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Effect of Fertilizer Nitrogen & Potassium on Difference Cultivars of Sweet Sorghum (*Sorghum bicolor* L. Moench) in North-24-Parganas, West Bengal

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Abstract

Sustainable and promising bio energy cropping system demands strategic management and efficient application of inputs. Sweet sorghum (*Sorghum bicolor* L. Moench) is identified as an industrial crop by virtue of accumulation of fermentable sugars in stem and the stalk syrup is an enriched source of bio ethanol. To make an indifferent profit from cultivation of sweet sorghum in Gangetic plains of West Bengal, several agronomic practices would be developed in general and nutrient management. This plot experiment was carried out under open pollinated field condition to assess the response of different N:K doses on growth and ethanol production of sweet sorghum cultivars (V) in this agro climatic region. The experiment was conducted at Sub-Divisional Adaptive Farm, Bashirhat, North 24-Pgs, West Bengal in the year 2016-17. Randomized block design (RBD) was used for the experiment. The total number of treatment combinations was 18 (N3×V2×K3) replicated thrice and total number of plots become 54. Data was collected on every 30 days interval starting from 40 Days after Sowing to 130 DAS. The maximum plant height of 189.64 cm was observed in N3V1K3 treatment at 130 DAS. The maximum Green Biomass of 25.31 t/ha was observed with N3V1K3 treatment at 100 DAS. The maximum sugar concentration of 10.91% was observed with N3V1K3 treatment at 100 DAS and highest sugar yield of

1937.88 kg/ha was observed with N3V1K3 at 100 DAS. Harvesting at 100 to 130 days after sowing might be suitable for sweet sorghum for this agro climatic zone of West Bengal with N3V1K3.

Keywords: Sweet Sorghum, Variety, Bio ethanol, Stalk, Green Biomass, Sugar yield.

INTRODUCTION

One of the most important challenges for the present world is to find out the nonconventional resources of biofuel such as new generation bio energy agricultural crops. Sorghum [Sorghum bicolor (L.) Moench] is a cost effective, different agro-climatic conditions adaptable potential bio energy crop that aggregates sugar in its stem apart from producing grain. This grain crop builds an importance in the global agro market that it can be used as a source of food, fiber, fuel, feed, and chemical/biofuels. Sorghum is a leading tropical crop having larger genomes and more genes like sugarcane which is most promising crop of world's most efficient biomass-production and the leading biofuel source in the world (Paterson et al., 2009). High biomass production, high Brix (%), short growing period and low water requirement (4,000 cubic m ha-1) and greater adaptability like criteria of this bio energy crop draws an extra attention for scientific research (Reddy et al. 2005). The total sugar content increases according to the maturing stages in sweet sorghum and reach to its highest following stem growth stage (Parvatikar and Manjunath, 1991) which indicates a relationship between sugar content and stages of growth (Vietor et al., 1990). Zanini (1990) in sweet sorghum reported that at the plant maturity inversely proportional with the sugar quantity. For good yield of sorghum plant proper balancing of exogenous nutrient input is necessary. Sorghum is a crop with good nitrogen (N) use efficiency (Gardner et al., 1994) but inappropriate N fertilization limits yields. Depending on soil fertility, sorghum producers often apply 45 to 224 kg N ha-1 (Zhao et al., 2005). However, high N fertilization should be avoided since excessive N may reduce crop ethanol yield (Wiedenfeld, 1984) as well as considerably increase production costs and reduce energy efficiency, due to the fact that N fertilization accounts for up to 50% of the total energy input in arable crops (Kuesters and Lammel, 1999). Nevertheless, the appropriate timing of N application is reported to have a higher effect on plant growth rate (Tsialtas and Maslaris, 2005) and yield (Almodares and Darany, 2006) than the total amount of N applied. A significant response of Sorghum to potassium is also reported by Sharma and Ramna (1993). In water stess condition potassium has an effect on sorghum general parameters (Sharma and akumari 996). Different cultivar may show independent responses according to environment factors (Alhassan et al. 2008; Yeye and Alhassan 2008).) Genotypes have significant effect on plant height, stem girth, brix percentage

and ethanol yield (Sandeep et al. 2009). Almodares. et al. (2008) also emphasized on the variety of sorghum has an impact on its basic properties. In this study a fertilizer dosimetry with nitrogen and potassium is combined in a variable manner with two cultivar of sweet sorghum in open pollinated suitable climatic condition and the proper yield efficiency is standardized by collecting data in parameters such as plant hight, sugar content, sugar percentage and fresh green biomass, etc with a repeated method.

