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Productivity, Nutrient Balance and Profitability of Foxtail Millet (*Setaria italica* L.) Varieties As Influenced By Levels of Nitrogen

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Abstract: *A field experiment was conducted during kharif, 2014 at Tirupati with four foxtail millet varieties (SiA 3088, SiA 3085, SiA 3156 and Srilaxmi) in combination with three nitrogen levels (0, 25, 50 kg N ha^{-1}). The results of the experiment revealed that among the four foxtail millet varieties, SiA 3085 recorded the higher grain and straw yield. Application of 50 kg N ha^{-1} markedly improved the growth and yield. While, they were found to be at their lowest with no nitrogen application. The nutrient uptake and economic returns also followed the same trend both in case of varieties and nitrogen levels. The results concluded that the foxtail millet variety SiA 3085 with the application of 50 kg N ha^{-1} was more productive, profitable and maintains the soil health.*
Key words: *Foxtail millet, varieties, nitrogen, yield, economics*

I. Introduction

Considerable literature is available regarding the effect of nitrogenous fertilizers on the yield of promising varieties of foxtail millet (*Setaria italica* L.) (Intodia,1994 and Saini and Negi,1996) but little is known about the influence of nitrogen on the uptake of N, P and K by foxtail millet under rainfed conditions. Studies conducted earlier by Naik *et al*. (1995) and Basavarajappa *et al*. (2002) revealed that nitrogen application to foxtail millet enhanced nutrient uptake by the crop. Study of nutrient uptake by the crop and post harvest fertility status may be a helpful guide for the formulation of sound fertilizer management programme.

The present investigation was, therefore, taken up to study the N, P and K uptake by the four newly developed varieties of foxtail millet as affected by different levels of nitrogen under rainfed condition.

II. Material and Methods

A field experiment was carried out during kharif, 2014 at S.V. Agricultural College Farm, Tirupati. The experimental soil was sandy loam in texture, neutral in reaction (pH 6.9), low in organic carbon (0.43 per cent) and available nitrogen (188.0 kg ha^{-1}), high in available phosphorus (44.2 kg ha^{-1}) and medium in potassium (170.2 kg ha^{-1}). The experiment was laid out in randomized block design with factorial concept with twelve treatment combinations and replicated thrice. The treatments comprised of four varieties (SiA 3088, SiA 3085, SiA 3156 and Srilaxmi) and three nitrogen levels (0, 25 and 50 kg N ha^{-1}). The crop was sown in lines, 20 cm apart by adopting all the standard package of practices except the treatments. A basal dose of 30 kg P_2O_5 ha^{-1} and 20 kg K_2O ha^{-1} was applied uniformly in all the treatments. The scheduled nitrogen was applied in two equal splits viz., first half at the time of sowing as basal and remaining half as top dressing at 30 DAS.

Five plants were selected at random from net plot area and labeled with tags for recording growth attributes throughout the crop growing period. The grains and straw obtained from the net plot area including the sampled plants were thoroughly sun dried, weighed and expressed as kg ha^{-1}. Oven dried plant samples of foxtail millet at harvest were finely powdered and used for chemical analysis. Nitrogen, phosphorus and potassium content was analysed by the standard procedures outlined by Jackson (1973). The uptake of N, P and K at harvest was calculated by multiplying the nutrient content with corresponding dry matter production and expressed as kg ha^{-1}. Immediately after harvest of the crop, soil samples were drawn from each treatment and analysed for available nitrogen (Subbiah and Asija, 1956), available phosphorus (Olsen *et al*., 1954) and available potassium (Jackson, 1973). The data obtained on various parameters during the study was statistically analysed by following the analysis of variance for Randomized Block Design with factorial concept as suggested by Panse and Sukhatme (1985). Statistical significance was tested by 'F' test at five per cent level of probability. Critical difference for the significant source of variation was calculated at five per cent level of significance. Treatmental differences those were not significant were denoted by NS.

