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Physiological performance and economics of foxtail millet [*Setaria italica* (L.)] varieties to different nitrogen levels

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Abstract
The experiment was conducted with four foxtail millet varieties (Prasad, Narasimharaya, SiA 3156 and CO-2) and four nitrogen levels (0, 20, 40 and 60 kg N ha^{-1}) on sandy clay soil of Agricultural College Farm, Bapatla, during *kharif*, 2018. Results of the experiment revealed that the variety Prasad and 60 kg N ha^{-1} application recorded the highest SPAD chlorophyll, crop growth rate and relative growth rate at grain development stage and also recorded the highest leaf area index, grain, stover yields, gross returns, net returns and returns per rupee investment.

Keywords: Foxtail millet, varieties, nitrogen levels, SPAD chlorophyll, crop growth rate, relative growth rate, leaf area index

Introduction
Millets, a gluten- free whole grain, consumed in various parts of the world are gaining significance in climate-smart agriculture. Millets hold great promise for food security and nutrition amid ever-increasing agricultural costs, climate change and burgeoning mouths to feed world-wide. They are known for their climate resilient features including adaptation to a wide range of ecological conditions, less irrigational requirements, better growth and productivity in low nutrient input conditions, less reliance on synthetic fertilizers and minimum vulnerability to environmental stress (Kole *et al*., 2015) [4]. These features accentuate millets as crops of choice for the world population amid growing concerns about climate change.

Foxtail millet is the best suited under the situations like frequent occurrence of aberrant monsoon coupled with higher temperatures, replacement of high input cash crops with low input, traditional and climate smart millets. The yield potential of foxtail millet was not realized because of usage of low yielding cultivars, insufficient usage of fertilizers and poor management practices. Hence, the present investigation was therefore taken up with four varieties and four nitrogen levels.

Material and Methods
A field experiment was carried out on sandy clay soils of Agricultural College Farm, Bapatla during *kharif*, 2018. The treatments consisted of four varieties Prasad (V_1), Narasimharaya (V_2), SiA 3156 (V_3) and CO-2 (V_4) and four nitrogen levels *viz.*, 0 kg N ha^{-1} (N_1), 20 kg ha^{-1} (N_2), 40 kg ha^{-1} (N_3) and 60 kg ha^{-1} (N_4) replicated thrice. The soil was neutral in soil reaction, very low in available nitrogen and medium in organic carbon and available phosphorus, very high in available potassium. The experiment was laid out in randomized block design with factorial concept. The crop was sown at 30 cm and 10 cm inter and intra row distance, respectively, on 06.09.2018 and adopted all the standard package of practices. The entire dose of phosphorus@ 20 kg ha^{-1} was applied uniformly to all plots as basal. The scheduled nitrogen was applied in two equal splits as per the treatments *viz.*, half as basal and remaining half as top dressing at 30 DAS. A total of 187.2 mm rainfall was received in 14 rainy days during the crop growth period. The data on SPAD chlorophyll reading, crop growth rate, relative growth rate, leaf area index, grain yield and stover yield were recorded as per standard procedures. Gross and net returns were calculated and also returns per rupee investment were calculated by dividing net returns with cost of cultivation. All data was analyzed statistically following the standard procedures as described by Gomez and Gomez (1984) [2].

Results and Discussion

SPAD chlorophyll reading

There was significant increase in SPAD chlorophyll readings with advancement in age of crop upto 60 DAS and it decreased towards maturity. Irrespective of the variety, SPAD chlorophyll readings during the entire crop growth period were non-significant. However, numerically higher SPAD chlorophyll readings were recorded by Narasimharaya variety (38.0), Prasad variety (45.7) and CO-2 (20.7) at 30, 60 DAS and at harvest, respectively (Table 1.).

Among the nitrogen levels, significantly superior values (40.2, 48.9 and 21.9) of SPAD chlorophyll reading were noticed with application of nitrogen@ 60 kg ha^{-1} at 30, 60 DAS and at harvest (Table 1.), while the lowest readings were recorded with no nitrogen application at all the growth stages. This might be due to luxurious nitrogen availability and more nitrogen content in plant structure at 60 kg N ha^{-1} levels. The results are supported with finding of Muniratnam and Kumar (2015) [5].

Crop growth rate

Crop drymatter production can be analyzed in terms of crop growth rate (CGR) and relative growth rate (RGR), which are two important growth indices used in growth analysis (Watson, 1952) [9].