MATERIALS AND METHODS

The research experiment was conducted in 2016-2017 at Sub-Divisional Adaptive Farm, Bashirhat, North 24-Pgs and Soil texture of Bashirhat is mainly loam and organic carbon low to medium and phosphate & potash content is low type, and pH range between 6.0 to 7.8

The experiment was arranged as a randomized block design (3×2×3) where total treatment combinations are eighteen (18) with three (3) replications and each plot measuring (4m×3m). To study the influence of different levels of N and K on the growth and quality of two sorghum cultivars .The experiment was arranged as three levels of Nitrogen {0 (N1), 50 (N2) and 100 (N3) Kg/ha} were applied as urea (46% N). Two levels of Verity { MADHURA (V1), SSV-84 (V2) } Sweet sorghum varieties Madhura was supplied from Dry land cereals Research Programme, ICRISAT (International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh) & Sweet sorghum varieties SSV-84 was supplied from Indian Institute of Millets Research (IIMR) and three levels of potassium {0 (K1), 60 (K2), 80 (K3) Kg/ha} wear applied as Muriate of potash (60% K). Potassium applied as basal dose where as Half of the nitrogen was applied as basal and another half as top dressing at 30 days after Sowing. All the data was statistically analyzed using Analysis of Variance technique as described by Gomez and Gomez (1984).

Row to Row 45 cm and Plant to Plant 15 cm spacing were maintained. Plot Size 12 Sq. m (4m×3m), Plant Population 96 /Plot (12×8). Data was collected every 30 days interval starting from 40 DAS (Days After Sowing) up to 130 DAS so, the research experiment started from 04/06/2016 to 12/10/2016. Randomly ten selected plant were collected from each treatment for plant heights, green bio mass, sugar concentration, sugar yield from four different harvests. Plant height/stalk length (cm):Height of the primary shoot was measured from the ground level to the base of the youngest fully opened leaf until ear head emergence, after which plant height was measured from the base of the plant to the tip of the ear head and expressed in centimeters. Green Bio-mass:Total weight of ten randomly selected plants in each treatment and expressed as the average bio-mass yield (t/ha). Sugar concentration (%) Brix is the percentage of solids in the sample. Juice brix values were recorded by using hand refractometer (0-

300) and correction was made with room temperature and corrected values were expressed in percentage. Sugar Yield (Kg/ha):Sugar yield:Calculated sugar yield per hectare was worked out using the formula and expressed in terms of ton per hectare(Reddi 2006).

$$\text{Calculated sugar yield (t/ha)} := \{S-0.4\ (B-S)\} \times F \times Y/100$$

RESULTS AND DISCUSSION

Effect on plant height (cm):

The effect of plant height on individual doses of nitrogen, potassium, and cultivars were showed significantly different from each other (Table-1). In case of nitrogen N3 (100 kg/ha) gave highest data (186.04 cm) at 130 DAS this result indicate that increase of nitrogen application plant height will be increase similar results was found Salvatore et al. (2012) and they also proposed that yield was less sensitive to N level. In case of potassium K3 (80 kg/ha) height length (174.94 cm) at 130 DAS. On the other hand Madhura cultivars of sweet sorghum show height length (172.65). In case of Interaction effects between nitrogen, potassium and cultivars N3V1K3 gave highest length (187.98 cm).