III. Results and Discussion

Growth

Among the four varieties evaluated, the taller plants were produced by the variety SiA 3156 followed by SiA 3085, without any significant difference between them. While, the shorter plants were produced by SiA 3088. Maximum leaf area index and dry matter production were recorded with the variety SiA 3085, which was however comparable with that of SiA 3156 variety. The lower values of these growth parameters viz., plant height, leaf area index and dry matter production were registered with the variety SiA 3088. The total number of tillers m^{-2} were not significantly influenced by the different varieties (Table 1). The difference in the growth characters may be attributed to the genetic constitution of the varieties.

Higher stature of growth attributes viz., plant height, leaf area index, dry matter production and number of tillers m^{-2} was observed with the application of 50 kg N ha^{-1}. While all these parameters were at their lowest value with no nitrogen application (Table 1). It could be attributed to the fact that higher nitrogen levels might have accelerated the synthesis of more chlorophyll and amino acids and stimulated the cellular activity, which is useful for the process of cell division, meristematic growth coupled with cell enlargement, resulting in production of larger leaves which ultimately leads to enhanced dry matter accrual.

Productivity

The variety SiA 3085 produced the highest grain and straw yield which was however comparable with that of SiA 3156, while they were at their lowest with Srilaxmi and SiA 3088 with no significant difference between them (Table 2). Difference in yields among the varieties can be attributed to their genetic potentiality to utilize and translocate photosynthates from source to sink. The results were in conformity with the findings of Saini and Negi (1996), Munirathnam *et al*. (2006).

Significant increase in grain and straw yields were observed with increase in nitrogen levels from 0 to 50 kg N ha^{-1} (Table 2). The improvement in yield with enhanced nitrogen application might be attributed to better availability and uptake of nutrients which in turn lead to efficient metabolism.

Among different varieties tested, the highest harvest index was produced by SiA 3088 followed by Srilaxmi with no significant difference between them. The next best variety was SiA 3085, which was at par with that of SiA 3156 which has produced the lowest harvest index (Table 1).

The highest harvest index was recorded with 25 kg N ha^{-1} which was however, comparable with no nitrogen application(Table 2).The lowest harvest index was recorded with application of 50 kg N ha^{-1}. At higher nitrogen levels, there was less increase in grain yield corresponding to increase in biological yield.

The varieties and nitrogen levels interaction failed to influence the yields and harvest index significantly.

Post-Harvest Soil Fertility Status

The highest post-harvest status of soil available nitrogen and phosphorus were recorded with the SiA 3088 grown plot however for nitrogen, it was on par with that of Srilaxmi, while it was found to be the lowest in SiA 3085 variety grown plot. The post harvest soil available potassium was highest in SiA 3088 and all the other three varieties were at par with each other (Table 3). This might be due to better uptake efficiency of the variety SiA 3085 which has been reflected in low available nitrogen in the soil after harvest.

The nitrogen availability in soil after harvest was found to be significantly superior with 50 kg N ha^{-1} applied plots. There was a substantial increase in the available nitrogen status with 50 kg N ha^{-1} over the control. The difference in the available nitrogen status between 0 and 50 kg N ha^{-1} treatments was 77 kg N ha^{-1} which was even higher than the applied nitrogen. Due to increase in nitrogen application, there was an increase in the root exudates that act as a substrate for the micro-organisms and mineralise the organic nitrogen, thus, increasing the nitrogen status of the soil. However, more availability of phosphorous and potassium after harvest has been noticed with 0 kg N ha^{-1}. The availability of phosphorous and potassium content in the soil was found to be significantly lower with increasing dose of nitrogen when compared to the preceding dose (Table 3). The greater application of nitrogen has led to the better uptake of other nutrients from the soil leading to their lower availability in soil after harvest.

