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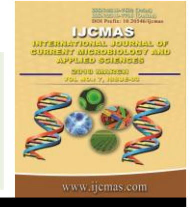

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Performance of Sorghum Hybrids under Different Nitrogen Levels in Rice-Fallow Conditions of North Coastal A.P., India

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A B S T R A C T

A field experiment entitled "Performance of Sorghum hybrids under different nitrogen levels in rice-fallow conditions of North Coastal A.P." was conducted at Agricultural College Farm, Naira in sandy loam soil during *rabi* 2016-17. The treatments comprised of combination of four sorghum hybrids and four nitrogen levels laid out in Split plot design with three replications. Sorghum hybrid CSH 25 and application of 120 kg ha^{-1} recorded the highest growth parameters as well as leaf area index. Significantly higher grain yield was obtained with CSH 25 among hybrids and with 120 kg N ha^{-1}. However, stover yield was highest with hybrid CSH 15R at 120 kg ha^{-1}, harvest index was also highest with CSH 16 at the highest level of N tried (120 kg ha^{-1}) and hence found promising for North Coastal Zone of Andhra Pradesh.

Introduction

Sorghum (*Sorghum bicolor* L. Moench) is traditionally grown for food in semi-arid tropics of India and occupies an area of 6.32 m. ha with a total production of 6.03 m.t and a productivity of 1,004 kg ha^{-1} (ASG, 2011). As per the latest estimates, the crop is being grown under rice-fallows in an extent of 24,000 ha with a productivity of 6.5 t ha^{-1} (Chapke *et al.*, 2014). Of late, Sorghum is emerging as a potential alternate food, fodder and bio-energy crop owing to its tolerance to high temperature and drought there by making it suitable for different agro climatic zones of Andhra Pradesh. Sorghum cultivation is an emerging scenario in rice-fallows under zero tillage. In this changed scenario, farmers are now growing maize in assured irrigated areas as *rabi* crop. However, there is a prospective situation especially in areas having frugal water resources in rice-fallows of this zone for taking up sorghum as an alternate crop to pulses. For any crop, standardisation of agro techniques for realizing the higher yields is a prerequisite. Therefore, to identify a suitable hybrid and to arrive at a required dose of nitrogen and to work out their best combination for achieving higher yield of Sorghum under rice fallow situation of this zone is considered as utmost priority and hence this study was undertaken.

Materials and Methods

A field experiment was conducted during *rabi*, 2016-17 at Agricultural college, Naira The soil was sandy loam in texture with a neutral pH of 7.42 and EC of 0.064 dSm^{-1}, medium in organic carbon (0.56%), low in available nitrogen (96 kg ha^{-1}), low in available phosphorus (12.4 kg ha^{-1}) and medium in available potassium (151 kg ha^{-1}). The experiment was laid out in Split plot design with three replications. The treatments comprised combination of four sorghum hybrids *viz.*, V_1- CSH 15R, V_2- CSH 16, V_3-CSH 25and V_4- MLSH 296 and four nitrogen levels N_1: 0 kg N ha^{-1}, N_2: 80 kg N ha^{-1}, N_3: 100 kg N ha^{-1} and N_4: 120 kg N ha^{-1}. A total rainfall of 8.0 mm was received in 2 rainy days during the growth period of rice fallow sorghum. A recommended dose 80 kg P_2O_5 and 80 kg K_2O ha^{-1} was applied as basal and nitrogen was applied in the form of urea in three splits at 15 DAS, 60 DAS and at flowering. Data on growth parameters like plant height at harvest dry matter accumulation at harvest, number of panicles per m^2 and leaf area index. Yield parameters like grain yield, stover yield, harvest index. Nitrogen harvest index, final N, P, K of soil was recorded. Statistical analysis of all the data collected are carried out following the analysis of variance technique for split plot design as outlined by Panse and Sukhatame, 1985.

Results and Discussion

The results indicated that the growth parameters (Table 1) *viz.*, plant height data of rice fallow sorghum varied significantly with different hybrids and nitrogen levels while their interaction was found to be significant at stage of harvest. At harvest, CSH 15R (V_1) was significantly taller than all other hybrids except CSH 16 (V_2). Plant height recorded with CSH 25 (V_3) was on par with all the hybrids except CSH 15R (V_1). The lowest stature of sorghum was recorded with MLSH 296 (V_4). Plant height obtained was highest with N_4 (120 kg ha^{-1}) and was significantly higher than other levels of nitrogen except N_3 (100 kg ha^{-1}) with which it was comparable. Plant height recorded with N_2 (80 kg ha^{-1}) was in parity with all the levels of nitrogen doses except N_4. The lowest plant height was recorded with N_1 (0 kg ha^{-1}). Interaction effect at harvest revealed that plant height was highest with the hybrid CSH 16 at 120 kg N ha^{-1} (V_2N_4) and the lowest was recorded by MLSH 296 at 0 kg ha^{-1}(V_4N_1). The variabilities in the plant height can be attributed to the variation in the genetic constitution of different hybrids Increase in plant height might be due to the fact that nitrogen promotes plant growth and increases the number and length of the internodes which results in progressive increase in plant height. The variabilities in the plant height can be attributed to the variation in the genetic constitution of different hybrids. These results were in conformity with Angadi *et al.*, (2004).