Table 1: Plant Height (cm) At Various Growth Stages of Sweet Sorghum by Different Fertilizer Doses

TREATMENT	PLANT HIGHT			
	40 DAS	70 DAS	100 DAS	130DAS
NITROGEN				
N1	48.60	128.09	150.55	155.23
N2	60.60	141.58	170.90	175.74
N3	68.44	150.25	180.58	186.04
SE	0.49	0.42	0.31	0.36
LSD	1.00	0.86	0.63	0.73
POTASSIUM				
K1	56.08	137.35	164.78	169.52
K2	59.32	139.96	167.48	172.54
K3	62.25	142.60	169.77	174.94
SE	0.49	0.42	0.31	0.36
LSD	1.00	0.86	0.63	0.73

VERITY				
V1	60.45	142.67	168.00	172.65
V2	57.98	137.27	166.68	172.02
SE	0.40	0.35	0.25	0.29
LSD	0.82	0.70	0.52	0.60
INTERACTION				
N1V1K1	47.30	128.82	149.16	152.91
N1V1K2	50.27	129.42	151.03	155.16
N1V1K3	51.67	132.77	154.50	158.65
N2V1K1	58.86	141.80	167.76	172.22
N2V1K2	62.40	145.10	172.39	176.59
N2V1K3	64.70	146.87	174.11	178.34
N3V1K1	67.85	150.28	179.10	183.30
N3V1K2	68.21	154.33	180.88	187.08
N3V1K3	72.75	154.63	183.10	189.64
N1V2K1	44.23	122.76	146.61	152.04
N1V2K2	47.88	125.40	150.43	155.74
N1V2K3	50.26	129.36	151.55	156.85
N2V2K1	56.79	137.03	168.23	173.53
N2V2K2	58.98	138.44	170.32	175.55
N2V2K3	61.88	140.22	172.60	178.20
N3V2K1	61.44	143.41	177.81	183.11
N3V2K2	68.16	147.05	179.85	185.13
N3V2K3	72.22	151.78	182.75	187.98
SE	1.20	1.04	0.76	0.88
LSD	2.46	2.11	1.55	1.79

Effect on green biomass (ton/ha):

The results showed the effect of green biomass on individual doses of nitrogen, potassium, and cultivars were significantly different from each other (Table-2). In case of nitrogen N3 (100 kg/ha) gave highest data (25.00 t/ha) at 100 DAS. This result indicate that increasing nitrogen application helps to sweet sorghum yield production similar results was found Mengel and Kirkby (2001), they mentioned that corn and sorghum yield would have dropped by 41% and 19%, respectively, without nitrogen fertilizer application. In case of potassium K3 (80 kg/ha) gave highest data (24.71

t/ha) at 100 DAS, which is similarly observed by Sharma and Kumari (1996) that with increase in K fertilizer application. On the other hand Madhura cultivars of sweet sorghum show height green biomass (24.85t/ha).where the highest green biomass (t/ha) yield found of 100 DAS (25.25 t/ha) at N3V1K3 treatment combination.

Table 2: Green Biomass (t/ha) At Various Growth Stages Of Sweet Sorghum By Different Fertilizer Doses

TREATMENT	GREEN BIOMASS			
	40 DAS	70 DAS	100 DAS	130DAS
NITROGEN				
N1	13.75	18.20	24.22	23.37
N2	14.04	18.48	24.66	23.75
N3	14.43	18.84	25.00	24.14
SE	0.0081	0.0081	0.0089	0.0073
LSD	0.0164	0.0165	0.0181	0.0149
POTASSIUM				
K1	13.95	18.42	24.53	23.65
K2	14.09	18.51	24.64	23.76
K3	14.18	18.59	24.71	23.85
SE	0.0081	0.0081	0.0089	0.0073
LSD	0.0164	0.0165	0.0181	0.0149
VERITY				
V1	14.51	18.73	24.85	23.97
V2	13.63	18.29	24.40	23.54
SE	0.0066	0.0066	0.0073	0.0060
LSD	0.0134	0.0134	0.0148	0.0121
INTERACTION				
N1V1K1	14.10	18.40	24.38	23.47
N1V1K2	14.26	18.45	24.44	23.59
N1V1K3	14.32	18.52	24.52	23.65
N2V1K1	14.41	18.62	24.76	23.88
N2V1K2	14.48	18.71	24.89	23.96
N2V1K3	14.56	18.77	24.96	24.07
N3V1K1	14.73	18.92	25.11	24.24
N3V1K2	14.81	19.03	25.25	24.38
N3V1K3	14.95	19.11	25.31	24.47