Nutrient Uptake

The nitrogen and phosphorous uptake was highest with the variety SiA 3085 which was at par with that of SiA 3156. The potassium uptake was highest with SiA 3085 and all the other three varieties were at par for potassium uptake. The lowest nutrient uptake was obtained with the variety SiA 3088(Table 4). The differential rooting pattern of varieties might have resulted in a difference in nutrient uptake. SiA 3085 could be efficient in exploring the nutrients exhaustively from the soil.

Regarding the nitrogen levels, increments of added nitrogen had a distinct effect on the N uptake. Higher uptake of nitrogen was observed with the application of 50 kg N ha^{-1}, which was significantly higher than 25 kg N ha^{-1} and no nitrogen application (Table 4). The increase in dry matter yield together with higher nitrogen levels has led to the higher uptake of nitrogen by plants. The present investigation confirms the documented evidence of Naik *et al*. (1995) and Basavarajappa *et al*. (2002).

Nitrogen levels also exercised a favorable and significant influence in increasing the P uptake by the rhizosphere acidification which results in the solubilisation of insoluble phosphates and release of more orthophosphates into the soil solution. The results are in conformity with the findings of Basavarajappa *et al*. (2002).

Uptake of potassium values also followed the similar trend of results as in the case of nitrogen and phosphorus uptake. It might be due to efficient absorption of large quantities of mineral nutrients, coupled with higher dry matter production under higher nitrogen levels. The results are in conformity with the findings of Naik *et al*. (1995).

Nutrient Budgeting

The dynamics of soil available nutrients as influenced by varieties and fertilizer application, nutrient uptake by the crop, the balance expected and actual quantity available after the harvest of the crop during the experiment are much influenced.

The initial value of soil available nitrogen was 188 kg N ha^{-1}. The application of varying doses of nitrogen increased the total available nitrogen accordingly, when compared to control. The actual soil nitrogen after harvest was found higher when compared to the expected nitrogen in soil. In all the four varieties, actual level of nitrogen in control plots (0 kg N ha^{-1}) was however less than the expected level. Maximum gain of nitrogen in soil was found with variety SiA 3088 at 50 kg N ha^{-1} (Table 5).

The initial value of soil available phosphorous was 44.2 kg P_2O_5 ha^{-1}. In all the treatments, actual balance was found less than the expected balance. Maximum loss of phosphorous was found with the variety Srilaxmi at 25 kg N ha^{-1} (Table 5). During the initial stages of crop growth, activity of phosphatase enzymes was higher in soil. However, during maturity of the crop the activity of enzyme reduced drastically which leads to more fixation of phosphorous in the soil.

The initial value of soil available potassium was 170 kg K_2O ha^{-1}. Significant removal of potassium was reported in all the treatments, however, the actual balance of potassium was found higher than expected (Table 5). The maximum potassium built up was found under variety SiA3088 at 0 kg N ha^{-1}. This might be due to lower removal of potassium by above variety.

Economics

The highest gross returns, net returns and benefit cost ratio were realized with the variety SiA 3085 which was however stastically at par with that of variety SiA 3156, while they were found to be the lowest with SiA 3088 (Table 7). This might be due to the maximum productivity of the former variety SiA 3085. The lowest economic returns with the SiA 3088 could be attributed to the lower values of grain and straw yields. These results are in line with Munirathnam *et al*. (2006).

With regard to nitrogen levels, significantly higher values of gross returns, net returns and benefit cost ratio were obtained with application of 50 kg N ha^{-1}, which was significantly superior to that of 25 kg N ha^{-1}. The lowest economic returns were recorded with no nitrogen application (Table 6). The higher economic returns might be due to higher grain and straw yields registered under higher nitrogen levels. Present investigation confirms the results reported by Divya and Maurya (2013).

Conclusively, the present investigation revealed that higher productivity, profitability of foxtail millet and soil health of could be obtained with cultivation of the variety SiA 3085 with the application of 50 kg N ha^{-1} during *kharif* season in alfisols of Southern Agro-Climatic zone of Andhra Pradesh

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Table 1 Growth parameters of foxtail millet at harvest as influenced by varieties and nitrogen levels.

