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PRODUCTIVITY AND ERGONOMICS OF FOXTAIL MILLET AS INFLUENCED BY VARIETIES AND NITROGEN LEVELS

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ABSTRACT

The experiment was conducted with four foxtail millet varieties (SiA 3088, SiA 3088, SiA 3156 and Srilaxmi) with three nitrogen levels (0, 25, 50 kg N ha^{-1}). Results of the experiment revealed that variety SiA 3085 recorded the highest grain and straw yield. Nitrogen levels had significant response on yield and maximum grain yield was recorded with 50 kg N ha^{-1}. With respect to the energitics, irrespective of the varieties tried, the total input energy utilization was more in the treatmental plots which received 50 kg N ha^{-1}, The lowest input energy use was in the treatmental plots without nitrogen application. The net energy return was found highest with the variety SiA 3085 with 50 kg N ha^{-1} and the lowest values was with SiA 3088 variety with no nitrogen. The input: output ratio and energy productivity were highest with SiA 3085 variety with no nitrogen application whereas, the lowest values were noticed with SiA 3088 variety with 50 kg N ha^{-1}. Hence, among the treatments SiA 3085 variety with 50 Kg N ha^{-1} was the best combination.

INTRODUCTION

Future trends of food requirement indicate that millet crop production will increase globally because of the increase in number of millet consumers as they are nutritionally miles ahead of rice and wheat. Millets is known to be 'crops of the future' as they can be well adapted and cultivated under harsh environment of arid and semi-arid region (RESMISA, 2012). During the present days of climatic change, high energy farming is slowly replaced with low energy traditional farming with climatic resilient crops like small millets for conservation and to aid in making sound and stable management under increasing evidence of less seasonal rainfall, increase in temperature and frequent occurrence of extreme weather events. Under such situations foxtail millet is best suited as it is of short duration, known for its drought tolerance and can withstand severe moisture stress and also suited to wide range of soil conditions with high energy use efficiency.

The yield potential of foxtail millet is low in India compared to the potentially achievable yield because of inadequate application of fertilizers, conventional cultivation of low yielding cultivars and lack of good management practices. The Maximum yield potential can be achieved by growing high yielding varieties with improved tolerance to drought, resistance to pests and diseases and response to higher rates of fertilizer applications.

Nitrogen is the major nutrient required by the millets which positively increases the growth, yield attributes and finally improve the yield (Prasad *et al*., 2014a). Foxtail millet realizes maximum yield potential with improved varieties and optimum nitrogen management. Recent studies also have shown that newly developed varieties of foxtail millet are more responsive to nitrogenous fertilizers (AICSMIP, 2013).

Keeping the importance of foxtail millet under semi arid region and importance of nitrogen fertilizer, an experiment was conducted to assess the yield and energitics of foxtail millet varieties with nitrogen levels.

MATERIALS 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 randomised 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 experimental field was prepared by working once with a tractor drawn cultivator followed by harrowing with bullock drawn blade harrow. The field was finally leveled with wooden plank and the plots were laid out according to the layout plan. The crop was sown in lines 20 cm apart by adopting all the standard package of practices except the imposed treatments. A basal dose of 30 kg P_2O_5 and 20 kg K_2O 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. Yield obtained from each plot was converted to kg/ ha. The data obtained on yield during the study was statistically analyzed by following the analysis of variance for Randomized Block Design with factorial concept as suggested by Panse and Sukhatme (1985). Energy efficiency of agricultural system was evaluated by the energy ratio between output and input. Human labour, machinery, diesel oil, fertiliser, pesticides and seed amounts and yield values of foxtail millet were used to estimate the energy ratio. The amounts of input were calculated per hectare and then, these input data were multiplied with the coefficient of energy equivalent. Energy equivalents as suggested by the Binning *et al.,* 1983(Table 1) were used for estimation. Basic information on energy inputs was entered into Excel spreadsheets and then energy equivalent were calculated accordingly as suggested by Abdollahpour and Zaree, 2009 (Table-2). Based on the energy equivalents of the inputs and output (Table 2), the energy ratio (energy use efficiency), energy productivity and net energy return were calculated by using the equation 1, 2 and 3 (Singh *et al.*, 1997).

