tissue but also in cell nuclei and protoplasm.

Further, nitrogen is essential for carbohydrates used within plants and simulates growth and development as well as uptake of other nutrients. This element encourages aerial growth and this favourable impact on higher plant height, more number of leaves, higher total chlorophyll content and higher dry matter accumulation might have reflected in terms of higher fodder yields.

These findings corroborate with the observations made by Sood and Sharma (1992), Mahakulkar *et al.,* (1996), Bhilare *et al.,* (2002a), Bishanoi *et al.,* (2005) and Verma *et al.,* (2005).

Table.1 Effect different nitrogen levels on plant height (cm) of fodder sorghum

Treatments	20DAS	40DAS	60DAS	At Harvest
		Nitrogen Levels (Kg ha^{-1})		
90	30.8	89.9	232.4	252.2
120	35.8	96.5	238.5	258.4
150	35.3	96.9	239.7	259.1
180	40.1	101.7	245.3	265.8
SEm±	0.37	0.68	1.64	1.03
CD($P \leq 0.05$)	**1.11**	**2.02**	**4.87**	**3.0**

Table.2 Effect of different nitrogen levels on leaf area index of fodder sorghum

Treatments	20DAS	40DAS	60DAS	At Harvest
		Nitrogen Levels (Kg ha^{-1})		
90	1.22	3.07	3.64	3.44
120	2.03	4.34	4.42	4.19
150	2.73	5.45	5.76	5.61
180	3.18	5.96	6.14	5.93
SEm±	0.018	0.060	0.025	0.045
CD($P \leq 0.05$)	**0.05**	**0.17**	**0.07**	**0.13**

Table.3 Effect of different nitrogen levels on dry matter accumulation (g/plant) of fodder sorghum

Treatments	20DAS	40DAS	60DAS	At Harvest
Nitrogen Levels (Kg ha^{-1})				
90	3.3	17.7	48.5	55.6
120	4.7	26.5	57.5	64.6
150	4.8	27.7	59.0	65.8
180	5.7	29.7	59.8	68.4
SEm±	0.082	0.48	0.52	0.52
CD(P≤0.05)	**0.24**	**1.43**	**1.57**	**1.57**

Table.4 Effect of different nitrogen levels on green fodder yield (qha^{-1}) of fodder sorghum

Treatments	Green fodder yield (qha^{-1})
Nitrogen Levels (Kgha^{-1})	
90	376.47
120	401.11
150	415.74
180	443.73
SEm±	7.79
CD(p≤0.05)	**23.38**

Table.5 Effect of different nitrogen levels on dry fodder yield (qha^{-1}) of fodder sorghum

Treatments	Dry fodder yield (qha^{-1})
Nitrogen Levels ($Kgha^{-1}$)	
90	109.70
120	116.85
150	119.62
180	121.07
SEm±	1.39
CD(p≤0.05)	**4.15**

Table.6 Effect of different nitrogen levels on Crude protein content (%) of fodder sorghum

Treatments	Crude protein content (%)
Nitrogen Levels ($Kgha^{-1}$)	
90	6.63
120	7.55
150	8.45
180	8.97
SEm±	0.27
CD(≤p0.05)	**0.81**

Table.7 Effect of different nitrogen levels on Crude fibre content (%) of fodder sorghum

Treatments	Crude Fibre content (%)
Nitrogen Levels ($Kgha^{-1}$)	
90	35.83
120	34.01
150	33.86
180	30.20
SEm±	0.54
CD(p≤0.05)	**1.61**

Fig.1 Effect of nitrogen levels on plant height of fodder Sorghum [*Sorghum bicolour* (L.) Moench]