Treatments	Plant height (cm)	Leaf area index	Number of tillers m^{-2}	Drymatter production (kg ha^{-1})

Varieties				
SiA 3088	79.9	1.61	73	2848
SiA 3085	91.3	1.82	76	3153
SiA 3156	93.7	1.80	76	3135
Srilaxmi	89.8	1.68	75	2970
SEm±	1.28	0.017	1.3	54.0
CD (P=0.05)	3.7	0.05	NS	159
Nitrogen levels				
0 kg ha^{-1}	66.4	0.85	58	2058
25 kg ha^{-1}	93.9	1.77	76	2956
50 kg ha^{-1}	105.6	2.56	92	4069
SEm±	1.11	0.015	1.2	47.0
CD (P=0.05)	3.2	0.05	2	138
Interaction				
SEm±	2.21	0.031	1.7	115.49
CD (P=0.05)	NS	NS	NS	NS

Table 2: Grain, straw yield (kg ha^{-1}) and harvest index (%) of foxtail millet as influenced by varieties and nitrogen levels

Treatments	Grain yield	Straw yield	Harvest index
Varieties			
SiA 3088	1001	1772	37.9
SiA 3085	1141	1956	36.6
SiA 3156	1106	1943	35.8
Srilaxmi	1022	1823	36.8
SEm±	26.0	42.0	0.43
CD (P=0.05)	77	124	1.3
Nitrogen levels			
0 kg ha^{-1}	730	1257	37.2
25 kg ha^{-1}	1075	1789	37.9
50 kg ha^{-1}	1398	2574	35.2
SEm±	23.0	37.0	0.37
CD (P=0.05)	67	108	1.1
Interaction			
SEm±	46.0	75.0	0.76
CD (P=0.05)	NS	NS	NS

Table3:Post harvest soil available Nitrogen (N), Phosphorus (P_2O_5) Potassium (K_2O) as influenced by foxtail millet varieties and nitrogen levels

Treatments	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})
Varieties			
SiA 3088	195.5	37.1	174.5
SiA 3085	178.6	32.3	166.8
SiA 3156	182.9	33.6	167.6
Srilaxmi	189.7	34.7	168.3
SEm±	2.98	0.75	1.00
CD (P=0.05)	8.6	2.2	3.0
Nitrogen levels			
0 kg ha^{-1}	146.3	39.4	178.0
25 kg ha^{-1}	190.5	34.5	167.8
50 kg ha^{-1}	223.3	29.4	162.2
SEm±	2.58	0.65	0.90
CD (P=0.05)	7.6	1.9	2.6
Interaction			
SEm±	5.17	1.30	1.80
CD (P=0.05)	NS	NS	NS

Table 4: Nutrient uptake of foxtail millet as influenced by varieties and nitrogen levels

Treatments	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})
Varieties			
SiA 3088	25.9	13.7	44.9
SiA 3085	31.5	16.6	48.2
SiA 3156	30.7	15.7	46.2
Srilaxmi	28.2	14.3	45.1
SEm±	0.54	0.38	0.65
CD (P=0.05)	1.6	1.1	1.9
Nitrogen levels			

0 kg ha^{-1}	17.1	9.8	41.7
25 kg ha^{-1}	29.6	14.9	45.3
50 kg ha^{-1}	40.6	20.5	51.3
SEm±	0.47	0.33	0.56
CD (P=0.05)	1.4	1.0	1.6
Interaction			
SEm±	0.93	0.66	1.12
CD (P=0.05)	NS	NS	NS

Table 5: Gross returns, Net returns (` ha^{-1}) and B:C ratio of foxtail millet as influenced by varieties and nitrogen levels