$$\text{Energy use efficiency} = \frac{\text{Energy output (MJ ha}^{-1})}{\text{Energy input (MJ ha}^{-1})} \rightarrow 1$$

$$\text{Energy productivity (kg MJ}^{-1}) = \frac{\text{Foxtail millet output (kg ha}^{-1})}{\text{Energy input (MJ ha}^{-1})} \rightarrow 2$$

Net energy return = Output energy (MJ ha^{-1}) - Input energy (MJ ha^{-1}) $\rightarrow$ 2

RESULTS AND DISCUSSION

Productivity

The grain yield and straw yield of foxtail millet was significantly influenced by the varieties and the nitrogen levels tried, while the interaction effect was not statistically traceable (Table 2).

The highest grain and straw yields were recorded by the variety SiA 3085 where as the lowest values were recorded with the variety SiA 3088. 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 confirmity with the findings of Divya and Maurya (2013).

Regarding nitrogen levels, application of 50 kg N ha^{-1} recorded the highest grain and straw yields which were significantly superior to the other nitrogen levels tried. The lowest grain yield was observed with no nitrogen application. 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. In turn the nitrogen application also increases the physico-chemical processes of crop which leads to higher grain yield. The results are supported by the finding of Hasan *et al*. (2013) and Prasad *et al* (2014 b).

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 2).

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.

Ergonomics

Amounts of inputs and outputs in foxtail millet production as influenced by varieties and nitrogen levels for each item are furnished in Table 3. Inputs, energy equivalences and ratio of inputs to output in the production of foxtail millet varieties as influenced by levels of nitrogen are furnished in Table 4.

Energy input

The energy requirement for the production of foxtail millet varieties as influenced by the levels of nitrogen was computed (Table 4). The results revealed that irrespective of the varieties tried, energy use for cultivation of foxtail millet was more in the treatmental plots which received 50 kg N ha^{-1}. Further, it was revealed that among the various inputs, the maximum energy was consumed in terms of chemical fertilizers, mechanical energy (diesel), human labour and seed in order of descent (Table 4). Among the chemical fertilizers, the share of phosphorous (333 MJ ha^{-1}), potassium (134 MJ $^{-1}$) is less

Table1: Energy conversion factors used

Input	Units	Equivalent energy (MJ)
Human labour (Adult)	human-hour	1.96
Diesel	Litre	56.31
Nitrogen (N)	kg	60.60
Phosphorus (P)	kg	11.10
Potash (K)	kg	6.70
Monocrotophas	ml	0.102
Output		
Foxtail millet grain	kg	14.68

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

Table 3: Amount Of Input And Output In Foxtail Millet Production * (ha^{-1})

Treatments	Seed(kg)	Human labour (h)	Machinery (Diesel) (l)	Nitrogen (kg)	Phosphorus (kg)	Potassium (kg)	Monocrotophas (ml)	Crop produce (kg)
C_1N_1	5	229	8	0	30	20	240	685
C_1N_2	5	229	8	25	30	20	240	1009
C_1N_3	5	229	8	50	30	20	240	1310
C_2N_1	5	229	8	0	30	20	240	767
C_2N_2	5	229	8	25	30	20	240	1169
C_2N_3	5	229	8	50	30	20	240	1486
C_3N_1	5	229	8	0	30	20	240	765
C_3N_2	5	229	8	25	30	20	240	1106
C_3N_3	5	229	8	50	30	20	240	1451
C_4N_1	5	229	8	0	30	20	240	703
C_4N_2	5	229	8	25	30	20	240	1017
C_4N_3	5	229	8	50	30	20	240	1346

