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Effect of fertility levels, dates and methods of sowing on growth attributes, grain or stalk yield and net returns in sweet sorghum (*Sorghum bicolor* (L.)

Meena Rani and Ramesh Kumar Singh

Abstract
A field experiment was conducted during *kharif* season of 2016 and 2017 to study the effect of fertility levels, dates of sowing and methods of planting on growth and yield parameters of sweet sorghum. The experiment consisted of two sowing dates, two methods of sowing (Ridge and furrow and Flatbed methods) and four fertility levels viz. 120+60+60, 90+45+45, 60+30+30 and 0 (control) NPK Kg ha^{-1}. Early sowing in first week of July and crop planted on beds were superior in terms of growth, yield and yield attributes of sweet sorghum than sowing in second fortnight of July and flatbed planting. Fertility level of 120+60+60 Kg/ha N+P+K recorded tallest plant, maximum number of leaf/plant and dry biomass/plant. Sweet sorghum yields and yield attributes were linearly increased with increase in fertility levels and maximum yields were produced under highest level of fertility.

Keywords: Sweet sorghum, fertility levels, sowing dates, sowing methods, growth and yield

Introduction
Sorghum [*Sorghum bicolor* (L.) Moench], is one of the most important millet crop widely grown for food, feed, fodder, forage and fuel. It is an important *kharif* (monsoon) season crop and is a herbaceous annual grass which is widely cultivated in tropical and sub-tropical regions of world. It ranks 5th in acreage next only to wheat, rice, maize and barley in the world (Mutegi *et al*. 2010) [9]. Being drought tolerant, it has a wider adaptability to relatively medium to low soil fertility and moisture conditions. With the threat of climate change looming large on the crop productivity, sorghum being a drought hardy crop may play an important role in food, feed, and fodder security in dryland areas. In India, before green revolution, it was the second largest grain but pushed to 5th place in terms of acreage and production and during 2016-17, sorghum occupied an area of 5.10 million hectare and produced 4.80 million metric tons of grains with average productivity of 0.94 Mt ha^{-1} (USDA, 2017) [14].

Sweet sorghum is a new generation bio-energy crop that has a potential to accumulate large amounts of sugars (10-15%) in its stalks as similar to sugarcane. Sweet sorghum stalk juice can be used successfully for the production of syrup, fuel-grade ethanol, glycols, specialty and bulk organic chemicals, industrial alcohol etc. This is because of the crop's high sugar content and biomass production, wide geographic and climatic adaptation, and relatively low water and fertilizer requirements. Considering all these aspects it is clear that sweet sorghum possesses considerable potential as an alternative crop to sugarcane.

Furthermore, the bagasse after extraction of juice had higher calorific value than sugarcane bagasse and can be used to cogenerate power of about 2.5 MW/ha/crop. Besides, whole plant biomass can be used as a substrate for production of lingo-cellulosic ethanol. Sweet sorghum is not only a drought-resistant crop but also can be grown in two crop seasons unlike single season for sugarcane. Therefore sweet sorghum is considered as the best alternative feedstock for bio-ethanol production. The biofuel industry requires the constant availability of biomass during most of year, so a major constraint in that industry is lack of feed stock, especially from sweet sorghum during a time best suited for biofuel processing industry. Therefore it is important to develop crop production practices that extend feedstock availability as long as possible.

There are many factors that influence the crop growth production potential and productivity. Among them, nutrients has played a key role in the modernization of Indian agriculture and in making the country sufficient in production (Meena *et al*. 2012) [7]. Balanced nutrition plays an important role in crop production. There exists a greater response to combined application of nutrients than their individual application.

Increasing levels of nitrogen application increases crop yield only upto certain levels. Similarly, phosphorus and potassium have their own limitations when applied alone.

Thus it is believed that proper ratio of nutrients is required for maximizing the crop productivity.

Inadequate supply of nitrogen results in lower stalk yield and sugar per unit area, while excessive application results in poor juice quality. Similar to nitrogen, Phosphorus is the constituent of sugar phosphates, nucleotides, nucleic acid, coenzymes and phospholipids (Reddy and Reddy, 2001) [11]. Potassium status in our soils is medium and hence its application may be skipped sometimes. Regular and judicious use of fertilizers not only help in raising good crop yields on a sustainable basis but can helps farmers to gain consistently higher profits.

