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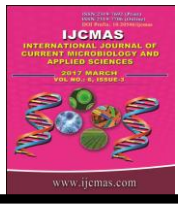

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Impact of Artificial Soil Fertility Gradient Strategy on Soil Fertility, Nutrient Uptake and Fodder Yield of Sorghum

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A B S T R A C T

To study the impact of artificial creation of soil fertility gradient strategy on soil fertility, nutrient uptake and green fodder yield of sorghum (*var*. CO 30) by following inductive methodology (fertility gradient concept), a field experiment was conducted during 2014-15 at farmer's holding of Coimbatore district. The experimental field was divided into three equal strips and three graded levels of fertiliser N, P_2O_5 and K_2O were applied in the form of urea, single super phosphate and muriate of potash, respectively to strip I ($N_0P_0K_0$), II ($N_1P_1K_1$) and III ($N_2P_2K_2$). The N_1 level was fixed based on the blanket recommendation of fodder sorghum and P_1 and K_1 levels were fixed based on the fixing capacities of phosphorus (100 kg ha^{-1}) and potassium (80 kg ha^{-1}) of the soil. Sorghum *var.* CO 30 was grown as a gradient crop and green fodder yield of sorghum was also recorded at harvest. At harvest, plant samples were collected and analyzed for their N, P and K contents and uptake of N, P and K was computed. The results confirmed that the application of graded levels of fertiliser N, P_2O_5 and K_2O significantly influenced soil fertility status, NPK uptake and green fodder yield of sorghum.

Introduction

Fertilisers constitute an integral part of improved crop production technology and proper amount of fertiliser application is considered as a key to the bumper crop production (Tariq *et al*., 2007). A unique field experimental approach (Inductive methodology) as followed in the All India Coordinated Research Project for Investigation on Soil Test Crop Response Correlation studies which has been evolved through creating a macrocosm of soil fertility variability within a microcosm of an experimental field (Ramamoorthy *et al*., 1967) by applying graded doses of fertilisers has been followed. This forms a basis for carrying out Soil Test Crop Response (STCR) studies which help to generate fertiliser prescription equations and calibration charts for recommending fertilisers on the basis of soil tests and achieving targeted yield of crops (Singh and Biswas, 2010).

Fodder sorghum is grown in about 2.5 million ha of area in the country (Shinde *et al*., 2015). It is the fourth most important cereal crop of India, next to rice, wheat and maize. Sorghum is important food and fodder crop in *kharif* season in the states of Maharashtra, Karnataka, Rajasthan and Andhra Pradesh (Srivastava *et al*., 2006). It is fast growing and

provides palatable, nutritious fodder during lean period and utilized as silage and hay besides fresh fodder (Sumeriya and Singh, 2014). Sorghum being an exhaustive crop will remove maximum nutrients from soil (Dwivedi *et al*., 2001) and its higher biomass yield will also contribute to higher uptake of nutrients. The objective of this investigation was to study the impact of artificial fertility gradient strategy on soil fertility, nutrient uptake and yield of fodder sorghum.

Materials and Methods

The methodology adopted in this study has been proposed by Ramamoorthy *et al*., (1967) as "Inductive cum Targeted yield model" which provides a scientific basis for balanced fertilisation between applied and soil available forms of nutrients. Operational range of variation in soil fertility was created deliberately to generate data covering appropriate range of values for each controllable variable (fertiliser dose) at different levels of uncontrollable variable (soil fertility) which could not be expected at one place normally. Hence, in order to create fertility variations in the same field, a field experiment is conducted with a gradient crop, in order to reduce the heterogeneity in the soil population studied, management practices adopted and climatic conditions prevailing. Keeping in view of the above facts, the present investigation was carried out to study the effect of artificial soil fertility gradient strategy on soil fertility and nutrient uptake and green fodder yield of sorghum, a field experiment was conducted at farmer's field located in the Allapalayam village in Coimbatore district of Tamil Nadu with the exhaustive or gradient crop of sorghum (*var.* CO 30) during 2014-15.

The experimental field was divided into three equal strips, the first strip received no fertiliser ($N_0P_0K_0$), the second and third strip received once ($N_1P_1K_1$) and twice ($N_2P_2K_2$) the standard dose of fertiliser N, P_2O_5 and K_2O respectively (Fig 1). The standard dose fertiliser of P_2O_5 and K_2O were fixed based on the phosphorus and potassium fixing capacities of the soil and the standard dose of N is fixed as per the blanket recommendation for the gradient crop of sorghum (Table 1). The blanket recommended dose of fertiliser N for fodder sorghum is 90 kg ha^{-1}. In strip II and III, 50% N and 100% P_2O_5 and K_2O were applied as basal and remaining 50% N was applied at 30 days after sowing. The fertiliser sources used were Urea, Single Super Phosphate and Muriate of Potash. Eight soil samples each at pre-sowing and post-harvest stages were collected from each fertility strip thus making a total of 24 samples, air dried and passed through 2 mm sieve and analysed for alkaline $KMnO_4$-N (Subbiah and Asija, 1956), Olsen-P (Olsen *et al*., 1954) and NH_4OAc-K status (Hanway and Heidal, 1952). At harvest eight plant samples from each strip were collected, processed and analysed for total N (Humphries, 1956), P and K (Piper, 1966) contents and uptake of N, P and K were computed. The gradient crop was harvested at 60^{th} day as fodder and strip wise green fodder yield was recorded.

