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Growth and Yield of Rice Fallow Sorghum as Influenced by Planting Density and Nitrogen

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ABSTRACT

A field experiment conducted during *rabi*, 2014-2015 on clay loam soils of Agricultural College Farm, Bapatla was laid out in factorial randomized block design with three replications. The treatments comprised of three planting densities (S_1: 3.33 lakh plants ha^{-1}, S_2: 2.22 lakh plants ha^{-1}, S_3: 1.66 lakh plants ha^{-1}) allotted to factor-A and four nitrogen levels (N_0 : 0 kg ha^{-1}, N_1 : 50 kg ha^{-1}, N_2 : 100 kg ha^{-1}, N_3 : 150 kg ha^{-1}) allotted to factor-B. The results revealed that the highest plant height (215.3cm) was recorded at a planting density of 1.66 lakh plants ha^{-1}), but higher drymatter production, yield attributes and grain yield was higher at a planting density of 2.22 lakh plants ha^{-1} with 150 kg N ha^{-1}.

Key words : Nitrogen, Planting density, Sorghum.

Sorghum (*Sorghum bicolor* L. Moench) is one of the most important coarse cereal crop grown in the world and is emerging as a potential alternate food, fodder and bio-energy crop in Krishna Agro-climatic Zone of Andhra Pradesh. A relatively low acreage crop and recognized as a drought tolerant crop (Bennett *et al.,* 1990 and Khosla *et al.,* 1995). It is traditional food crop in semi-arid tropics of India, occupies an area of 5.82 m ha with a productivity of 926 kg ha^{-1} and a total production of 5.39 m t (Agricultural Statistics at a Glance, 2014). Rice-fallow sorghum occupies an area of 21,000 ha and producing 6.8 t ha^{-1} under zero till conditions (Mishra *et al.,* 2011). Despite its multiple uses, and declined area besides grain sorghum, in India declined considerably. Sorghum production must be increased to meet the current and future fodder and food needs. In this changed scenario, farmers are now raising maize (in assured irrigated area) and sorghum (in less irrigated areas) under rice-fallows as an alternate crop to pulses. Optimum plant population and rate of nitrogen at proper time is considered to be the single most significant factor in improving the crop productivity. Therefore, matching optimum plant density with fertilizer schedule is essential to achieve the targeted yields. Influence of planting density on dynamics of applied nitrogen cannot be judged precisely due to contribution of soil nitrogen and residual effect of previous crop on the succeeding crop. Thus identifying a suitable planting density involving rice fallow sorghum under zero tillage and developing a sound and viable nitrogen dosage is a long felt need.

MATERIAL AND METHODS

A field trial was carried out on clay soil of Agricultural College Farm, Bapatla during *rabi*, 2014-2015. The soil was slightly acidic with neutral in reaction and high in organic carbon (0.9), low in available nitrogen (269.6 kg ha^{-1}) and medium in available phosphorus (32.8kg ha^{-1}) and high in available potassium (623.4kg ha^{-1}). The experiment was laid out in randomized block design with factorial concept and replicated thrice. The treatments consisted of factor–A with three planting densities *viz.*, S_1 (3.33 lakh plants ha^{-1}), S_2 (2.22 lakh plants ha^{-1}) and S_3 (1.66 lakh plants ha^{-1}) and factor-B with four nitrogen levels *viz.*, N_0 (0 kg N ha^{-1}), N_1 (50 kg N ha^{-1}), N_2 (100 kg N ha^{-1}) and N_3 (150 kg N ha^{-1}). The sorghum hybrid CSH16 was sown on 3rd January, 2015. A total of 2.8 mm rainfall (negligible) received during crop growth period. Sorghum was sown immediately after harvest of *kharif* rice by dibbling 2 seeds hill^{-1} with the help of bamboo pegs and nylon ropes. Thinning and gap filling was done at 10 DAS by keeping one seedling hill^{-1}. Entire dose of phosphorus and potassium were applied as basal in the form of single super phosphate and muriate of potash and nitrogen was applied in two equal splits through urea at 10 DAS and 30 days after first split of fertilizer application as per treatments. The data on plant height, drymatter accumulation, yield attributes, yield and net returns were recorded as per standard statistical procedures. The observation on growth parameters *viz.,*plant height, drymatter accumulation and days to 50 % ear emergence and yield parameters *viz.,* number of earheads m^{-2}, earhead length, number of grains $earhead^{-1}$, test weight, grain yield and stover yield were analysed by using standard procedures.