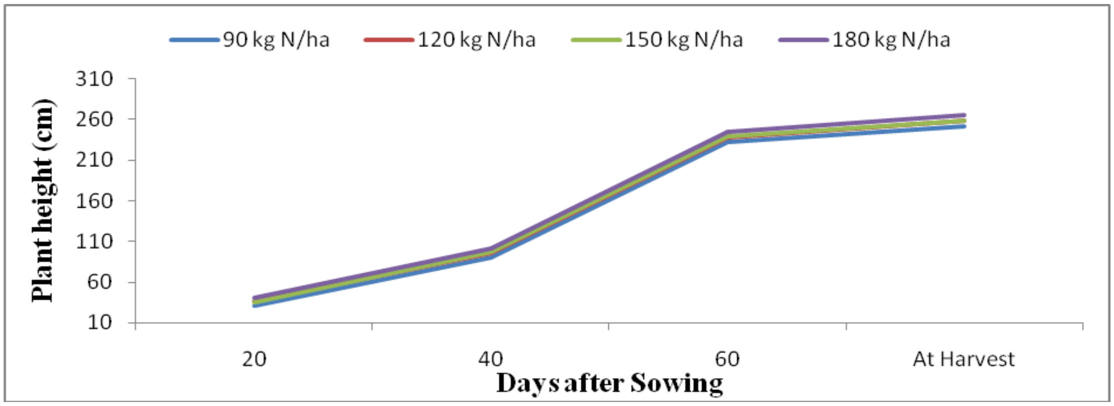


Fig.2 Effect of nitrogen levels on leaf area index of fodder sorghum [*Sorghum bicolour* (L.) Moench]

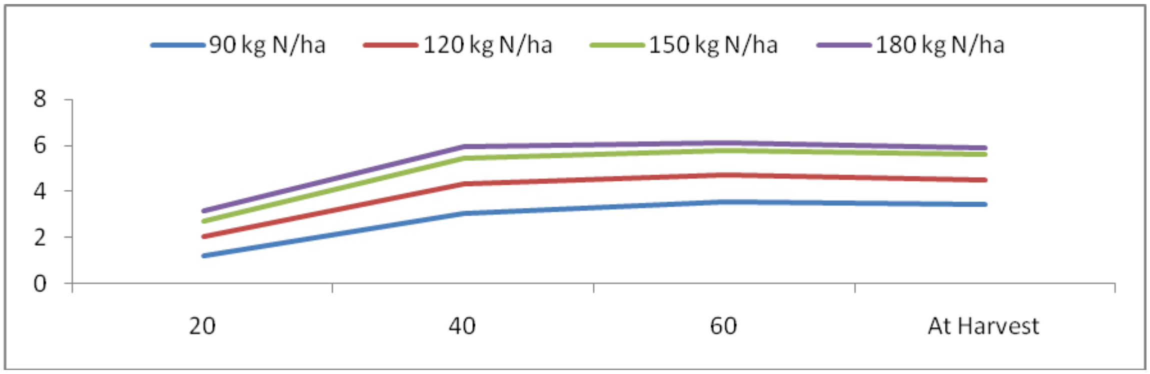


Fig.3 Effect of nitrogen levels on dry matter accumulation of fodder sorghum [*Sorghum bicolour* (L.) Moench]

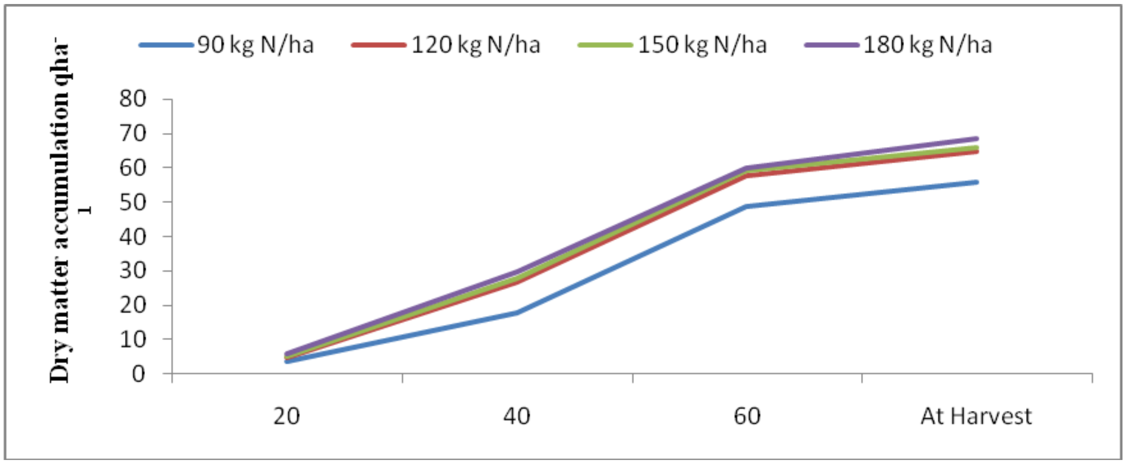


Fig.4 Effect of nitrogen levels on green fodder yield of fodder sorghum [*Sorghum bicolour* (L.) Moench]