The varietal variation with respect to crop growth rate (CGR) values was statistically significant at crop growth stage in between 30 - 60 DAS. At 30 - 60 DAS, significantly higher crop growth rate (5.85 g m^{-2} day^{-1}) was recorded by Narasimharaya over SiA 3156 (4.59 g m^{-2} day^{-1}) and CO-2 (3.54 g m^{-2} day^{-1}), which produced the least CGR values. However, Narasimharaya was on par with Prasad (5.78 g m^{-2} day^{-1}) (Table 2.). In between the crop growth stage of 60 DAS – harvest, CGR could not reach the level of significance. However, numerically higher CGR values (5.32 g m^{-2} day^{-1}) were recorded by Prasad, while the least (3.75 g m^{-2} day^{-1}) was produced by CO-2.

In between the crop growth stages of 30-60 DAS and 60 DAS-harvest, significantly higher CGR values (5.80 & 5.66, respectively) were recorded with higher dose of nitrogen *i.e.*, 60 kg ha^{-1} over no nitrogen application, while the lowest (2.95 & 2.75, respectively) was recorded with no nitrogen application. However, 60 kg ha^{-1} treatment was on par with 40 kg ha^{-1} and 20 kg ha^{-1} (Table 2.)

Relative growth rate

Irrespective of the varieties and nitrogen levels, relative growth rate increased with advancement of crop upto 30-60 DAS and thereafter decreased rate was observed.

In between the crop growth stage of 30-60 DAS, significantly higher RGR values (0.042 g g^{-1} day^{-1}) were recorded by Narasimharaya over SiA 3156 and CO-2, which recorded the lowest RGR values (0.032 g g^{-1} day^{-1}) (Table 3.). However, RGR values of Narasimharaya were on par with Prasad. The varietal variation with respect to relative growth rate (RGR) values was statistically non-significant at crop growth stage in between 60 DAS-harvest.

Significantly higher RGR values (0.041 g g^{-1} day^{-1}) were recorded with higher dose of nitrogen *i.e.*, 60 kg ha^{-1} over no nitrogen application, which recorded the lowest values (0.028 g g^{-1} day^{-1}) in between the crop growth stage of 30-60 DAS. However, 60 kg N ha^{-1} and 40 kg ha^{-1} treatments recorded equal RGR values and were on par with 20 kg N ha^{-1} (0.040 g g^{-1} day^{-1}) (Table 3.). Relative growth rate was not influenced with nitrogen levels in between the crop growth stage of 60 DAS-harvest.

Leaf Area Index

Irrespective of variety, growth stage and nitrogen levels, significant increase in leaf area index was obtained with advancement of crop age upto 60 DAS and a decreased trend towards maturity was noticed.

During the entire crop growth period, irrespective of the variety, leaf area index was observed to be non-significant. However, numerically, Prasad was observed to be the variety with maximum leaf area index (1.48, 2.81 & 1.23, respectively), while the least (1.16, 2.20 & 1.01, respectively) (Table 4.) was recorded with SiA 3156 at 30, 60 DAS and also at harvest. This might be due to variation on genetic potential for heavy vegetative structure. These results are corroborating with earlier findings of Aparna and Zuby (2017) [1] and Venkatesh Babu (2013) [8].

At 30 and 60 DAS and at harvest, leaf area index was significantly superior (1.74, 3.52 & 1.63, respectively) with the highest nitrogen application *i.e.*, 60 kg ha^{-1} when compared to 40 kg, 20 kg N ha^{-1} and no nitrogen application (0.86, 1.35 & 0.57, respectively). However, leaf area index of 40 kg N ha^{-1} application (1.39, 2.75 & 1.17, respectively) was on par with 20 kg N ha^{-1} application (1.62, 2.43 & 1.08, respectively) (Table 4.). Increased availability of cytokinins to the shoot, which in turn involved in elongation and expansion of newly produced leaves through increased cell division, elongation and number at the base of elongating leaves, heavy crop canopy with more number of tillers might be due to more nitrogen supply@ 60 kg N ha^{1}. Hence, all these factors might have attributed for maximum leaf area index for 60 kg N ha^{-1} treatment.

