Article AR2229

DOI: HTTPS://DOI.ORG/10.23910/1.2021.2229

International Journal of Bio-resource and Stress Management

Crossref

June 2021

Print ISSN 0976-3988
Online ISSN 0976-4038

IJBSM 2021, 12(3):199-204

Research Article

Natural Resource Management

Effect of Different NPK Levels on Fodder Production of Sudan Grass (*Sorghum bicolor* var. *Sudanese*)

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Citation: Singh et al., 2021. Effect of Different NPK Levels on Fodder Production of Sudan Grass (*Sorghum bicolor* var. *Sudanese*). International Journal of Bio-resource and Stress Management 2021, 12(3), 199-204. HTTPS://DOI.ORG/10.23910/1.2021.2229.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

Abstract

A field experiment was conducted at R.G.S.C, Banaras Hindu University, Mirzapur, Uttar Pradesh, India during 2016 in *kharif* season (Sep.-Oct.) The aim was to evaluate the effect of different nitrogen, phosphorus and potassium level on fodder production of sudan grass (*Sorghum bicolor* var. *Sudanese*) for optimization of growth and yield, crude protein content and economics of sudan grass. The experimental was laid out in split plot design with four levels of nitrogen i.e. 60 kg N ha^{1}, 80 kg N ha^{1}, 100 kg N ha^{1} and 120 kg N ha^{-1} as main plot treatments and in the sub-plot three levels of phosphorus and potassium i.e. 30 kg P_2O_5+20 kg K_2O ha^{-1}, 40 kg P_2O_5+25 kg K_2O ha^{-1} and 50 kg P_2O_5+30 kg K_2O ha^{-1}) were taken. The research findings revealed that application of nitrogen @ 120 kg ha^{-1} resulted maximum growth characters i.e. plant height (191.25 cm), number of leaf (8.02 plant^{-1}), fresh weight (124.47 g plant^{-1}), dry weight (21.10 g plant^{-1}) and green fodder production (11455 kg ha^{-1}), and as well as recorded maximum crude protein of sudan grass. The higher net return (₹ 7920.32 ha^{1}) was also recorded with nitrogen @ 120 kg ha^{-1} and in case of levels of phosphorus and potassium the application of 50 kg P_2O_5+30 kg K_2O ha^{-1} enhanced the growth, yield, quality and economics of sudan grass.

Keywords: Sudan grass, NPK, fodder, phosphorus level

1. Introduction

Sudan grass is a promising summer forage crop essentially in arid and semiarid regions as it is less sensitive to water shortage and produces large amounts of biomass (Ismail et al., 2018). Sudan grass as a forage crop has many reliable characters that include high yielding potential, drought and heat tolerance, very good water use efficiency, high response to N fertilization, less susceptibility to disease, and most importantly the crop's ability to provide 2-3 cuts per growing season (Machicek, 2018). Sudan grass is Feeding of green forage to livestock is essential for the maintenance of normal health and Reproduction. The productivity of Sudan grass is especially high in the periods with moisture reserves abundance (Basaran et al., 2017). Along with the resistance to droughts, Sudan grass has a good ability to tolerate soil salinization (Ziki et al., 2019). At present, in India only 4.4% of the cultivated area is under fodder crops with annual total forage production of 866 million ton. Whereas, the annual green fodder requirement is 1097 million

Article History

RECEIVED on 28th March 2021 RECEIVED in revised form on 30th May 2021 ACCEPTED in final form on 17th June 2021

tones and dry fodder is 609 million ton.