Accumulation of dry matter pertaining to CSH 25 (V_3) was significantly superior to all the hybrids (Table 1). Dry matter accumulation with CSH 16 (V_2) was found to be superior to all other hybrids except V_3, while yield with CSH 15R (V_1) was significantly superior to MLSH 296 (V_4), which was thus inferior to all the sorghum hybrids taken for trial. Dry matter accumulation at the highest nitrogen level (N_4) was significantly superior as compared to all the other the levels of nitrogen levels tried. Dry matter accumulation obtained with the application of 100 kg ha^{-1} (N_3) in parity with the application of 80 kg ha^{-1} (N_2). Both these nitrogen levels were significantly inferior to N_4 and significantly superior to, no application of nitrogen (N_1), which recorded the significantly lowest dry matter production among all the four levels of nitrogen tested in this experiment. Dry matter accumulation at harvest, was highest with the combination of hybrid CSH 25 at 120 kg Nha^{-1} (V_3N_4) and the lowest plant height was recorded by CSH 16 at 0 kg N ha^{-1} (V_2N_1) but was on par with MLSH 296 at 0 kg N ha^{-1} (V_4N_1) which was significantly inferior to all other combinations. Pushpendra Singh *et al.,* (2012) have also reported that higher leaf area has led to the higher accumulation of photosynthates in hybrid CSH 25 at harvest stage. The improvement in morphological as well as physiological parameters due to fertilizer application might have resulted into better interception of radiant energy leading to higher photosynthesis there by higher accumulation of dry matter per plant.

Analysis of the data (Table 1) showed that number of panicles m^{-2} of rice fallow sorghum hybrids were non-significant both for hybrids as well as N levels tested in this trial.

At 60 DAS (flowering stage) in rice fallow sorghum, Leaf area index of CSH 25 (V_3) was significantly superior to all the hybrids (Table 1). Leaf area index with MLSH 296 (V_4) was found to be superior to all other hybrids except V_3, while leaf area index ratio with CSH 16 (V_2) was significantly superior to CSH 15R (V_1). Significantly lowest leaf area index was recorded with CSH 15R (V_1) and was thus inferior to all the sorghum hybrids taken for trial and leaf area index were varied with increase in nitrogen levels from 0 to 120 kg ha^{-1}. Leaf area index obtained was higher with N_4 (120 kg ha^{-1}) and was significantly higher than other levels of nitrogen except N_3 (100 kg ha^{-1}) with which it was comparable. Leaf area index recorded with N_2 (80 kg ha^{-1}) was in parity with all the levels of nitrogen doses except N_4. The lowest leaf area index was recorded with N_1 (0 kg ha^{-1}) among the doses tried in trial.

Interaction effect between the hybrids and nitrogen levels for leaf area index was found to be statistically significant. Leaf area index was highest with the hybrid CSH 15 at 120 kg N ha^{-1} (V_1N_4) which was on par with CSH 16 at 120 kg N ha^{-1} (V_2N_4) and superior over other interaction combinations. The lowest leaf area index was recorded by CSH 15R at 0 kg N ha^{-1} (V_1N_1) but was on par with CSH 16 at 0 kg N ha^{-1} (V_2N_1) which was significantly inferior to all other combinations. Maximum leaf area was recorded at 60 DAS and successively decreased afterwards.

This is due to the tiller reduction and leaf senescence with arrival of maturity. The influence of applied nitrogen on the plant was reflected in the leaf area index. Successive increase of doses at rate of nitrogen has recorded significant higher leaf area index when compared to the preceding doses. As soil was low in available nitrogen content, increasing levels have recorded increased uptake resulting into better plant height and number of panicles and ultimately higher leaf area index. Similar results were found with the experiment conducted by Mishra *et al.,* (2013) where leaf area index significantly increased from 0 to 220 kg N ha^{-1}.