Besides fertility levels, management practices also influence the overall performance of the crop. There is urgent need to understand the crop response to management practices in relation to climatic factors. Optimum sowing time and methods are also the most important factors to augment higher crop yield per unit area. The proper sowing time and methods exerts a marked effect on the growth and eventually on the yield of a crop. Sowing of the crop at right time ensures better plant growth and also inhibits weed growth. There are evidences that optimum time of sowing is one of the several cultural manipulations and play vital role in boosting up the yield, particularly in Indian sub-continent where the optimum time of sowing varies to great extent due to varying agro-climatic conditions. The yield and quality of sweet sorghum has been reported to vary with different sowing dates and methods. Though, optimum time and methods of sowing is decided by several factors, environmental factors could be governed by sowing time which has great bearing on the realization of the yield potential of the crop. Therefore, adequate information on agronomic practices like sowing dates, sowing methods and optimum fertility levels for sweet sorghum is need to be investigated and refined to increase the growth, yield and bio-ethanol production from sweet sorghum. Considering the above facts, the present investigation was undertaken to study the "effect of fertility levels, dates and methods of sowing on growth attributes, grain or stalk yield and net returns in sweet sorghum (*Sorghum bicolor* (L.)".

Materials and Methods

A field experiment was carried during the Kharif season of 206-17 at Agricultural Research Farm, Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India situated at 25°18' N latitude, 83°03' longitude and an altitude of 128.93 m above the mean sea level. The site was well drained sandy clay loam soil, non-saline EC (0.30 and 0.31 ds/m) with pH 7.52 and 7.64 (1:2.5 soil: water) and contains 0.41 and 0.42 % organic carbon, 194.21 and 196.67 kg/ha N (Alkaline permanganate method, Subbiah and Assja, 1956), 22.12 and 22.85 Kg/ha available P (Olsen's methods 0.5 M $NaHCO_3$ extractable, Olsen *et al*., 1954) and 212.53 and 214.86 kg/ha available K (Flame photometer, Jackson, 1973) during 2016 and 2017 respectively. The weekly mean maximum temperature, during the period of crop growth of both year ranges from 25.4˚C to 41.0˚C (2016) and 24.7^{0}C to 32.9^{0}C (2017), respectively. The weekly mean minimum temperature varies from 29.9^{0}C to 11.7^{0}C (2016) and 26.0^{0}C to 8.5^{0}C (2017), during both the year respectively. Total rainfall received during both the year of experimentation, 2016 and 2017 was 1192.2 mm and 647.4 mm, respectively. The experiment was laid out in a split plot design consisting of 16 treatment combinations. Two different sowing dates (July 1 and 14 during, 2016 and July 2 and 15 during, 2017) and two different methods of sowing (flat bed and ridge and furrow) in the main plot and 4 fertility levels treatments (120+60+60, 90+45+45, 60+30+30 and 0 (control) NPK Kg ha^{-1}) taken in sub-plot.

Plant height of five randomly selected tagged plants of crop in net plot area was measured from ground level to base of fully opened leaf. After panicle emergence the height was measured from ground level to the top of panicles. The plant height was expressed as an average plant height in centimeter. For dry matter accumulation, destructive sampling was done leaving two rows from each side. Roots and shoots were separated manually. These samples were sun dried and later on transferred to hot air oven and dried at 70°C for 40 hours to get constant dry weight of plant and is expressed in g/plant row at 30, 60, 90 DAS and at harvest stages. Total number of leaves on five randomly selected plants in each treatment was counted and expressed as the average number of green leaves plant^{-1}. Number of nodes were recorded at 30, 60, 90 DAS and at harvest from five randomly selected plants from each net plot. The average values for each plot at each stage were counted and recorded. With the help of vernier calipers, diameter of the stem at middle place was measured for each tagged plant and averaged to express as cm stem^{-1}. Harvesting sweet sorghum plants from net plot area was done manually with the help of sickle at harvesting stage. After removal of leaves and leaf sheaths, the stalk was weighed. The stalk yield of the net plot was recorded for individual treatments and expressed in kg ha^{-1}. Crops from each net plot were threshed separately and grain yield recorded in kg/plot. This was finally converted in to grain yield kg/ha.

All observed data were subjected to statistical analysis as per standard procedure to draw a valid conclusion (Gomez and Gomez, 1984) [2].

Results and Discussion

Effect on crop growth

Among dates of sowing, early sowing of the crop in first week of July recorded significantly higher growth attributes viz. plant height, number of leaves and nodes plant^{-1}, stem diameter as well as dry matter production at 60 DAS over late sowing in second week of July. With higher photosynthetic activity under early sown crop, plant could exhibit more leaf number and area as well as chlorophyll content which ultimately leads to maximum dry matter production as well as stem diameter of crop. Similar findings were reported by (Almodares and Hoseini, 2016) [1].