C_1-SiA 3088, C_2-SiA 3085, C_3-SiA 3156, C_4- SrilaxmiN_1-0 kg N ha^{-1}, N_2-25 kg N ha^{-1} N_3-50 kg N ha^{-1}; *Irrigation water has not taken into consideration as foxtail millet is mainly grown under rainfed condition

Table 4: Equivalent energy values of input and output (MJ ha^{-1})

Treatments	Seed	Human labour	Machinery (Diesel)	N	P	K	Plant protection	Total input energy	Output energy	Net energy return	Energy use efficiency	Energy productivity (kg /MJ)
C_1N_1	73.4	448.84	450.48	0	333	134	24.48	1464.2	10051	8587	6.86	0.53
C_1N_2	73.4	448.84	450.48	1515	333	134	24.48	2979.2	14817	11838	4.97	0.36
C_1N_3	73.4	448.84	450.48	3030	333	134	24.48	4494.2	19226	14732	4.28	0.30
C_2N_1	73.4	448.84	450.48	0	333	134	24.48	1464.2	11264	9800	7.69	0.59
C_2N_2	73.4	448.84	450.48	1515	333	134	24.48	2979.2	17156	14177	5.76	0.42
C_2N_3	73.4	448.84	450.48	3030	333	134	24.48	4494.2	21814	17320	4.85	0.34
C_3N_1	73.4	448.84	450.48	0	333	134	24.48	1464.2	11235	9771	7.67	0.59
C_3N_2	73.4	448.84	450.48	1515	333	134	24.48	2979.2	16241	13262	5.45	0.39
C_3N_3	73.4	448.84	450.48	3030	333	134	24.48	4494.2	21301	16806	4.74	0.34
C_4N_1	73.4	448.84	450.48	0	333	134	24.48	1464.2	10325	8861	7.05	0.54
C_4N_2	73.4	448.84	450.48	1515	333	134	24.48	2979.2	14925	11945	5.01	0.36
C_4N_3	73.4	448.84	450.48	3030	333	134	24.48	4494.2	19759	15265	4.40	0.31

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}

and common to all treatments studied in the experiment, where as the nitrogen fertilizer occupies the largest share accounting for 1515 MJ ha^{-1} (25 kg N ha^{-1}) to 3030 MJ ha^{-1} (kg N ha^{-1}). With respect to the nitrogen levels tried, the total input energy ranged from 1296.7 to 4326.7 MJ ha^{-1}. These results corroborated the findings of (Chaudhary et al., 2004)

Energy out put

The highest total output energy was arrived by the variety SiA 3085 with 50 kg N ha^{-1} which was closely followed by the variety SiA 3156 with 50 kg N ha^{-1} and the lowest values was with SiA 3088 variety with no nitrogen (Table 4). From the results obtained it was revealed that the energy output was increase with increase in the nitrogen levels irrespective of the varieties tried which was owing to the increase in grain yield with enhanced nitrogen application.

Energy use efficiency, energy productivity and net energy return

The Energy use efficiency and energy productivity was highest with SiA 3085 variety with no nitrogen application whereas, Minimum energy use efficiency was realized with SiA 3088 variety with 50 kg N ha^{-1}, which was due to high input energy requirement and comparatively low output energy (Table 4). The treatmental combination SiA 3085 with 50 kg N ha^{-1} showed numerically high net energy return and total output energy though it has relatively lower energy use efficiency (Table 4). However, by taking monetary returns and net energy returns into consideration it can be concluded SiA 3085 variety with 50 kg N ha^{-1} (C_2N_3) was most efficient and profitable combination. On an average the input-output ratio in the present experiment was 1:5.73 when compared to raising of other major millets which has the same ratios in the range of 1:1.42 and 1:2.57. The results corroborates with the findings of David (2009).

From the assessment of the energitics, it can be arrived that the raising of foxtail millet is more energy efficient and environmentally sustainable climatic resilient crop for sustained productivity of dry lands.

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