Chahal el al. (2020) observed that plant height, shoots per square meter, leaf stem ratio and dry matter accumulation of sorghum sudan grass hybrid increased with increasing fertilizer levels. Nitrogen element is the nutrient that most frequently limits yield and plays an important role in quality of forage crops. Fertilization is one of the most important agronomic practices however; high amounts of N do not necessarily improve yields (Bean et al., 2013). Appropriate nitrogen fertilization plays a key role to increase the forage yield and quality and also, balanced N in soils promotes growth of plants and limits the adverse effect on growth caused by water stress (Villar-Salvador et al., 2013). However, N fertilizers need to be reduced or properly managed as much as possible so that waste is minimized and resource use efficiency is maximized (Mut et al., 2017). Nitrogen as an essential nutrient needed by plants is much required for improved agronomy of Sudan grass under the agroclimatic and deprived soil conditions in dry areas (Kaplan et al., 2019). The highest dry forage yield of Sudan grass (16.26 ton ha^{-1}) was achievable at the 1^{st} cut with the application of the highest N level (105 kg N/ha/cut) (Ziki et al., 2019). Jung et al. (2016) also suggested that more than 300 kg N/ha can improve dry matter yield to be above 116% compared to zero N, thus enhancing the agronomic characters of sorghum and sudan hybrid. Meh et al. (2015) reported that sorghum and sudan hybrid can be cultivated through the application of 80 kg N ha^{-1} and 10 kg P ha^{-1} for maximum production.

Abo-Zeid et al. (2017) showed that increasing nitrogen dose from 0 to 50, 75 and 100 kg N $acre^{-1}$ increased plant height, fresh and dry weight of sorghum forage. Anfinruda et al. (2013) found that there was a significant response in yield with increasing nitrogen rates. They added that there was a significant response in quality parameters such as N%, P%, K% and crude protein yield with increasing nitrogen rates. Several growth and yield parameters, including plant height, diameter, number of leaves and stem biomass were gradually increased using P fertilizers along with addition of K with P helps in strong root development and improve water use efficiency, prevent many diseases, heat damages and helps in cycling of nutrients. Roy and Khandaker (2010) observed that phosphorus application had significant effect on green forage yield and influenced by increasing the level of phosphorus at both cutting. In second cutting, green matter yield was highest at the level of 80 kg triple super phosphate per ha while the lowest yield. Similarly in third cutting, the highest yield was found in 80 kg triple super phosphate per ha. Kundu *et al*. (2015) reported that significantly maximum dry matter yield (51.54 quintal per ha) was found with the application of 60 kg phosphorus per ha. Kumar and Chaptot (2015) noted that fodder sorghum crop under the influence of 100 per cent RDF (80 kg N+40 kg P_2O_5+40 kg K_2O ha^{-1}) produced maximum biomass as well as fetched highest net returns of ₹ 59445 ha^{-1} and B : C ratio of 2.93. Dixit et al. (2017) concluded that for achieving higher system productivity, 60 kg phosphorus ha^{-1} should be applied during both the seasons (Kharif and Rabi) in fodder sorghum+cowpea - chickpea cropping system under semi-arid climate of central India. The maximum green (41.08 t/ha) and dry (12.26 t ha^1) fodder yields of *Sorghum bicolor* were observed by Meena et al. (2017) under the conjoint application of 100 kg N, 50 kg P_2O_5 and 50 K_2O ha^{-1}. The *Sorghum bicolor* crop fertilized with 125 per cent RDF (100 kg N+50 kg P_2O_5+50 kg K_2O ha^1) recorded highest plant height, stem girth, number of leaves $plant^{-1}$, leaf : stem ratio and dry matter accumulation (DMA) at harvest. The magnitude of increase in DMA plant over 100, 75 and 50 per cent RDF was to the tune of 7.8, 17.5 and 25.6%, respectively (Singh et al., 2016). Sutaria et al. (2013) revealed that the green and dry forage yields were significantly influenced due to the application of potassium. Information on the optimum level of NPK and their effective combination of fertilizer on forage biomass and dry matter yield are scanty. So, the appropriate level of NPK in sudan grass cultivation is needed to know. Keeping this view in mind, this research was done to evaluate the effect of different levels of nitrogen, Phosphorus and potash fertilizer on growth and yield, crude protein and economics of sudan grass.