Ridge method of sowing significantly recorded maximum growth attributes like plant height, number of nodes plant^{-1}, number of leaves plant^{-1}, stem diameter as well as dry matter production over flat sowing, during both the years of study. This might be due to fact that during rainy season water logging is often take place and crop on flat beds is adversely affected due to N leaching and poor root respiration under an aerobic conditions. These results are in conformity with (Kumar and Chawla, 2015) [6] who reported improved maize growth due to sowing on ridges than flat beds.

The application of 120 kg N + 60 kg P + 60 Kg K ha^{-1} recorded significantly maximum height during both the year of experimentation in comparison to other fertilizer treatments during first year and was found at par with 90kg N + 45 kg P + 45 Kg K ha^{-1} during the second year of experiment. The other growth parameters like number of nodes plant^{-1}, number of leaves plant^{-1}, stem diameter and dry matter production at 60DAS were recorded significantly higher with 120 kg N + 60 kg P + 60 Kg K ha^{-1} which was comparable with 90kg N + 45 kg P + 45 Kg K ha^{-1} during the both the years of study. The plant height is the varietal characteristics and may be influenced to some extent by environment and management practices. Also the increase in plant height might be due to readily availability of nutrients at early crop growth stage for good growth and increase in the number and elongation of internodes of sweet sorghum stem. The importance of nitrogen in stimulating and enhancing the photosynthetic and metabolic activities of the plant reflected on the increase in dry matter production as well as stem diameter of the crop. These results were in conformity with (Kagne *et al*. 2008) [4].

Effect on crop grain and stalk yield

Early sowing of sweet sorghum on first week of July increased grain and stalk yield of crop followed over crop sown in second week of July. (Houx and Fritschi, 2015) [3] also found the same results. It might be due to maximum temperature in first week of July results in higher photosynthetic activity which accumulates more photosynthates and their division to the economic parts of the plant and hence maximum yield is obtained in terms of yield and stalk.

Among different methods of sowing, ridge planting of crop significantly recorded maximum grain and stalk yield of sweet sorghum crop over flatbed sown crop during both the years of study. Similar results were found by (Singh and Vashist, 2015 and Singh, 2005) [12, 13]. The reason might be more proliferation of roots on ridges due to drainage of excess rainfall water results in increase in absorption capacity of roots for water and nutrients which ultimately increases the grain and stalk yield.

Significantly higher grain and stalk yield was obtained with the application of highest fertility level i.e. 120 kg N + 60 kg P + 60 Kg K ha^{-1} over other fertilizers levels. The increase in grain and stalk yield was perhaps as a result of better availability of nutrients which was proportional to high dry matter accumulation as well as diverting high proportion of assimilates to the economics part of the plants results in higher number of panicles m^{-2}, number of grains panicle^{-1}, length of panicle and 1000-grain weight. These results were in conformity with (Miri *et al*. 2012) [8]. The lowest yield of grain and stalk were recorded with control, where no fertilizer was applied.

Effect on net returns

The adoption of any technology in modern agriculture can only be feasible and acceptable to farmers if it is economically viable. Economic viability is a function of gain and loss. Among the two different sowing methods, crop sown with ridge method secured significantly higher net returns as compare to flatbed sown sweet sorghum crop. With increased absorption of nutrients and moisture on ridges due to drainage of excess water results in more yield and yield attributes and hence increases the net returns. Similar results were also showed by (Kaur, 2013) [5]. Sowing of sweet sorghum on first week of July significantly recorded maximum net returns over late sowing with second week of July. It might be due to high photosynthetic activity leads to higher grain and straw yield which lead to maximum net returns under this treatment.

Among various fertility level treatments, the application of 120 kg N + 60 kg P + 60 Kg K ha^{-1} recorded significantly higher net returns over rest of the lower levels of fertilizers. These results were in conformity with (Rakib *et al*. 2011) [10].

