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Growth, Yield and Quality of Sorghum [*Sorghum bicolor* (L.) Moench] as influenced by planting densities, genotypes and different levels of nitrogen

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ABSTRACT

Field experiment was conducted during summer season of 2006 at Research Farm of College of Agricultural, Indore, Madhya Pradesh to investigate the effect of plant density, genotypes and nitrogen levels on cane and grain yield of sweet sorghum. The results showed that the higher grain yield (2427 kg ha^{-1}) along with cane yield and juice yield was recorded under plant density 45 cm x15 cm. Plant density of 45 cm x 15 cm gave higher gross returns (Rs 37592 ha^{-1}), net returns (25871ha^{-1}) and benefit cost ratio (3.21). Among the genotypes, NSSH-104 was found better in respect of all the growth characters as well as yields attributing characters and yield. A positive correlation was observed between the growth, yield attributes and yield along with higher levels of nitrogen applied. Application of 120 kg N ha^{-1} was found suitable and recorded the maximum yields and monetary returns and benefit cost ratio.

Keywords: *Planting densities, genotypes and nitrogen.*

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INTRODUCTION

Sorghum [*Sorghum bicolor* (L.) Moench] is the most important cereal crop produced in India. The crop is extensively grown in central and southern states of the country. The production of sorghum in India is 8.0 million tonne from the area 8.8 million ha and the productivity is 9.08 q ha^{-1} (Economic survey, GOI, 2006-07). Sweet sorghum is an important crop for food, fodder and jaggery or sugar production. Sweet sorghum holds a great potential as a field crop for ethanol production throughout the world because it is adaptable for a wide range of growing conditions. A prerequisite for growing a successful sorghum crop is to obtain an adequate plant population density [5] and [8].

It is well known phenomenon that genotypes, an optimum plant density and nitrogen level not only increases the production, quality of grain and fodder but also improves the quality of juice obtained from green stalk of sweet sorghum. There is a need to identify the promising genotypes with their optimum plant density and nitrogen levels for sweet sorghum. For the high yielding varieties, nitrogen (N) is the most important plant nutrient for productivity improvement [2]. Nitrogen recommendation varies with expected yield, soil properties, cultivars and cropping sequence. In general, N requirement of sweet sorghum is less than that of other alternative biofuel crops such as sugarcane and maize. Inappropriate application of N fertilizer is the reason for used inefficient fertilizer protocol that might affect the environment. The work reported here was taken up for investigating the effect of plant density, genotypes and nitrogen levels on cane and grain yield of sweet sorghum.

MATERIAL AND METHODS

The experiment field is situated at Indore in Malwa plateau in western part of Madhya Pradesh on a latitude of 22°43" N and longitude of 75°66" E with an altitude of 555.5 meters above mean sea level.. The study was conducted during the Kharif seasons of 2006 at Research Farm of College of Agricultural, Indore, Madhya Pradesh. Total annual rainfall Total rainfall received during the experimental period between 28th June, 2006 and 22nd November, 2006 was 1091.3 mm in 33 rainy days. The soil of experimental field was medium black having a depth of 150 cm. The soil of the experimental field was mixed red and black with clay loam in texture and slightly alkaline in reaction with pH 7.5, EC 0.22 dS\m having organic carbon 0.25 per cent and available nitrogen 150 kg\ha, phosphorus 13 kg\ha and potassium 422 kg\ha at 0-15 cm soil depth. The field experiment was laid out in split plot design with three replications and 16 treatment combinations. Main plot treatment consisted of two plant density *viz*.,45 cm X 15 cm and 60 cm x 15 cm and two sweet sorghum genotypes *viz*., SSV-84 and NSSH 104. The sub plot treatment comprised of nitrogen levels *viz*., 30 kg ha^{-1}, 60 kg ha^{-1}, 90 kg ha^{-1} and 120 kg ha^{-1} with full P_2O_5 (50 kg ha^{-1}) and K_2O (50 kg ha -1) at sowing. The nitrogen was applied through urea in three split doses. Half dose of N and full doses of P and K were applied as basal just before transplanting and remaining half quantity of nitrogen was applied at 35 DAS. The other agronomical cultural practices such as weeding and plant protection measures have been performed as per requisite. The growth attributes, viz. plant height (cm), functional leaves plant^{-1}, flag leaf area (cm^2 plant^{-1}), dry weight (g plant^{-1}) and yield contributing characters, viz. ear head length (cm), ear head weight (g), grain weight earhead^{-1} (g), 1000 grain weight (g) were measured from five randomly selected tagged plants in each plot. The net plot area was harvested manually at the maturity and the grain and straw yields were recorded.