Analysis of the data (Table 2) on grain yield of sorghum indicated that yield obtained with CSH 25 (V_3) was significantly higher than all the other hybrids except CSH 16 (V_2) with which it was statistically comparable (Table 1). Grain yield recorded with MLSH 296 (V_4) was on par with all the hybrids except CSH 25 (V_3). The lowest grain yield was recorded with CSH 15R (V_1) among all the hybrids taken for study. Grain yield obtained at highest nitrogen level (N_4) was significantly superior as compared to all the nitrogen levels tried. Yield obtained with the application of 100 kg ha^{-1} (N_3) was next best treatment but was, however, comparable with the application of 80 kg ha^{-1} (N_2).

Table.1 Effect of different hybrids and nitrogen levels on plant height, dry matter accumulation, leaf area index and number of panicles m^{-2} of rice fallow sorghum

Treatments	Plant Height at harvest (cm)	Dry Matter production at harvest (kg ha^{-1})	Leaf area index	Number of panicles m^{-2}
Hybrids				
CSH 15R	240.63	9503.75	3.9	11.9
CSH 16	212.10	9872.44	4.0	12.5
CSH 25	189.16	12542.83	4.5	12.5
MLSH 296	185.60	8664.69	4.2	12.7
SEm ±	1.40	193.00	0.03	0.23
CD (P=0.05)	4.96	680.85	0.10	NS
CV%	2.35	6.59	5.5	1.03
N-levels (kg ha^{-1})				
0	170.48	6953.28	3.1	12
80	199.03	8854.39	4.1	12
100	218.63	11759.56	4.5	12.4
120	239.35	13022.48	4.9	13.2
SEm ±	1.86	157.51	0.04	0.27
CD (P=0.05)	5.47	462.49	0.13	NS
CV%	3.1	5.38	7.1	3.12
H at N				
SEm ±	3.72	334.19	0.08	0.36
CD (P=0.05)	10.88	1047.17	0.25	NS
N at H				
SEm ±	2.80	386.00	0.06	0.29
CD (P=0.05)	11.30	987.14	0.27	NS

Table.2 Effect of different hybrids and nitrogen levels on grain yield, stover yield, harvest index, nitrogen harvest index and final N, P and K of rice fallow sorghum

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index	Nitrogen harvest index	Post-harvest soil fertility status		
Hybrids					**Final N**	**Final P**	**Final K**
CSH 15R	5023	15477	24.50	60.23	148.6	8.5	207.7
CSH 16	6068	12873	32.04	61.85	155.7	8.1	184.0
CSH 25	6841	15536	33.57	60.61	154.9	8.0	193.9
MLSH 296	6044	9222	39.59	60.16	123.8	8.5	194.8
SEm ±	294	169.4	1.25	0.89	1.93	0.28	9.87
CD (P=0.05)	1037	598	4.41	NS	6.8	NS	NS
CV%	14	4.7	13.4	5.0	4.5	13.9	13.0
N-levels (kg ha^{-1})							
0	3436	8872	27.91	61.58	88.5	5.9	137.7
80	6296	11992	34.42	60.78	147.6	7.4	256.9
100	6751	14043	32.46	60.51	159.9	9.1	198.4
120	7491	16201	31.61	60.98	187.0	10.8	187.4
SEm ±	202	138.5	0.96	0.80	2.85	0.39	7.65
CD (P=0.05)	593	407	2.78	NS	8.3	1.15	22.48
CV%	13	8.2	10.1	4.5	6.7	14	12
H x N							
SEm ±	588	294	3.7	1.25	5.3	0.5	16.5
CD (P=0.05)	NS	920	NS	NS	16	NS	52
N x H							
SEm ±	498	339	2.8	1.77	3.8	0.8	19.7
CD (P=0.05)	NS	868	NS	NS	17.2	NS	48

Both these nitrogen levels were significantly superior to N_4 and significantly superior to no application of nitrogen (N_1), which recorded the significantly lowest grain yield among all the four levels of nitrogen tested in this experiment.

The Superiority of hybrid CSH 25 (V_3) in terms of yield under rice fallow conditions of sorghum can be attributed to its higher number of grains per panicle, dry matter accumulation at harvest as compared to other three hybrids. It has also the ability to put up the growth under low temperature conditions at early stages. Similar observations were reported by Mishra *et al.,* (2011) and Chapke *et al.,* (2014). The increase in the grain yields with enhanced N application could be ascribed to better plant growth and dry matter production due to higher photosynthetic area.

This further supported by the fact that soil of the experimental field was low in nitrogen (96 kg ha^{-1}). These results are in corroboration with Madhukumar *et al.,* (2013), Mishra *et al.,* (2014) and Vara Prasad *et al.,* (2014).