Treatments	**Gross returns**	**Net returns**	**B:C ratio**
Varieties			
SiA 3088	16082	5511	1.51
SiA 3085	18284	7713	1.72
SiA 3156	17779	7208	1.67
Srilaxmi	16424	5853	1.55
SEm±	408.16	408.16	0.038
CD (P=0.05)	1197	1197	0.11
Nitrogen levels			
0 kg ha^{-1}	11707	1446	1.14
25 kg ha^{-1}	17202	6631	1.63
50 kg ha^{-1}	22517	11637	2.07
SEm±	353.5	353.5	0.033
CD (P=0.05)	1037	1037	0.10
Interaction			
SEm±	707	707	0.066
CD (P=0.05)	NS	NS	NS

Table 6: Balance sheet of nutrient applied, nutrient uptake (kg ha^{-1}) by plant and remaining in soil

Treat ments	Initial soil N (A)	N through fertilizer (B)	Crop removal (C)	Expected balance of N D=(A+B)-C	Actual balance of N (E)	Net gain or loss of N (D-E)	Initial soil P (a)	P through fertilizer (b)	Crop removal (C)	Expected balance of P d=(a+b)-c	Actual balance of P (e)	Net gain or loss of P (d-e)	Initial soil K (A)	K through fertilizer (B)	Crop removal (C)	Expected balance of K D=(A+B)-C	Actual balance of K (E)	Net gain or loss of K (D-E)
C_1N_1	188.0	0.0	14.15	173.85	155.9	-17.95	44.2	30.0	8.9	65.3	41.1	-24.2	170.2	20.0	40.8	149.4	185.3	+35.9
C_1N_2	188.0	25.0	26.83	186.17	198.1	+11.93	44.2	30.0	13.6	60.6	36.7	-23.9	170.2	20.0	44.4	145.8	171.4	+25.6
C_1N_3	188.0	50.0	36.72	201.28	232.6	+31.29	44.2	30.0	18.4	55.8	33.7	-22.1	170.2	20.0	49.5	140.7	166.9	+26.2
C_2N_1	188.0	0.0	19.91	168.09	139.2	-28.92	44.2	30.0	11.1	63.1	37.6	-25.5	170.2	20.0	43.6	146.6	174.9	+28.3
C_2N_2	188.0	25.0	31.05	181.95	184.7	+2.75	44.2	30.0	16.6	57.6	33.2	-24.5	170.2	20.0	47.3	142.9	165.7	+22.8
C_2N_3	188.0	50.0	43.47	194.53	212.1	+17.54	44.2	30.0	22.1	52.1	26.3	-25.9	170.2	20.0	53.7	136.5	159.9	+23.4
C_3N_1	188.0	0.0	19.05	168.95	139.2	-29.79	44.2	30.0	10.0	64.2	39.2	-24.9	170.2	20.0	41.5	148.7	175.7	+27.0
C_3N_2	188.0	25.0	30.65	182.35	187.3	+4.91	44.2	30.0	15.5	58.7	33.9	-24.9	170.2	20.0	45.6	144.6	166.5	+21.9
C_3N_3	188.0	50.0	42.70	195.30	222.4	+27.10	44.2	30.0	21.6	52.6	27.6	-25.0	170.2	20.0	51.6	138.6	160.8	+22.2
C_4N_1	188.0	0.0	15.31	172.69	150.9	-21.79	44.2	30.0	9.2	65.0	39.8	-25.2	170.2	20.0	40.8	149.4	176.3	+26.9
C_4N_2	188.0	25.0	29.86	183.14	192.1	+8.93	44.2	30.0	13.9	60.3	34.2	-26.1	170.2	20.0	44.1	146.1	167.5	+21.4
C_4N_3	188.0	50.0	39.50	198.50	226.2	+27.70	44.2	30.0	19.7	54.5	29.9	-24.6	170.2	20.0	50.4	139.8	161.1	+21.4

C_1-SiA 3088, C_{2-} SiA 3085, C_3-SiA 3156, C_4- Srilaxmi, N_1-0 kg N ha^{-1}, N_2-25 kg N ha^{-1} N_3-50 kg N ha^{-1}