N1V2K1	13.14	17.82	23.89	23.10
N1V2K2	13.32	17.93	24.00	23.15
N1V2K3	13.36	18.08	24.08	23.25
N2V2K1	13.47	18.18	24.31	23.47
N2V2K2	13.58	18.26	24.48	23.54
N2V2K3	13.70	18.34	24.55	23.59
N3V2K1	13.81	18.58	24.71	23.76
N3V2K2	14.08	18.68	24.77	23.96
N3V2K3	14.20	18.73	24.85	24.04
SE	0.0198	0.0198	0.0218	0.0179
LSD	0.0402	0.0402	0.0443	0.0364

Effect on sugar percentage (%):

The results showed the effect of sugar percentage (%) on individual doses of nitrogen, potassium, and cultivars were significantly different from each other (Table-3). In case of nitrogen N3 (100 kg/ha) gave sugar percentage (10.01 %) at 100 DAS. This result indicate that increasing nitrogen application helps to improved sweet sorghum sugar percentage but Ramadan (2003) found that increasing nitrogen rate up to 100 kg/fed markedly increased stalk diameter, stalk length, LA and reducing sugar as well as stalk yield and syrup yield, while increasing nitrogen rate upto 120 kg/fed decreased sucrose, Brix and purity percentages. In case of potassium K3 (80 kg/ha) gave highest sugar percentage (9.36 %) at 100 DAS but Barik and Roy (2015) was found that applying potassium 90 kg/ha gave highest data 8.99% in sugar percentage so we can indicate that increasing potassium application is not helpful to improved sweet sorghum sugar percentage. On the other hand Madhura cultivars of sweet sorghum show height sugar percentage (10.09%).In case of Interaction effects between nitrogen, potassium and cultivars N3V1K3 highest sugar percentage (%) was found in 100 DAS (10.91 %) treatment combination.

Table 3: Sugar percentage (%) At Various Growth Stages Of Sweet Sorghum By Different Fertilizer Doses

TREATMENT	SUGAR PERCENTAGE			
	40 DAS	70 DAS	100 DAS	130DAS
NITROGEN				
N1	3.92	7.03	8.56	8.31
N2	5.41	8.01	9.19	8.99
N3	6.20	8.44	10.01	9.75

SE	0.0085	0.0087	0.0070	0.0088
LSD	0.0172	0.0177	0.0143	0.0179
POTASSIUM				
K1	5.04	7.72	9.14	8.89
K2	5.20	7.85	9.26	9.01
K3	5.29	7.92	9.36	9.16
SE	0.0085	0.0087	0.0070	0.0088
LSD	0.0172	0.0177	0.0143	0.0179
VERITY				
V1	6.12	8.98	10.09	9.74
V2	4.23	6.67	8.41	8.29
SE	0.0069	0.0071	0.0057	0.0072
LSD	0.0140	0.0144	0.0117	0.0146
INTERACTION				
N1V1K1	4.70	8.08	9.28	8.98
N1V1K2	4.74	8.24	9.39	9.10
N1V1K3	4.76	8.32	9.49	9.20
N2V1K1	6.27	9.01	9.97	9.63
N2V1K2	6.43	9.18	10.09	9.78
N2V1K3	6.55	9.22	10.16	9.90
N3V1K1	6.97	9.46	10.73	10.21
N3V1K2	7.27	9.62	10.80	10.30
N3V1K3	7.40	9.73	10.91	10.60
N1V2K1	2.99	5.82	7.68	7.42
N1V2K2	3.12	5.84	7.73	7.52
N1V2K3	3.18	5.87	7.78	7.66
N2V2K1	4.27	6.77	8.08	8.05
N2V2K2	4.40	6.89	8.37	8.23
N2V2K3	4.56	6.99	8.49	8.36
N3V2K1	5.02	7.17	9.09	9.06
N3V2K2	5.23	7.29	9.20	9.12
N3V2K3	5.28	7.35	9.30	9.22
SE	0.0207	0.0213	0.0172	0.0216
LSD	0.0421	0.0433	0.0350	0.0438