RESULT AND DISCUSSION

Effect of plant density

From the Table 1 it is observed that the difference in plant height at 60 in treatments having plant density 60 cm x 15 cm and plant density 45cm x 15cm was found to be significant. The significantly taller plants (200.4 cm) were recorded under plant density 60cm x15cm as compared to plant density 45 cm x 15cm at harvest. Availability of sufficient space, nutrient, moisture and less competition resulted for their growth. Similar results were found by [1].Different plant densities failed to cause any significant difference in number of Numbers of Functional Leaves. Whereas, plant density 60cm x15cm gave significantly superior (37.63 cm^2) flag leaf area over the plant density 45cm x15cm (35.08 dm^2). Maximum dry matter accumulation was recorded under the plant density 60cm x15cm and it was significantly higher than plant density 45cm x15cm. This may be due to mutual competition between plant for light, moisture and space, higher density lowered dry matter accumulation. Plant density strongly affects leaf area index (LAI), and therefore light interception and canopy photosynthesis [3].

The yield attributes and yield differed significantly differed for different plant densities (Table-2). Significantly superior ear head length (24.58cm), ear head weight (51.49 g) and grain weight per ear head (48.50 g) and 1000 grain weight (21.93 g) were recorded under plant density 60cm x 15cm as compared to plant density 45cm x 15cm.

The plant density 45cm x15 cm gave significantly superior grain yield (2427 kg ha^{-1}), and juice yield (13596 lit ha^{-1}) as compared to plant density 60cm x 15cm. The cane yield was unaffected by plant density It may be due to decrease in inter-plant and intra-plant competition for various nutrients coupled with more area per plant and lesser competition the results are in close conformity with [9] and [6].

Effect of genotypes

Significant difference between the two genotypes was observed at all stages. Genotype NSSH 104 gave significantly higher plant height (216.96 cm) over genotype SSV 84. Higher number of leaves was recorded in case of NSSH 104 (8.27) than the genotype SSV 84 (7.79). The results under the genotype NSSH 104 were found to be significantly superior over the genotype SSV 84. The leaf area under genotype NSSH 104 (34.57 cm^2) was found to be higher than the genotype SSV-84 (38.14 cm^2). The genotype NSSH 104 was observed to be having the higher value of dry matter accumulation than genotype SSV-84. The results are similar to those observed by [8]. It was found that all the four factors viz: maximum ear head length (26.19cm), ear head weight (51.59g), grain weight (47.50g) and 1000-grain weight (22.38g) under the genotype NSSH 104 were significantly superior to genotype SSV 84. Genotype NSSH-104 gave significantly superior grain yield (3082 kg ha^{-1}), cane yield (26705 kg ha^{-1}) and juice yield (12994 lit ha^{-1}) as compared to genotype SSV-84. The genotype NSSH 104 showed significantly superiority in harvest index (9.62%) and fodder yield (39750 kg ha^{-1}) over SSV 84 but genotype SSV 84 gave higher juice extraction percentage (46.05%) as compared to NSSH 104(43.93%). The performance of genotype in respect to non-reducing sugar, reducing sugar, and total sugar were found non significant but in case of brix percent it was significant. The genotype SSV 84 gave significantly higher brix % (18.97) as compared to genotype NSSH 104.

Effect of nitrogen

All the growth parameters increased significantly with each successive increase in N application rate up to 120 kg N\ha at 60 DAS (Table 1). Maximum plant height (204.15 cm) was recorded under the application of 120 kg N\ha. Number of functional leaves increased with increasing levels of nitrogen up to 120 kg N ha^{-1}. Highest leaf area at flag leaf stage of 45.18 cm^2 was obtained under the 120 kg N ha^{-1} followed by 90 kg N ha $^{-1}$ (28.51 cm^2). Maximum dry matter accumulation of 59.99 (g $plant^{-1}$) was recorded under the 120 Kg N ha^{-1} while it was minimum (45.56 g $plant^{-1}$) in case of 30 Kg N ha^{-1}. Thus, there was increasing trend observed in all the four levels of nitrogen at every stage of growth of the sweet sorghum crop. The effect of four nitrogen levels on yield attributes were studied and it was found that it significantly increased the ear head length, ear head weight, and grain weight per ear head, and 1000 grain weight with increasing levels of Nitrogen from 30 Kg N ha^{-1} to 120 Kg N ha^{-1} .The grain yield, cane yield, and juice yield increased significantly with each increasing levels of nitrogen up to 120 kg ha $^{-1}$. The maximum grain yield (2626 kg ha^{-1}) cane yield (27255 kg ha^{-1}) and juice yield (15262 lit ha^{-1}) were obtained by 120 kg N kg ha $^{-1}$. When the four nitrogen levels applied are compared, it was found that it significantly increased the fodder yield and juice extraction percentage with increasing level of nitrogen up to 120 kg N ha^{-1}. Higher harvest index (8.33) was recorded in treatment N_4 (120 Kg ha^{-1}) followed by treatment N_2 for harvest index (7.33). Whereas, different nitrogen levels could not produce any significant effect on non-reducing sugar, reducing sugar, total sugar and brix (%).