Table 1: Effect of fertility levels, dates and methods of sowing on growth parameters at 60 DAS in sweet sorghum

Treatments	Plant height (cm)		Number of nodes plant^{-1}		Number of leaves plant^{-1}	
	2016	2017	2016	2017	2016	2017
Sowing dates						
Meteorological week no. 27 (July 2-8)	204.91	219.73	6.38	6.99	7.40	7.89
Meteorological week no. 29 (July 16-22)	189.26	206.06	5.90	6.47	7.33	7.80
SEm±	4.05	3.87	0.14	0.14	0.18	0.16
CD (p=0.05)	14.02	13.40	0.47	0.48	NS	NS
Sowing methods						
Flatbed method	189.02	204.93	5.83	6.45	6.91	7.36
Ridge and furrow method	205.16	220.86	6.45	7.01	7.81	8.33
SEm±	4.05	3.87	0.14	0.14	0.18	0.16
CD (p=0.05)	14.02	13.40	0.47	0.48	0.61	0.57
Fertility levels						
Control	183.46	200.76	5.51	6.17	6.86	7.31
60kg N + 30 kg P + 30 Kg K	188.97	205.19	5.85	6.47	7.23	7.68
90kg N + 45 kg P + 45 Kg K	198.74	217.82	6.44	6.93	7.53	8.02
120kg N + 60 kg P + 60 Kg K	217.18	227.81	6.76	7.37	7.84	8.36
SEm±	4.74	4.41	0.14	0.15	0.17	0.15
CD (p=0.05)	13.84	12.87	0.41	0.45	0.50	0.45

Table 2: Effect of fertility levels, dates and methods of sowing on growth parameters i.e. stem diameter (cm) and dry matter production (g plant^{-1}) at 60 DAS in sweet sorghum

Treatments	Stem diameter (cm)		Dry matter production (g plant^{-1})	
	2016	2017	2016	2017
Sowing dates				
Meteorological week no. 27 (July 2-8)	1.22	1.39	57.93	58.56
Meteorological week no. 29 (July 16-22)	1.15	1.32	55.06	55.31
SEm±	0.02	0.02	0.81	0.90
CD (p=0.05)	0.07	0.07	2.81	3.11
Sowing methods				
Flatbed method	1.14	1.31	54.68	54.86

Ridge and furrow method	1.23	1.40	58.32	59.01
SEm±	0.02	0.02	0.81	0.90
CD (p=0.05)	0.07	0.07	2.81	3.11
Fertility levels				
Control	1.13	1.30	54.28	54.17
60kg N + 30 kg P + 30 Kg K	1.16	1.33	55.03	55.47
90kg N + 45 kg P + 45 Kg K	1.20	1.37	56.98	57.20
120kg N + 60 kg P + 60 Kg K	1.26	1.43	59.70	60.90
SEm±	0.02	0.02	0.92	1.03
CD (p=0.05)	0.06	0.06	2.67	3.00

Table 3: Effect of fertility levels, dates and methods of sowing on grain yield, stalk yield after maturity and net returns in sweet sorghum

Treatments	Grain yield (Kg ha^{-1})		Stalk yield after maturity (Kg ha^{-1})		Net returns (Rs ha^{-1})	
	2016	2017	2016	2017	2016	2017
Sowing dates						
Meteorological week no. 27 (July 2-8)	1931.86	2293.88	4120.71	4237.38	57453.62	70319.80
Meteorological week no. 29 (July 16-22)	1772.30	1884.36	4025.19	4118.11	51734.38	59711.46
SEm±	35.11	34.21	53.84	55.03	1457.75	1187.62
CD (p=0.05)	121.50	118.39	NS	NS	5044.44	4109.68
Sowing methods						
Flatbed method	1668.22	1975.68	3906.9	4073.5	49717.24	59139.29
Ridge and furrow method	2035.94	2202.55	4239.0	4281.9	59470.76	70891.97
SEm±	35.11	34.21	53.84	55.03	1457.75	1187.62
CD (p=0.05)	121.50	118.39	186.33	190.43	5044.44	4109.68
Fertility levels						
Control	1269.25	1560.27	3861.12	3927.79	41225.41	48872.81
60kg N + 30 kg P + 30 Kg K	1826.55	2055.24	4039.32	4122.65	49645.23	59943.18
90kg N + 45 kg P + 45 Kg K	1984.91	2281.14	4139.45	4281.11	58448.33	70888.24
120kg N + 60 kg P + 60 Kg K	2327.62	2459.81	4251.91	4379.41	69057.03	80358.29
SEm±	26.20	33.10	47.80	37.23	1300.90	1108.99
CD (p=0.05)	76.46	96.62	139.52	108.66	3797.02	3236.89

Conclusion

It was concluded that ridge sown crop under early sowing of crop with first week of July and be fertilized with 120 kg N + 60 kg P + 60 Kg K ha^{-1} may be recommended for higher yield and net returns in sweet sorghum crop for Varanasi region Uttar Pradesh.

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