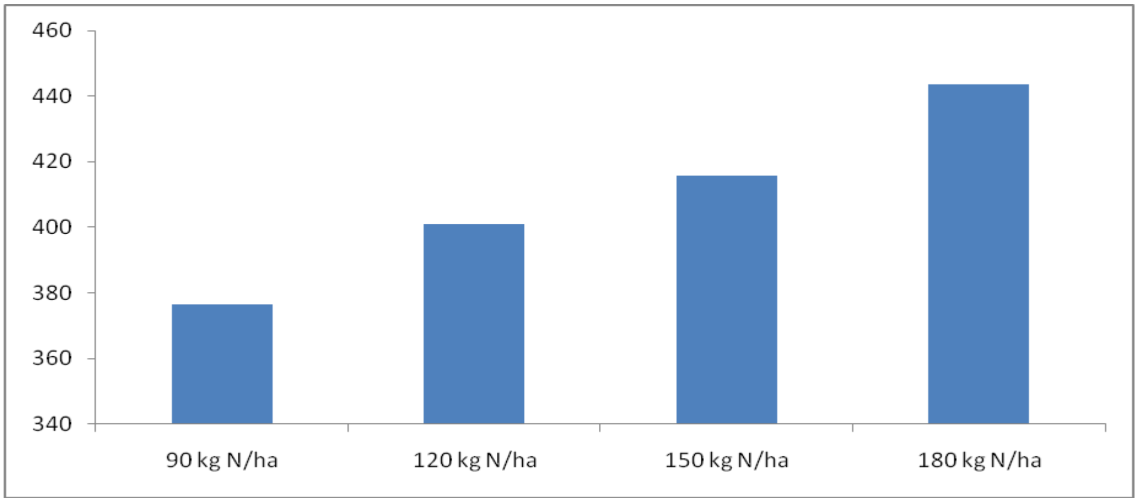
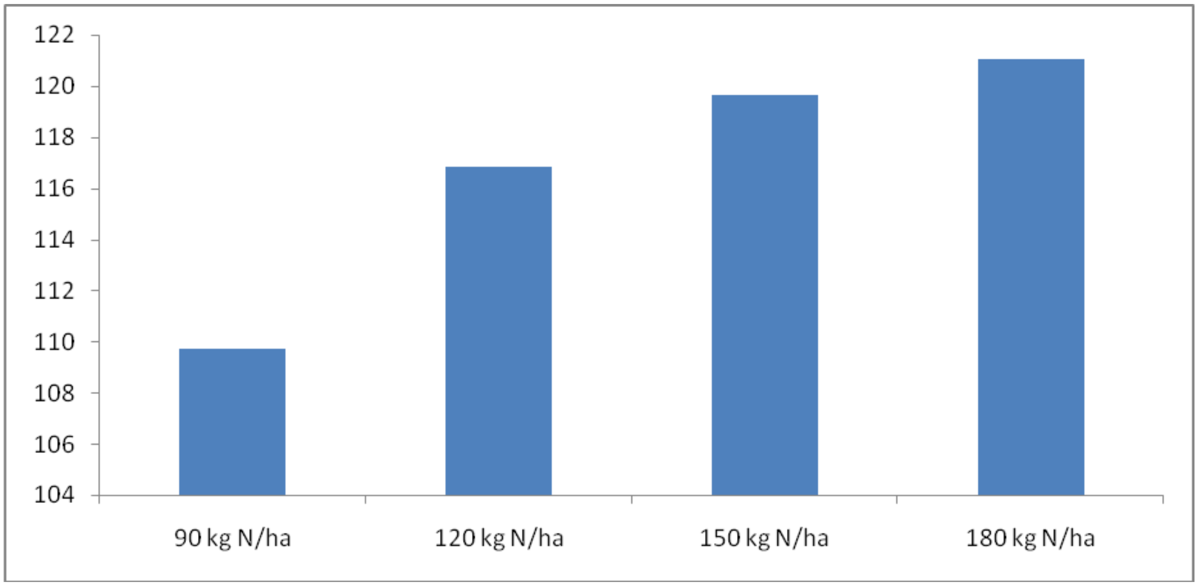