RESULTS AND DISCUSSION

Growth parameters

The results revealed that the plant height was significantly affected by plant densities and nitrogen levels. However, numerically taller plants were produced at a planting density of 1.66 lakh plants ha^{-1} than that of 2.22 lakh plants ha^{-1} and 3.33 lakh plants ha^{-1} at all stages of growth period. This might be due to greater light interception, efficient utilization of soil moisture and nutrients under low degree of inter - plant competition at wider spacing. Taller plants were produced by the application of 150 kg N ha^{-1} compared to other nitrogen levels (0 and 50 kg N ha^{-1}) due to cell elongation, cell enlargement and more chlorophyll synthesis, resulted in better plant growth. Similar findings of production of taller plants with increasing row spacing were reported by Yakadri and Murali (2009).

Drymatter accumulation ha^{-1} was significantly superior at a planting density of 2.22 lakh plants ha^{-1} at all the stages of crop growth (60, 90 DAS and at harvest) except at 30 DAS, at this stage higher drymatter production was accumulated from higher planting density of 3.33 lakh plants ha^{-1} due to slow growth of crop at initial stages that resulted in less competition. Drymatter accumulated $plant^{-1}$ was higher at lower planting density of 1.66 lakh plants ha^{-1}than at higher planting densities. Application of 150 kg N ha^{-1} produced significantly higher amount of drymatter than rest of the nitrogen levels at 30, 60 and 90 DAS. But at harvesting stage higher drymatter was produced at 150 kg N ha^{-1} than rest of the nitrogen levels, which was on a par with 100 kg N ha^{-1}, but significantly superior to other N levels (0 kg N ha^{-1} and 50 kg N ha^{-1}). These results were in confirmation with the findings of Gutte and Karanjikar)2007).

Days to 50% ear emergence and days to maturity were significantly influenced by nitrogen levels but not by the planting densities. Sorghum grown at lower planting density of 1.66 lakh plants ha^{-1} (62 and 98) and no nitrogen application took higher number of days (65) to 50% ear emergence, however less number of days (97) to reach maturity. These results were similar to that of Buah and Mwinkaara (2009).

Yield attributes

Number of earheads m^{-2} at a planting density of 3.33 lakh plants ha^{-1} (32), was significantly higher than that of 2.22 lakh plants ha^{-1} (21) and 1.66 lakh plants ha^{-1} (16) in rice fallow sorghum. It was because of the fact that increased plant densities unit $area^{-1}$ resulted in higher number of earheads m^{-2} compared to other level of planting densities. These results were similar with that of Ali El-Toum Hassan (2002). Nitrogen levels had no significant effect on number of earheads m^{-2}.

Earhead length recorded significantly higher at the lowest planting density (32.3 cm) over remaining two plant densities (30.3 cm and 28.8 cm) due to adequate space, nutrients, and moisture availability and less competition from less plant population compared to high density. The highest earhead length was recorded with the application of 150 kg N ha^{-1} (34.2 cm) followed by 100 kg N ha^{-1} (32.4 cm) and 50 kg N ha^{-1} (29.8 cm). Such an effect of greater earhead length due to 150 kg N ha^{-1} could be attributed to its favourable effect on cell enlargement, production of larger leaves and improves photosynthetic efficiency of plants. These results are in tune with the findings reported by Mishra *et al.* (2013).

The number of grains $earhead^{-1}$ was significantly influenced by both planting densities and nitrogen levels. The higher number of grains $earhead^{-1}$ was recorded at lower planting density of 1.66 lakh plants ha^{-1} (2172), which was significantly superior to 3.33 lakh plants ha^{-1} (1519) and 2.22 lakh plants ha^{-1} (1870) due to competition for nutrients and space. Similar result were also

Table 1. Growth parameters of rice fallow sorghum as influenced by planting density and nitrogen levels.

Treatment	Plant height (cm)				Drymatter accumulation (kg ha^{-1})				Days to 50% ear emergence	Days to maturity
	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest		
Planting density (lakh plants ha^{-1})										
S_1 - 3.33 (30 cm x 10 cm)	20.8	153.3	184.2	194.3	809	9481	12720	15021	61	97
S_2 - 2.22 (45 cm x 10 cm)	27.1	163.2	195.3	205.2	693	10227	14026	17258	62	98
S_3 - 1.66 (60 cm x 10 cm)	31.4	174.5	205.5	215.3	632	8681	11448	12923	62	98
S.Em±	0.77	3.17	3.22	3.56	19.7	170.2	229.8	283.9	0.5	0.2
CD (p = 0.05)	2.2	9.3	9.4	10.4	58	499	674	833	NS	NS
Nitrogen levels (kg ha^{-1})										
N_0 - 0	21.9	146.1	176.0	186.4	555	8517	11511	13765	65	97
N_1 - 50	25.1	158.5	189.6	198.8	654	9098	12324	14627	61	97
N_2 - 100	28.1	169.6	200.7	213.0	736	9785	13141	15572	61	98
N_3 -150	30.6	180.5	213.8	221.5	899	10453	13949	16306	60	99
S.Em±	0.89	3.66	3.71	4.11	22.7	196.6	265.4	327.8	0.6	0.3
CD (p = 0.05)	2.6	10.7	10.9	12.0	67	577	778	962	2.0	1.0
Interaction (S X N)										
S.Em±	1.54	6.35	6.44	7.13	39.4	340.5	459.7	567.8	1.1	0.5
CD (p = 0.05)	NS	18.6	NS	NS	NS	999	NS	NS	NS	NS
CV (%)	10.1	6.7	5.7	6.0	9.6	6.2	6.2	6.5	3.0	1.0

DAS - Days after sowing Sig*- Significant NS- Not significant
CD- Critical difference CV- Coefficient of variation

Table 1.1 Interaction between planting density and nitrogen on plant height (cm) at 60 DAS.