Economics

The effect of plant density on gross returns was assessed and it was found that plant density 45cm x15cm proved significantly superior gross returns (Rs 37592 ha^{-1}) net returns (Rs 25871 ha^{-1}) and B:C ratio (3.20) as compared to plant density 60cm x15cm. Highest gross return (Rs 42926) net returns (Rs 31285) and B:C ratio (3.65) were obtained in genotype NSSH 104 as compared to genotype SSV 84, thus, the genotype NSSH 104 was significantly superior to genotype SSV 84. The gross returns, net returns and B:C ratio increased significantly with each increasing level of nitrogen. Application of 120 N Kg ha^{-1} gave significantly superior gross returns of Rs 40860.86 ha^{-1} net returns of Rs 28714 and B:C ratio of 3.35 followed by 90 kg N ha^{-1}.

Table 1: Effect of plant density, genotypes and nitrogen levels on growth parameters of sorghum

Treatment	Plant Height (cm)	Numbers of Functional Leaves	Flag Leaf Area (cm^2 $Plant^{-1}$)	Dry Weight (g $Plant^{-1}$)
Plant density				
45 cm x 15cm	195.2	8.03	35.08	50.41
60 cm x 15cm	200.4	8.03	37.63	54.2
SEm ±	1.32	0.03	0.53	0.77
CD (5%)	4.57	NS	1.88	2.66
Genotypes				
SSV-84	178.63	7.79	34.57	44.28
NSSH 104	216.96	8.27	38.14	60.33
SEm+/-	1.32	0.03	0.53	0.77
CD(5%)	4.57	0.1	1.83	2.66
Nitrogen levels				
30 kg ha^{-1}	190.68	7.86	28.51	45.56
60 kg ha^{-1}	197.6	8.03	32.76	49.7
90 kg ha^{-1}	199.86	7.94	38.97	53.96
120 kg ha^{-1}	204.15	8.29	45.18	59.99
SEm ±	1.95	0.05	0.93	0.83
CD (5%)	5.68	0.14	2.72	2.43

Table 2: Effect of plant density, genotypes and nitrogen levels on yield attributes of sorghum

Treatment	Ear head length (cm)	Ear head weight (g)	Grain weight earhead^{-1} (g)	1000 grain weight (g)
Plant density				
45 cm x 15cm	23.26	48.66	41.58	21.09
60 cm x 15cm	24.58	51.49	48.5	21.93
SEm ±	0.32	0.78	0.58	0.33
CD (5%)	1.1	2.7	2.02	1.13
Genotypes				
SSV-84	21.64	48.56	42.58	20.64
NSSH 104	26.19	51.59	47.5	22.38
SEm+/-	0.32	0.78	0.58	0.353
CD(5%)	1.1	2.7	2.02	1.13
Nitrogen levels				
30 kg ha^{-1}	21.56	40.15	38.42	11.41
60 kg ha^{-1}	23.01	45.38	42.33	17.52
90 kg ha^{-1}	24.99	52.45	47.58	26.49
120 kg ha^{-1}	26.19	62.32	51.83	30.61
SEm ±	0.39	0.98	1.37	0.71
CD (5%)	1.14	2.87	4.00	2.06

Table 3: Effect of plant density, genotypes and nitrogen levels on yield and economics of sorghum

Treatment	Grain yield (kg ha^{-1})	Cane yield (kg ha^{-1})	Fodder yield (kg ha^{-1})	Juice extraction (%)	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B: C ratio
Plant density							
45 cm x 15cm	2427	24637	36680	49.96	37592	25871	3.2
60 cm x 15cm	1967	23899	35860	40.03	34748	23158	2.99
SEm ±	33	243	410	0.62	436	397	0.04
CD (5%)	115	NS	NS	2.13	1509	1375	0.13
Genotypes							
SSV-84	1312	21830	32790	46.05	29414	17877	2.54
NSSH 104	3082	26705	39750	43.93	42926	31152	3.65
SEm+/-	33	243	410	0.62	436	397	0.04
CD(5%)	115	839	1400	2.13	1509	1375	0.13
Nitrogen levels							
30 kg ha^{-1}	1720	20861	31060	39.33	30257	18963	2.7
60 kg ha^{-1}	2077	23552	35930	42.4	35275	23711	3.06
90 kg ha^{-1}	2366	25403	38110	47.03	38462	26760	3.26
120 kg ha^{-1}	2626	27255	49970	51.21	40687	28625	3.35
SEm ±	31	374	670	1.29	618	626	0.06
CD (5%)	92	1091	1940	3.78	1804	1828	0.16

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