Results and Discussions

Soil analysis

The soil of the experimental field belongs to Periyanaicken palayam series which is mixed black calcareous, moderately deep and well drained, sandy clay loam in texture with a pH of 8.10 and electrical conductivity (EC) of 0.14 dS m^{-1}. The initial soil available N, P and K status were 182, 16.5 and 346 kg ha^{-1}, respectively. The P and K fixing capacities of the soil were 100 and 80 kg ha^{-1}, respectively. The DTPA extractable zinc (Zn), iron (Fe), manganese (Mn) and copper (Cu) were in sufficient range.

Soil available nutrient status

Available nutrient status of initial soil samples

Twenty four soil samples were collected prior to sowing of the gradient crop of fodder sorghum and analyzed for $KMnO_4$-N, Olsen-P and NH_4OAc-K. The values of $KMnO_4$-N ranged from 181 to 186 kg ha^{-1} with a mean value of 184, 184 and 183 kg ha^{-1} for strips I, II and III respectively. The status of Olsen-P ranged from 15 to 19 kg ha^{-1} with a mean value of 16.9, 16.9, and 17.1 kg ha^{-1} for strips I, II and III respectively. With respect to NH_4OAc-K, the range of values were 350 to 356 kg ha^{-1} and the mean values were 352, 354 and 353 kg ha^{-1} for strips I, II and III respectively.

Available nutrient status of post - harvest soil samples

The post- harvest soil samples of fodder sorghum were analysed for $KMnO_4$-N, Olsen-P and NH_4OAc-K to know the effect of graded levels of fertiliser application on the creation of fertility gradients. The range and mean values of available soil nutrients are presented in table 2.

The mean values of post-harvest $KMnO_4$-N were 173, 196 and 216 kg ha^{-1}, for strips I, II and III, respectively (Table 2). The mean values of post-harvest Olsen-P status were 13, 29 and 37 kg ha^{-1}, for strips I, II and III respectively. The mean value of post-harvest NH_4OAc-K in the soil was 326 kg ha^{-1} in strip I, 369 kg ha^{-1} in strip II and 386 kg ha^{-1} in strip III. The statistical analysis showed that each strip is statistically different from the other and the addition of graded levels of N, P and K fertilisers resulted in significant increase in the soil available N, P and K status of the soil indicating the creation of soil fertility gradients in the experimental field.

Thus, the creation of soil fertility gradients was confirmed from the soil analytical data for all the three primary nutrients. The statistical analysis of post-harvest soil test data brought out the fact that significant variations in soil fertility status existed among the three strips.

Green fodder yield

The results showed that the effect of N, P and K levels on green fodder yield were significant (Table 3). Green fodder yield has increased significantly by increasing fertiliser N, P_2O_5 and K_2O levels compared to control. The green fodder yield of sorghum in strip I where fertilisers were not applied ($N_0P_0K_0$) was 11.25 t ha^{-1}. In strip II, where phosphorus and potassium fertilisers were applied equal to the P and K fixing capacities of the soil and nitrogen at 90 kg ha^{-1} (blanket recommendation) ($N_1P_1K_1$), the fodder yield obtained was 22.15 t ha^{-1} which was 94.6 per cent higher than strip I. In strip III, where the fertiliser N, P_2O_5 and K_2O applied were twice as that of strip II, the yield was 29.50 t ha^{-1} recording an increase of 162.2 and 33.2 per cent over strip I and II respectively. It may be due to the fact that graded levels of fertiliser application enhanced the nutrient uptake and growth parameters like plant height which ultimately reflected in increased total green yields. Verma *et al.*, (2015) also found that application of graded level of fertilisers to gradient crop of rice recorded higher grain and straw yield. The increase in green and dry fodder yields of sorghum with application of N could be attributed to its marked impact on improving growth attributes of plant (Meena *et al*., 2012). Positive effect of nitrogen fertilisation on fodder yield of sorghum has also been reported by Marsalis *et al*., (2010). The results of present investigation are in close agreement with the findings of Chotiya (2005), Singh (2007) and Singh (2014) in sorghum. This might be due to the increasing

availability of soil nutrients with the increase in N, P and K fertiliser levels and positive effect of N, P and K nutrients on the production of fodder crops. Similar results were obtained by Alias *et al*., (2003) on fodder maize and Rashid and Iqbal (2012) on fodder sorghum. Meena *et al*., (2012) also indicated that increasing the level of N from 40 to 120 kg ha^{-1} has recorded significant increase in green fodder yield of hybrid sorghum.