2. Materials and Methods

The experiment was carried out at the Agroforestry Block of Agricultural Research Farm at Rajiv Gandhi South Campus (25° 10′ latitude, 82° 37′ longitude), Barakachha, Mirzapur (BHU), Uttar Pradesh during *kharif* season (Sep.-Oct.) in 2016. The soil of the experimental field was sandy loam in texture having pH 6.31, EC 0.072 dSm^{-1} and organic carbon 0.16% with, medium in available nitrogen and potassium and high in available phosphorus. The experimental design was split plot design and the main plot treatments were four levels of nitrogen (60, 80, 100 and 120 kg ha^{-1}) and in sub-plot the three levels of phosphorus and potassium ($P_{30}K_{20}$, $P_{40}K_{25}$, and $P_{50}K_{30}$ kg ha^{-1}) with three replications. Sudan grass variety MFSH-4 was sowing for green fodder production. The plot size was 4x3 m^2. The crop was sown at 08/09/2016 in the furrow opened by spade at a planned row to row (30 cm) distance. Relatively higher seed rate 40 kg ha^{-1} sudan grass for green fodder. Biometric observations three plants from each plot were randomly selected and tagged for recording the biometric observations at different growth stages. The observations on growth attributes viz. plant height, number of leaves $plant^{-1}$, dry matter accumulation were recorded at an interval of 20 days. Yield attributes and yield were studied before and after harvesting as per investigation required. Thereafter, the total green fodder yield all above ground plant part harvested from net plot area were carefully bundled, tagged and the individual bundle weight was recorded. The fodder yield per plot was finally expressed in kg per ha. The uptake of nitrogen and phosphorus by crop was estimated by the using the formula.

Nutrient uptake (kg ha^{-1})=Nutrient content (%)×Fodder yield (kg ha^{-1})/100

Crude protein content of fodder was determined by multiplying the nitrogen % with 6.25 and was expressed as percentage on dry weight basis. The sum of amount of all input needed for raising crop is the cost of cultivation. Net returns was calculated by subtracting cost of cultivation from gross returns and benefit cost ration was obtained by dividing gross returns with cost of cultivation. The data were analyzed as per the standard procedure for "Analysis of Variance" (ANOVA) (Gomez and Gomez, 1984).

3. Results and Discussion

3.1. Effect of nitrogen levels on sudan grass

3.1.1. Growth parameters

The growth attributes viz., plant height, number of leaves plant^{-1}, fresh and dry weight plant^{-1} were found highest in treatment 120 kg nitrogen ha^{-1} levels (Table 1). This could be possible because nitrogen were suppressed by application of nitrogen which creates favorable environment, provide ample plant nutrient for growth in addition to effective plant height, number of leaves, fresh weight and dry weight of the sudan grass. Since nitrogen promotes growth, it enhanced leaf expansion and development. This influence may result in an increase in leaf length and width and leaf blade size. This result is in conformity with Ullah et al. (2017) who reported that different nitrogen levels have significant effects on plant height, dry matter yield, green fodder yield, crude protein, of fodder maize cultivar Kissan. Khaleduzzaman et al. (2007) reported that dry matter yield increased of napier grass up to 160 kg N ha^{-1} because napier grass had a higher vegetative growth having more tethering.

Table 1: Effect of nitrogen, phosphorus and potassium levels on growth and yield of sudan grass under horti-pastoral system