Stover yield (Table 2) obtained with CSH 15R (V_1) was significantly superior to all the hybrids. Yield of stover with CSH 25 (V_3) was found to be superior to all other hybrids except V_1, while yield with CSH 16 (V_2) was significantly superior to MLSH 296 (V_4). Stover yield at the highest nitrogen level (N_4) was significantly superior as compared to all the other the levels of nitrogen levels tried. Stover yield obtained with the application of 100 kg ha^{-1} (N_3) was the next best treatment but was, however, significant superior to 80 kg ha^{-1}(N_2). No application of nitrogen (N_1) recorded the significantly lowest yield among all the four levels of nitro gen tested in this experiment. Stover yield was highest with the hybrid CSH 15R at 120 kgha^{-1} (V_1N_4) which was superior over other interaction combinations. The lowest stover yield was produced by MLSH 296 at 0 kg N ha^{-1}(V_4N_1). Higher stover yield with CSH 15R (V_1) might be owing to its tall growing nature as reflected by its highest plant height and also dry matter production. The same observations made by Patil (2007) and Chapke *et al.,* (2014). Highest stover yield recorded with the application of 120 kg N ha^{-1} might be due to the fact that nitrogen application increases the activity of cytokinin in plant which leads to the increased cell division and elongation. Madhukumar *et al.,* (2013) also made similar observations.

Harvest index data (Table 2) of rice fallow sorghum varied significantly among different hybrids and nitrogen levels while their interaction was found to be non-significant (Table 1). Harvest index was highest with MLSH 296 (V_4) which was significantly higher as compared to all the other hybrids tried. Harvest index was highest at nitrogen level (N_2) as compared to all the nitrogen levels tried. Harvest index obtained with the application of 100 kg ha^{-1} (N_3), however, was comparable with the application of 80 kg ha^{-1} (N_2) and 120 kg ha^{-1} (N_4). Harvest index decreased with increased levels of nitrogen. The similar observations were made by Madhukumar *et al.,* (2013).

Analysis of the data (Table 2) showed that nitrogen harvest index of rice fallow sorghum hybrids were non-significant both for hybrids as well as nitrogen levels tested for this experiment.

Analysis of the data (Table 2) on post-harvest soil nitrogen of sorghum indicated that soil nitrogen content recorded with CSH 16 (V_2) was significantly higher than all the other hybrids except CSH 25 (V_3), while CSH 15R (V_1) was on par with CSH 25 (V_3). The significantly lowest soil nitrogen was recorded with MLSH 296 (V_4).

Soil nitrogen at the highest nitrogen level (N_4) was significantly superior as compared to all the other the levels of nitrogen levels tried. Soil nitrogen obtained with the application of 100 kg ha^{-1} (N_3) was the next best treatment but was, however, significant superior to 80 kg ha^{-1}(N_2).

Both these nitrogen levels were significantly inferior to N_4 but were significantly superior to no application of nitrogen (N_1), which recorded the significantly lowest final nitrogen among all the four levels of nitrogen tested in this experiment. Soil nitrogen was higher with the hybrid CSH 15R at120 kgha^{-1} (V_1N_4) which was superior over other interaction combinations and the lowest soil nitrogen was noticed with MLSH 296 at 0 kg N ha^{-1} (V_4N_1). The increase in post-harvest soil available nitrogen might be due to increased mineralization as a result of increased nitrogen fertilization. Bhanavase *et al.*, (2005) and Bangar *et al.*, (2003) also reported similar results.

Post-harvest soil phosphorus, did not differ with sorghum hybrids and were non-significant. Soil phosphorus for N levels followed the similar trend as that of soil nitrogen. The interaction was non-significant. Available phosphorus increased with increase in nitrogen level. This might be probably due to positive interaction of phosphorus with increased nitrogen application i.e., the acidifying effect of added nitrogen fertilizer which enhance the phosphorus solubility thereby increase the availability of phosphorus to the plants and leaving available phosphorus in the soil after harvest at higher nitrogen levels and vice versa (Sharma and Tandon, 1992).

Analysis of the data showed that post-harvest soil potassium of rice fallow sorghum hybrids did not differ with each other and were non-significant. Soil potassium with 80 kg N ha^{-1} (N_2) was significantly superior followed by application of 100 kg ha^{-1} (N_3), which was in parity with 120 kg ha^{-1}(N_4).

All these nitrogen levels were significantly superior to no application of nitrogen (N_1), which recorded the significantly lowest soil potassium. Soil potassium was higher with the hybrid MLSH 296 at 80 $kgha^{-1}$ (V_4N_2) and lowest soil potassium was noticed with MLSH 296at 120 kg Nha^{-1} (V_4N_4).

Hence from the above, it can be concluded sorghum can be successfully grown by choosing sorghum hybrid CSH 25 (V_3) and with application of 120 kg N ha^{-1} (N_4) for the obtaining highest yield making it technically feasible and economically profitable proposition under the resource constrained rice fallow conditions of North Coastal Zone of Andhra Pradesh.

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