Yield (kg ha^{-1})

Among the varieties, Prasad variety (V_1) gave significantly higher grain yield (1609 kg ha^{-1}) and shown its statistical supremacy over the remaining three varieties. The lowest grain yield was recorded by CO-2 (860 kg ha^{-1}). Nitrogen@ 60 kg ha^{-1} resulted in maximum grain yield (1645 kg ha^{-1}) and was significantly superior over 20 kg N ha^{-1} and no nitrogen levels (741 kg ha^{-1}). However, it was on par with grain yield@ 40 kg N ha^{-1} (table 5.)

With respect to stover yield, Prasad variety (2405 kg ha^{-1}) produced maximum and was significantly superior over SiA 3156 and CO-2 varieties, which recorded the lower stover yield (1959 kg ha^{-1}). However, stover yield of Prasad was on par with Narasimharaya. Among the nitrogen levels, the maximum stover yield was produced with 60 kg N ha^{-1} application (2467 kg ha^{-1}) which was significantly superior over 20 kg N and 0 kg N ha^{-1}, which resulted in significantly lower stover yield (1612 kg ha^{-1}) (Table 5.). However, stover yield obtained with N_4 treatment was statistically on par with N_3 treatment.

Significant superiority of Prasad variety for both grain and stover yields might be due to its genetic constitution of yield attributing morpho-physiological parameters and maximum drymatter content. Similar results were also expressed by Ramyasri *et al.* (2018) [6], Shanthi *et al.* (2017) [7] and Jyothi *et al.* (2016) [3].

Gross and net returns

The highest gross and net returns were recorded by Prasad (₹ 46497 ha^{-1} and ₹ 26160 ha^{-1}, respectively) which was significantly superior over the remaining varieties *i.e.*,

Narasimharaya, SiA 3156 and CO-2. The lowest gross and net returns were recorded by CO-2 (₹ 25256 ha^{-1} and ₹ 4920 ha^{-1}, respectively). The second best variety was Narasimharaya with gross and returns of ₹ 40567 ha^{-1} and ₹ 20231 ha^{-1}, respectively.

Among the nitrogen levels, the highest gross and net returns were produced with the highest nitrogen level *i.e.,* 60 kg ha^{-1} (₹ 47540 ha^{-1} and ₹ 26362 ha^{-1}, respectively) which was significantly superior over gross and net returns obtained with 20 kg N ha^{-1} and 0 kg N ha^{-1}. However, gross and net returns of N_4 treatment was on par with N_3. Gross and net returns were the least with no nitrogen application (₹ 21722 ha^{-1} and ₹ 2602 ha^{-1}, respectively).

Returns per rupee investment

The highest returns per rupee investment were recorded by Prasad (1.29) which was significantly superior over the remaining varieties *i.e.,* Narasimharaya, SiA 3156 and CO-2. The lowest returns per rupee investment were recorded by CO-2 (0.24). The second best variety was Narasimharaya (0.99) (Table 5.).

Among the nitrogen levels, the highest returns per rupee investment were produced with the highest nitrogen level *i.e.,* 60 kg N ha^{-1} (1.24)

which was significantly superior over returns per rupee investment obtained with 20 kg N ha^{-1} and 0 kg N ha^{-1}. However, returns per rupee investment of 60 kg N ha^{-1} treatment was on par with 40 kg ha^{-1}, the least returns per rupee investment were produced with no nitrogen application (0.13) (Table 5.).

The interaction effect between varieties and nitrogen levels was non-significant for all parameters studied.

Conclusion

It can be concluded that Prasad variety of foxtail millet performed well with respect to yields, gross returns, net returns and returns per rupee investment. Among the nitrogen levels, 60 kg N ha^{-1} resulted in higher yields, gross returns, net returns and returns per rupee investment. However, it was on par with 40 kg N ha^{-1}.

Table 1: SPAD chlorophyll reading of foxtail millet varieties as influenced by varieties and nitrogen levels

Treatments	30 DAS	60 DAS	At harvest
Varieties			
V_1 – Prasad	37.4	45.7	17.6
V_2 – Narasimharaya	38.0	41.7	17.8
V_3 - SiA 3156	36.7	39.7	18.1
V_4 - CO – 2	37.8	39.5	20.7
SEm±	1.56	1.85	0.99
CD (P=0.05)	NS	NS	NS
Nitrogen levels (kg ha^{-1})			
N_1 - 0	30.4	31.3	17.7
N_2 - 20	38.2	40.0	18.2
N_3 – 40	39.6	46.4	20.7
N_4 – 60	40.2	48.9	21.9
SEm±	1.56	1.85	0.99
CD (P=0.05)	4.5	5.3	2.8
Interaction (V × N)			
SEm±	3.12	3.70	1.98
CD (P=0.05)	NS	NS	NS
CV%	14.6	15.4	17.8

Table 2: Crop growth rate (g m^{-2} day^{-1}) of foxtail millet varieties as influenced by nitrogen levels.