Plant density (lakh plants ha^{-1})	N levels (kg ha^{-1})				Mean
	N_0 -0	N_1 -50	N_2 -100	N_3 -150	
S_1 - 3.33 (30 cm x 10 cm)	128.0	147.3	161.0	177.0	153.3
S_2 - 2.22 (45 cm x 10 cm)	159.6	160.2	169.8	165.0	163.2
S_3 - 1.66 (60 cm x 10 cm)	150.8	167.9	179.8	199.6	174.5
Mean	146.1	158.5	169.6	180.5	
S.Em±			6.35		
CD (p = 0.05)			18.6		

Table 1.2 Interaction between planting density and nitrogen on drymatter accumulation (kg ha^{-1}) at 60 DAS.

Plant density (lakh plants ha^{-1})	N levels (kg ha^{-1})				Mean
	N_0 -0	N_1 -50	N_2 -100	N_3 -150	
S_1 - 3.33 (30 cm x 10 cm)	9065	9081	9209	10571	9481
S_2 - 2.22 (45 cm x 10 cm)	8657	9560	11401	11289	10227
S_3 - 1.66 (60 cm x 10 cm)	7828	8652	8746	9499	8681
Mean	8517	9098	9785	10453	
S.Em±			340.5		
CD (p = 0.05)			999		

Table 2. Yield attributes, yield and economics of rice fallow sorghum as influenced by planting density and nitrogen.

Treatment	Number of earheads m^{-2}	Earhead length (cm)	No. of grains $earhead^{-1}$	Test weight (g/1000 grains)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
Planting density (lakh plants ha^{-1})						
S_1 - 3.33 (30 cm x 10 cm)	32	28.8	1519	24.8	4911	11867
S_2 - 2.22 (45 cm x 10 cm)	21	30.3	1870	25.2	5758	11180
S_3 - 1.66 (60 cm x 10 cm)	16	32.3	2172	25.7	4379	9465
S.Em±	0.3	0.45	58.5	0.34	93.2	195.6
CD (p = 0.05)	1.0	1.3	172	NS	273	574
Nitrogen levels (kg ha^{-1})						
N_0 - 0	23	25.6	1105	24.6	4113	9730
N_1 - 50	22	29.8	1542	24.9	4846	10549
N_2 - 100	23	32.4	2213	25.3	5334	11220
N_3 -150	24	34.2	2555	26.0	5771	11850
S.Em±	0.4	0.52	67.5	0.40	107.6	225.8
CD (p = 0.05)	NS	1.5	198	NS	316	662
Interaction (S X N)						
S.Em±	0.7	0.91	117.0	0.69	186.4	391.2
CD (p = 0.05)	NS	2.6	343	NS	547	NS
CV (%)	5.4	5.1	10.9	4.8	6.4	6.3

DAS - Days after sowing   Sig*- Significant   NS- Not significant
CD- Critical difference   CV- Coefficient of variation

obtained by Zand *et al.* (2014). The highest number of grains $earhead^{-1}$ was observed with the application of 150 kg N ha^{-1} (2555) which was significantly higher than that of lower levels of nitrogen, 0 kg ha^{-1} (1105), 50 kg ha^{-1} (1542) and 100 kg ha^{-1} (2213). The increased availability of nutrients and photosynthates might have enhanced higher number of grains $earhead^{-1}$. Similar results were also reported by Pushpendra Singh *et al.* (2012).

Maximum test weight (g) was observed at a planting density of 1.66 lakh plants ha^{-1} (25.7 g) over other two planting densities. Among the nitrogen levels, application of 150 kg N ha^{-1} (26.0 g) recorded the highest test weight, which was at par with the 50 and 100 kg N ha^{-1} (24.9 g and 25.3g) due to availability of adequate and balanced nutrients at higher nitrogen level. Further, in most of cereals, greater assimilating surface at reproductive development results in better grain formation because of adequate production of metabolites and their translocation towards grain. This might have resulted in increased weight of individual grain. Similar results were also reported by Pushpendra Singh *et al.* (2012).