Nutrient uptake

The results revealed that the nitrogen uptake progressively increased from strip I to strip III and the mean values were 35.81, 60.5 and 81.7 kg ha^{-1}, respectively. The per cent increase in uptake of N in strip III over strip II and strip I were 35.0 and 128.0, respectively and that of strip II over strip I was 68.9. The mean uptake values for P were 9.36, 15.1 and 21.5 kg ha^{-1} for strip I, II, and III, respectively exhibiting significant differences among gradient strips. The K uptake values were 27.5, 53.2 and 74.9 kg ha^{-1} in strip I, II, and III, respectively. The per cent increase in uptake of P and K in strip III over strip II and strip I were 42.4 and 129.7, 40.1 and 172.0, respectively (Table 3). Similarly the per cent increase in the uptake of P and K in strip II over strip I was 61.3 and 93.5, respectively. This might be due to the fact that there exist a linear relationship between yield and uptake. It is evident from the present investigation that N, P and K uptake by fodder sorghum was significantly influenced due to the application of graded levels of fertiliser N, P_2O_5 and K_2O over control and uptake of N, P and K increased with increasing levels of fertiliser doses.

Table.1 Fertiliser doses applied to the gradient crop of fodder sorghum

Strip	Levels of Nutrients			Fertiliser doses (kg ha^{-1})		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
I	N_0	P_0	K_0	0	0	0
II	N_1*	P_1**	K_1**	90	229	97
III	N_2	P_2	K_2	180	458	194

* N_1:As per blanket recommendation, ** P_1 and K_1: As per P and K fixing capacities of the experimental field

Table.2 Effect of application of graded levels of N, P_2O_5 and K_2O on post-harvest soil fertility status of gradient experiment

Strip	Fertiliser doses (kg ha^{-1})			$KMnO_4$ –N (kg ha^{-1})	Olsen-P (kg ha^{-1})	NH_4OAc- K (kg ha^{-1})
	N	P_2O_5	K_2O			
I	0	0	0	173	13	326
II	90	229	97	196	29	369
III	180	458	194	216	37	386
SEd				**3.3**	**1.4**	**3.6**
CD (P= 0.05)				**7**	**3**	**8**

Table.3 Effect of application of graded levels of fertiliser N, P_2O_5 and K_2O on plant height, yield and nutrient uptake by fodder sorghum

Strip	Fertiliser doses (kg ha^{-1})			Plant height (cm)	Green fodder yield (t ha^{-1})	Nutrient uptake (kg ha^{-1})		
	N	P_2O_5	K_2O			N	P	K
I	0	0	0	153	11.25	35.8	9.36	27.5
II	90	229	97	242	22.15	60.5	15.1	53.2
III	180	458	194	260	29.50	81.7	21.5	74.9
SEd				**4.23**	**1.35**	**3.95**	**0.93**	**3.11**
CD (P= 0.05)				**9.10**	**2.89**	**7.70**	**2.01**	**6.68**

Reddy and Bhanumurthy (2010) reported that in fodder maize, N uptake was significantly higher by the application of 240 kg N ha^{-1} and Bhoya *et al*., (2013) also revealed that application of 120 kg N ha^{-1} recorded the higher N uptake by sorghum. The significant increase in P uptake was due to higher levels of phosphorus application which would have led to higher root proliferation of the crop (Verma *et al*., 2015). Singh *et al*., (2015) also recorded that application of graded levels of N, P_2O_5 and K_2O fertilisers increased the N, P and K uptake by rice crop. Siam *et al*., (2008) reported that the increase in level of N up to 140 kg N fed^{-1} significantly increased plant height, N, P and K uptake by maize. These results are in close conformity with those reported by Sonune *et al*., (2010) and Singh (2014) in sorghum.

Plant height

The effect of fertilisation on plant height of fodder sorghum was significant. The fertilisation of different levels of N, P and K fertilisers improved the plant height of fodder sorghum (Table 3). The highest mean plant height was recorded in strip III (260 cm) which received twice of N, P and K fertilisers. It was 7.4 and 69.9 per cent higher than strip II and strip I, respectively. The mean plant height recorded at strip II and strip I is 242 and 153 cm, respectively. The per cent increase of plant height in strip II over strip I is 58.2 which might be due to better nutrient uptake by fodder sorghum and due to relatively higher fertility status in strip II. The plant height increased significantly with increase in the level of nitrogen. The higher plant height recorded due to higher levels of nitrogen was mainly attributed to more availability and uptake of nitrogen by crop which resulted in more vegetative growth and acceleration in the process of cell division, expansion and differentiation thereby resulting in luxuriant growth. Moghimi and Emam (2015) showed that height of fodder sorghum has increased due to nitrogen fertilisation. Ayub *et al*., (1999 and 2002) also reported a significant increase in plant height of sorghum with nitrogen application. The findings of Agarwal *et al*., (2005) and Tiwana and Puri (2005) confirmed the results. Bhatt *et al*., (2012) also reported that application of 150 per cent RDF of N, P and K produced significantly higher plant height and fodder yield of sorghum as compared to lower levels of fertiliser.

In conclusion, the results from the above investigation confirmed that the application of graded levels of N, P and K fertilisers created artificial soil fertility gradient in the experimental field and it also had a significant influence on post-harvest soil fertility, nutrient uptake and green fodder yield of sorghum.

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