Treatment	Plant height (cm)			No. of leaf plant^{-1}			Fresh weight (g plant^{-1})			Dry weight (g plant^{-1})			Green fodder production (kg ha^{-1})
	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	
Nitrogen level (kg ha^{-1})													
N_{60}	55.91	158.49	174.94	4.47	5.17	6.82	3.67	37.86	74.14	0.61	3.71	9.07	7990
N_{80}	56.49	161.26	180.15	4.87	5.29	6.94	4.69	49.39	98.23	0.74	4.74	11.83	9100
N_{100}	61.18	167.39	187.39	5.29	5.90	7.14	5.06	52.53	111.93	0.92	5.22	14.68	10313
N_{120}	63.44	171.92	191.25	5.32	6.38	8.02	7.40	61.60	124.47	1.19	7.41	21.10	11455
SEm±	1.37	2.25	2.39	0.18	0.26	0.24	0.56	3.92	9.77	0.09	0.60	1.46	8.0
CD (p=0.05)	4.75	7.79	8.27	0.61	0.88	0.83	1.95	13.56	33.82	0.29	2.08	5.05	29
Phosphorus and potassium level (kg ha^{-1})													
$P_{30}+K_{20}$	56.50	160.61	177.94	4.71	5.40	6.73	4.55	45.17	89.49	0.81	4.63	12.5	9298
$P_{40}+K_{25}$	58.47	163.80	182.47	4.72	5.50	7.15	5.00	50.53	105.25	0.71	4.69	13.07	9697
$P_{50}+K_{30}$	62.8	169.89	189.89	5.53	6.15	7.83	6.07	55.35	111.84	1.07	6.49	16.89	10147
SEm±	1.56	2.34	2.32	0.18	0.19	0.28	0.41	2.63	6.00	0.09	0.40	1.03	10
CD (p=0.05)	4.69	7.03	6.96	0.55	0.58	0.84	1.22	7.89	17.99	0.29	1.21	3.08	30

3.1.2. Green fodder yield

Yield is the ultimate outcome of the crop efficiency to convert dry matter into yield components. Timely and proper fertilizer application provide plant nutrient give high dividend in the form of increased yield. Nitrogen in agriculture is the major nutrient which determine crop yield. It plays an important role in plant growth as an essential constituent of cell components having direct effect on growth, yield and quality of crop (Mohan et al*.,* 2015). In the present study green fodder yield was maximum under 120 kg nitrogen per ha among all the nitrogen levels (Table 1). Jung et al. (2016) supported this finding, in their experiment they found that increasing nitrogen level from 0 to up to 300 kg N ha^{-1} can improve yield in sorghum and sudan hybrid. Meh et al. (2015) noted significantly highest green biomass yield of sorghum and sudan hybrid grass due to application of 80, 120 and 160 kg N ha^{-1} compared to other 0 and 40 kg N ha^{-1} treatments might be due to its tremendous response of nitrogen fertilizer on yield. Fresh and dry fodder yields of sudan grass were significantly increased as nitrogen rate increases from 50 to 100 kg (Abo-Zeid et al., 2017).

3.2. Effect of phosphorus and potassium on sudan grass

3.2.1. Growth parameters

The growth attribute viz. plant height, number of leaves, fresh weight and dry weight were significantly affected by different levels of phosphorus+potassium. All growth parameters were significantly high due to more growth of sudan grass with phosphorus+potassium (P_{50} K_{30} kg per ha) level (Table 1). This could be possible because phosphorus+potassium were creating favorable environment i.e. more cellular respiration, metabolic activity, CO_2 fixation, sugar metabolism and energy storage and transfer. This is also reported by Mohan et al., (2015).

3.2.2. Green fodder production

Phosphorus and potassium are essential macro nutrient for proper growth and development. In the present study green fodder yield was maximum under $P_{50}+K_{30}$ kg per ha among all the phosphorus+potassium levels. It could be possible due to phosphorus+potassium creates favorable environment to maximum growth of plant height, number of leaves, fresh weight and dry weight of the sudan grass. Singh et al., (2016) also found that phosphorus and potassium application has primitive effect on plant morphological traits like plant height, number of leaves, fresh and dry weight which were increased green fodder yield of crop.