Effect on sugar yield (kg/ha):

The results showed the effect of sugar yield (kg/ha) on individual doses of nitrogen, potassium, and phosphorous were significantly different from each other (Table-4). In case of nitrogen N3 (100 kg/ha) gave highest sugar yield (1624.84 kg/ha) at 100 DAS. In case of potassium K3 (80 kg/ha) gave highest sugar yield (1638.01 kg/ha) at 100 DAS and Madhura cultivars of sweet sorghum show height sugar yield (1760.60kg/ha). In case of Interaction effects between nitrogen, potassium and cultivars N3V1K3 highest sugar yield (kg/ha) was found in 100 DAS (1937.88kg/ha) treatment combination.

Table 4: Sugar Yield (kg/ha) At Various Growth Stages of Sweet Sorghum by Different Fertilizer Doses

TREATMENT	SUGAR YIELD			
	40 DAS	70 DAS	100 DAS	130DAS
NITROGEN				
N1	380.59	899.86	1455.73	1364.02
N2	536.34	1040.69	1591.75	1499.44
N3	630.74	1116.85	1756.46	1652.93
SE	0.57	0.85	0.91	1.07
LSD	1.17	1.73	1.85	2.18
POTASSIUM				
K1	498.00	1000.31	1575.42	1477.77
K2	518.62	1021.80	1603.68	1504.17
K3	531.04	1035.30	1624.84	1534.45
SE	0.57	0.85	0.91	1.07
LSD	1.17	1.73	1.85	2.18
VERITY				
V1	625.09	1181.47	1760.60	1639.87
V2	406.69	856.79	1442.03	1371.06
SE	0.47	0.70	0.74	0.87
LSD	0.95	1.41	1.51	1.78
INTERACTION				
N1V1K1	464.67	1042.76	1587.86	1479.06
N1V1K2	474.72	1066.93	1609.71	1505.73
N1V1K3	478.50	1081.62	1632.54	1526.92
N2V1K1	633.63	1177.38	1731.55	1613.38
N2V1K2	653.45	1205.62	1761.61	1643.66

N2V1K3	668.83	1214.97	1779.99	1671.81
N3V1K1	720.56	1255.21	1891.36	1736.25
N3V1K2	755.31	1284.76	1912.87	1762.57
N3V1K3	776.09	1304.02	1937.88	1819.44
N1V2K1	275.68	727.86	1287.40	1201.97
N1V2K2	291.84	734.72	1302.31	1221.16
N1V2K3	298.10	745.24	1314.54	1249.28
N2V2K1	403.99	863.45	1377.69	1325.15
N2V2K2	419.36	882.95	1436.95	1358.83
N2V2K3	438.77	899.79	1462.69	1383.79
N3V2K1	489.47	935.19	1576.64	1510.81
N3V2K2	517.03	955.78	1598.64	1533.05
N3V2K3	525.96	966.13	1621.39	1555.47
SE	1.41	2.08	2.23	2.63
LSD	2.86	4.23	4.53	5.35

CONCLUSION

The nutritive ratio of nitrogen and potassium has a significant effect on different cultivar of Sweet Sorghum when the other parameters remain constant. Height, biomass as well as sugar content; responded independently in different manner from the combined cases which indicates that this area demands for further study. Different variety may response spontaneously in different climatic condition. In Gangetic planes climatic condition of West Bengal Madhura variety of Sorghum showed an all over good yield in all aspects in both individual doses as well as combination doses of nitrogen and potassium.

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