Treatments	30 - 60 DAS	60 DAS – Harvest
Varieties		
V_1 – Prasad	5.78	5.32
V_2 – Narasimharaya	5.85	3.98
V_3 - SiA 3156	4.59	4.68
V_4 - CO – 2	3.54	3.75
SEm±	0.445	0.691
CD (P=0.05)	1.29	NS
Nitrogen levels (kg ha^{-1})		
N_1 – 0	2.95	2.75
N_2 – 20	5.35	4.05
N_3 – 40	5.65	5.28
N_4 – 60	5.80	5.66
SEm±	0.445	0.691
CD (P=0.05)	1.29	1.99
Interaction (V × N)		
SEm±	0.891	1.381
CD (P=0.05)	NS	NS
CV%	11.3	13.9

Table 3: Relative growth rate (g g^{-1} day^{-1}) of foxtail millet varieties as influenced by nitrogen levels.

Treatments	30 - 60 DAS	60 DAS – Harvest
Varieties		
V_1 – Prasad	0.040	0.018
V_2 – Narasimharaya	0.042	0.012
V_3 - SiA 3156	0.036	0.018
V_4 - CO – 2	0.032	0.017
SEm±	0.0018	0.0025
CD (P=0.05)	0.005	NS
Nitrogen levels (kg ha^{-1})		
N_1 – 0	0.028	0.013
N_2 – 20	0.040	0.015
N_3 – 40	0.041	0.017
N_4 – 60	0.041	0.019
SEm±	0.0018	0.0025
CD (P=0.05)	0.005	NS
Interaction (V × N)		
SEm±	0.0036	0.0050
CD (P=0.05)	NS	NS
CV%	16.5	12.9

Table 4: Leaf area index of foxtail millet varieties as influenced by nitrogen levels

Treatments	30 DAS	60 DAS	At harvest
Varieties			
V_1 – Prasad	1.48	2.81	1.23
V_2 – Narasimharaya	1.39	2.62	1.19
V_3 - SiA 3156	1.16	2.20	1.01
V_4 - CO – 2	1.27	2.43	1.02
SEm±	0.085	0.161	0.070
CD (P=0.05)	NS	NS	NS
Nitrogen levels (kg ha^{-1})			
N_1 - 0	0.86	1.35	0.57
N_2 - 20	1.32	2.43	1.08
N_3 – 40	1.39	2.75	1.17
N_4 – 60	1.74	3.52	1.63
SEm±	0.085	0.161	0.070
CD (P=0.05)	0.25	0.47	0.20
Interaction (V × N)			
SEm±	0.171	0.323	0.139
CD (P=0.05)	NS	NS	NS
CV%	18.3	15.2	16.7

Table 5: Grain, stover yield (kg ha^{-1}) and returns per rupee investment of foxtail millet varieties as influenced by nitrogen levels

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	Returns per rupee investment
Varieties					
V_1 – Prasad	1609	2405	46497	26160	1.29
V_2 – Narasimharaya	1402	2201	40567	20231	0.99
V_3 - SiA 3156	1366	2075	39483	19146	0.94
V_4 - CO – 2	860	1959	25256	4920	0.24
SEm±	69.5	93.5	1970.3	1970.3	0.100
CD (P=0.05)	200	270	5690	5690	0.29
Nitrogen levels (kg ha^{-1})					
N_1 - 0	741	1612	21722	2602	0.13
N_2 - 20	1336	2134	38702	18479	0.91
N_3 – 40	1514	2426	43839	23014	1.10
N_4 – 60	1645	2467	47540	26362	1.24
SEm±	69.5	93.5	1970.3	1970.3	0.100
CD (P=0.05)	200	270	5690	5690	0.29
Interaction (V × N)					
SEm±	138.9	187.0	3940.7	3940.7	0.200
CD (P=0.05)	NS	NS	NS	NS	NS
CV%	18.4	15.0	17.9	18.7	20.6

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