3.3. Effect of NPK levels on nutrient uptake and crude protein

The maximum nitrogen, phosphorus and potash uptake were recorded with 120 kg nitrogen per ha followed by 100, 80 and 60 kg nitrogen ha^{-1} (Table 2). Phosphorus and potassium level ($P_{50}+K_{30}$) recorded significantly higher nitrogen, phosphorus and potassium uptake as compared to ($P_{30}+K_{20}$) kg ha^{-1}. Awan and Abbasi (2000) and Meh et al. (2015) reported that nitrogen and phosphorus uptake increased with increasing

Table 2: Effect of NPK levels on nutrient uptake and crude protein of sudan grass fodder under horti-pastoral system

Treatment	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Crude protein (%)
Nitrogen level (kg ha^{-1})				
N_{60}	38.95	34.49	87.09	8.03
N_{80}	51.86	39.98	103.80	8.46
N_{100}	66.89	49.82	110.23	9.28
N_{120}	73.44	65.45	127.59	11.63
SEm±	3.88	3.14	5.58	0.094
CD (p=0.05)	13.42	10.85	19.32	0.33
Phosphorus and potassium level (kg ha^{-1})				
$P_{30}+K_{20}$	44.97	42.39	97.03	8.76
$P_{40}+K_{25}$	57.25	43.44	102.77	9.30
$P_{50}+K_{30}$	71.14	56.48	121.74	9.97
SEm±	6.36	2.89	6.65	0.12
CD (p=0.05)	19.08	8.68	19.95	0.36

Table 3: Effect of NPK level on sudan grass fodder economics under horti-pastoral system

Treatment	Cost of cultivation (₹ ha^{-1})		Gross return (₹ ha^{-1})			Net return (₹ ha^{-1})	B:C ratio
	Variable cost	Total	Fodder crop	Fruit	Total		
$N_{60}P_{30}K_{20}$	3185	30812	9490	25857	35347	4535	1.14
$N_{60}P_{40}K_{25}$	3879	31507	9940	25857	35797	4290	1.13
$N_{60}P_{50}K_{30}$	4544	32171	10535	25857	36392	4221	1.13
$N_{80}P_{30}K_{20}$	3446	31073	10869	25857	36726	5653	1.18
$N_{80}P_{40}K_{25}$	4140	31768	11322	25857	37179	5411	1.17
$N_{80}P_{50}K_{30}$	4804	32432	11935	25857	37792	5360	1.16
$N_{100}P_{30}K_{20}$	3707	31334	12479	25857	38336	7002	1.22
$N_{100}P_{40}K_{25}$	4401	32029	12861	25857	38718	6689	1.20
$N_{100}P_{50}K_{30}$	5110	32738	13336	25857	39193	6455	1.19
$N_{120}P_{30}K_{20}$	3966	31594	13657	25857	39514	7920	1.25
$N_{120}P_{40}K_{25}$	4662	32290	14367	25857	40224	7934	1.24
$N_{120}P_{50}K_{30}$	5326	32954	14934	25857	40791	7838	1.23

1 US$= 72.93 INR (Average value of the harvesting months were two)

levels of N and P fertilizers. Kumar et al. (2001) observed significant increase in crude protein yield from 0.39 to 0.83 MT ha^{-1} as the level of N fertilizer increased from 0 to 160 kg ha^{-1} in oat forage. This might be due to more availability of nitrogen, phosphorus and potassium due to higher doses of these nutrients and poor fertility status of soil. According to Gopalan et al. (2007), Patel et al. (2018) and Singh et al. (2012) application of potassium released the fixed NH_4^+ from soil and helped the crop for better uptake of nitrogen.

3.4. Relative economics

Maximum net return (₹ 7934.23 ha^{-1}) was recorded in 120 kg nitrogen per ha in combination with P_{50}+K_{30} kg ha^{-1} whereas B: C ratio was maximum (1.25) in 120 kg nitrogen ha^{-1} in combination with P_{30}+K_{20} kg ha^{-1} (Table 3). This is due to fact that 120 kg N ha^{-1} increased the green fodder yield, gross return and net return. Pankhaniya et al. (1997) and Rana et al., (2012) reported that the economics of the sorghum increased with application nitrogen.

5. Conclusion

Application of 120 kg N, 50 kg P_2O_5 and 30 kg K_2O ha^{-1} produced significant plant height, fresh and dry plant weight, green fodder yield of sudan grass as well as accumulate more NPK and crude protein, this was found more remunerative fertilization practice under present study.

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