Fig.5 Effect of nitrogen levels on dry fodder yield of fodder Sorghum [*Sorghum bicolour* (L.) Moench]



Dry fodder Yeild

Dry fodder yield significantly increased with each increment in N level from 90 to 180 kg N ha^{-1}. The better performance at higher levels of nitrogen might be due to the cumulative effect of substantial improvement in growth characteristics *viz.*, plant height, number of leaves $plant^{-1}$, dry matter accumulation and higher green fodder yield through efficient metabolic activity and increased photosynthesis which ultimately reflected in increased dry fodder yield of fodder sorghum. These results are in conformity with the findings of Gil *et al.*, (1988), Gangawar and Niranjan (1991), Vasanthi *et al.*, (1998), Nanjudappa *et al.*, (2000), and Ammaji and Suryanarayana (2003).

Quality parameters

Crude protein content

Crude protein content is the most important parameter to evaluate the quality of fodder sorghum. Higher the crude protein better is the quality of fodder. The data on the crude protein content revealed that the crude protein per cent increased with increased nitrogen levels. Nitrogen plays an important role in plant metabolism. As a constituent of amino acids (RNA and DNA), it transfers genetic information and regulates cellular metabolism of amino acids and proteins that form structural units and biological catalysts *i.e.*, enzymes, co-enzymes *etc.* of phosphorylated compounds involved in energy transformations. It is a major structural constituent of cell and even of cell wall (5%N), thus increasing the quality of fodder by improving the protein content (Takkar, 2006). Since the crude protein content is calculated by multiplying nitrogen content of the plant with 6.25, increased nitrogen supply results in increased crude protein content (Kumar and Sharma, 2002) and Verma *et al.*, (2005).

Crude Fibre Content

Crude fibre content is the most important quality parameter influencing the digestibility of fodder. Low crude fibre content is the indication of higher palatability and digestibility of fodders. Lower crude fibre in the fodder means higher total digestible nutrients. The significant decrease in crude fibre content with increase in fertilizer nitrogen might be due to the higher nitrogen supply. The more rapidly synthesized carbohydrates are converted into proteins and to protoplasm and only smaller portion is available for cell wall material. Cells thus produced tend to be large with thin wall since protoplasm contains more water than cell wall material. The leaves of a plant rich in nitrogen contain a relatively high proportion of water, low proportion of dry matter, more succulent and low in crude fibre content (Kothari and Saraf, 1987). These results are in conformity with the findings of Mohamed and Hameed (1998).

The present investigation was conducted at Wadura campus of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, during Kharief 2018 with following objective.

To find out the optimum level of nitrogen for higher productivity of green biomass of sorghum.

The treatments comprised of four nitrogen levels (90, 120, 150, 180 kg ha^{-1}). MP Chari variety was used as the test variety. The experiment was laid out in split plot design with three replications and 12 treatment combination. The salient findings of the investigation are summarized.

Growth parameters, quality parameters as well as green fodder and dry fodder yield was significantly improved by application of nitrogen up to 180 kg N ha^{-1}.Crude protein content (%) was improved with the application of nitrogen up to 180 kg N ha^{-1}.

However fibre content decreased with increase in level of nitrogen application up to 180 kg N ha^{-1}. Net returns (Rs. 60602) as well as benefit cost ratio (1.70) was higher when 180 kg N ha^{-1} was applied. Application of nitrogen significantly improved the plant height, dry matter, crude protein and fodder yield of fodder sorghum, highest net returns and B: C ratio was recorded with the application of 180 kg N ha^{-1}

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