Yield

Grain yield of rice fallow sorghum recorded at a planting density of 2.22 lakh plants ha^{-1} was found significantly higher (5758 kg ha^{-1}) than that of 3.33 lakh plants ha^{-1} (4911kg ha^{-1}) and 1.66 lakh plants ha^{-1} (4378.5kg ha^{-1}). The percent increase in grain yield from a planting density of 3.33 lakh plants ha^{-1} to 2.22 lakh plants ha^{-1} was 17.2 and from 1.66 lakh plants ha^{-1} to 2.22 lakh plants ha^{-1} is 31.5. The better availability of nutrients at 2.22 lakh plants ha^{-1} might have helped the plants to grow profusely. Similarly rapid initiation of leaves and their expansion ultimately, resulted in high rate of photosynthesis besides vigorous growth of individual

Table 2.1 Interaction between planting density and nitrogen on Earhead length (cm).

Plant density (lakh plants ha^{-1})	N levels (kg ha^{-1})				Mean
	N_0 -0	N_1 -50	N_2 -100	N_3 -150	
S_1 - 3.33 (30 cm x 10 cm)	21.9	28.5	31.7	33.4	28.8
S_2 - 2.22 (45 cm x 10 cm)	28.4	29.0	31.3	32.6	30.3
S_3 - 1.66 (60 cm x 10 cm)	26.4	31.8	34.4	36.7	32.3
Mean	25.6	29.8	32.4	34.2	
S.Em±			0.91		
CD (p = 0.05)			2.6		

Table 2.2 Interaction between planting density and nitrogen on Number of grains $earhead^{-1}$

Plant density (lakh plants ha^{-1})	N levels (kg ha^{-1})				Mean
	N_0 -0	N_1 -50	N_2 -100	N_3 -150	
S_1 - 3.33 (30 cm x 10 cm)	985	1403	1703	1985	1519
S_2 - 2.22 (45 cm x 10 cm)	1154	1492	2239	2595	1870
S_3 - 1.66 (60 cm x 10 cm)	1176	1731	2697	3084	2172
Mean	1105	1542	2213	2555	
S.Em±			117.0		
CD (p = 0.05)			343		

Table 2.3 Interaction between planting density and nitrogen on Grain yield (kg ha^{-1})

Plant density (lakh plants ha^{-1})	N levels (kg ha^{-1})				Mean
	N_0 -0	N_1 -50	N_2 -100	N_3 -150	
S_1 - 3.33 (30 cm x 10 cm)	4111	4722	5231	5582	4911
S_2 - 2.22 (45 cm x 10 cm)	4420	5533	6191	6889	5758
S_3 - 1.66 (60 cm x 10 cm)	3808	4283	4581	4842	4379
Mean	4113	4846	5334	5771	
S.Em±			186.4		
CD (p = 0.05)			547		

plants. These results corroborate with the previous findings of Sumeriya (2010). Application of 150 kg N ha^{-1} significantly improved the grain yield (5771 kg ha^{-1}) of rice fallow sorghum over 0 kg N ha^{-1} (4113 kg ha^{-1}), 50 kg N ha^{-1} (4846 kg ha^{-1}) and 100 kg N ha^{-1} (5334). Grain yield obtained with the application of 150 kg N ha^{-1} was about 40.3, 19.0 and 8.2 per cent higher than that of 0 kg N ha^{-1}, 50 kg N ha^{-1} and 100 kg N ha^{-1}, respectively. This might have promoted the growth of roots as well as functional activity resulting in higher extraction of nutrients from soil environment to aerial plant parts. The improvement in yield attributes with N consequently resulted in higher yield. These results are in complete agreement with the findings of Miko and Manga (2008). The highest stover yield was obtained at higher planting density of 3.33 lakh plants ha^{-1} (11867 kg ha^{-1}) which was significantly superior to 1.66 lakh plants ha^{-1} (9465 kg ha^{-1}) and 2.22 lakh plants ha^{-1} (11180 kg ha^{-1}). Application of 150 kg N ha^{-1} produced maximum stover yield (11850 kg ha^{-1}), which was on a par with the 100 kg N ha^{-1} (11220 kg ha^{-1}) but was significantly superior to 0 kg N ha^{-1} (9730 kg ha^{-1}) and 50 kg N ha^{-1} (10549 kg ha^{-1}). The highest net returns (Rs. 64921 ha^{-1}) and B : C ratio (2.74) were recorded with application of 150 kg N ha^{-1} at planting density of 2.22 lakh plants ha^{-1} (45 cm x 10 cm) over all other treatment combinations. The interactions of plant height and drymatter accumulation at 60 DAS, earhead length, number of grains $earhead^{-1}$, grain yield, significantly influenced by planting densities and nitrogen levels.

Conclusion:

The highest grain yield was recorded with the application of 150 kg N ha^{-1} at planting density of 2.22 lakh plants ha^{-1} (45 cm x 10 cm) over other treatments.

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