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Effect of fertility level on growth and yield of sweet sorghum [*Sorghum bicolor* (L). Moench] genotypes

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Abstract
A field experiment was conducted on clayey loam soil at Udaipur (Rajasthan) during *kharif* season of 2019-20 to study the effect of fertility levels on growth and yield of Sweet Sorghum [*Sorghum bicolor* (L). Moench]. The experimental results revealed that significant variation was recorded in plant height, leaf area index and dry matter accumulation plant^{-1} at various growth stages of sorghum with different genotypes. With respect to plant height, SPV 2530 attained significantly higher plant height at 30, 60 DAS and harvest compare to the CSV 19SS and CSV 24SS genotypes. Further, SPV 2530 proved to be significantly superior in terms of leaf area index over rest of the both of the genotypes at 30 and 60 DAS. Therefore, dry matter accumulation plant^{-1} at 30, 60 DAS and at harvest observed significantly higher in CSV 19SS compare to the rest of the genotypes. In respect to the fertility levels, application of 125% RDF (80 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1}) recorded significant maximum plant height at 30 DAS, 60 DAS and at harvest (107.28 cm, 237.06 cm and 360.28 cm, respectively). Application of 125% RDF observed significantly higher leaf area index by 41.5 and 16.45 per cent over 75% and 100% RDF respectively. Dry matter accumulations highest observed with 125% RDF at 30 DAS, 60 DAS and at harvest (11.20, 96.58 and 158.11 g plant^{-1}) and data indicate that CSV 24SS observed significantly higher grain yield (4831 kg ha^{-1}) as compared to CSV 19SS (4374 kg ha^{-1}) and SPV 2530 (4482 kg ha^{-1}) and genotypes CSV 19SS observed the maximum stover yield (12721 kg ha^{-1}), which was significantly superior over rest of the genotypes except that of CSV 24SS (11054 kg ha^{-1}) and SPV 2530 (12471 kg ha^{-1}). Yield attributes in respect to the fertility levels application of 125% RDF significantly increase stover yield to the tune of 7.26 and 2.33% over 75% and 100% RDF respectively.

Keywords: Yield, plant height, leaf area index, genotypes and dry matter accumulation

Introduction

Sorghum (*Sorghum bicolor*) is a most growing crop in the world, it is traditionally grown for food (as grain and in sorghum syrup or "sorghum molasses"), animal fodder, the production of alcoholic beverages and biofuels. Most sorghum varieties are drought and heat-tolerant, and are especially important in arid regions, where the grain is one of the staples foods for poor and rural people. India is having ranks third in area after Nigeria and Sudan and fourth in production after USA. Nigeria and Mexico, USA being the largest producer which also tops in productivity (USDA, 2018) [15]. Sweet sorghum many varieties of the sorghum grass whose stalks have high sugar content. Sweet sorghum thrives better under drier and warmer conditions than many other crops and is grown primarily for silage, syrup and forage production. Sweet sorghum syrup is known as "sorghum molasses" and used on pancakes, cornmeal mush, grits and other hot cereals. In India sweet sorghum syrup is used being promoted as a health food. Sweet sorghum grains are rich in energy and non-energy nutrients.

Uses of sweet sorghum as a food, yielding in the form of grain, fuel in the form of ethanol from its stem juice, and fodder from its leaves, paper and grain. It is an important feed, food and fodder for animal, cattle and poultry. Sorghum is a widely adaptable species that is cultivated as an annual cereal and forage crop in tropical and subtropical regions of the world. Growing sweet sorghum instead of grain sorghum could increase farmer's income because it can provide food, feed, and fuel with grain sorghum currently grown on over 11 million ha in Asia and on 23.4 million ha in Africa, a switch to sweet sorghum could have a considerable economic impact (ICRISAT, 2007) [7]. Sorghum grains contain about 3.35% fat, 72.42% carbohydrate, 10.60% moisture and 9.35% protein (Adebiyi *et al*., 2005) [1].

Material and Methods

The present study was conducted throughout *kharif* season of 2019-20 at the College Farm, College of Agriculture, Udaipur (Rajasthan), to study Effect of fertility levels on growth and yield of Sweet Sorghum [*Sorghum bicolor* (L). Moench] genotypes. The soil of the experimental plot was clay Loam in texture and slightly alkaline in reaction with pH 8.0 and EC of 0.75 dSm^{-1}. The soil was low in available nitrogen (248 kg ha^{-1}), medium in available phosphorus (21 kg ha^{-1}) and high in available potash (357 kg ha^{-1}). The experiment was conducted in factorial randomized block design with total 9 treatment combination consisting of 3 fertility levels *i.e* 75% RDF, 100% RDF and 125% RDF (100% RDF = 80 kg N + 40kg P_2O_5 + 40 kg K_2O, respectively). These treatments were replicated three times. Recommended dose of nitrogen, phosphorus and potassium in the form of urea (46% N), di-ammonium phosphate (46% P_2O_5 and 18% N) and muriate of potash (60% K_2O), 40 kg ha^{-1} nitrogen and full dose of phosphorus (as per treatments) and potash were applied as basal application and rest 40 kg ha^{-1} nitrogen was applied at 30 days after sowing.

Results and Discussion

Effect of Genotype on Growth Attributes

Significant variation was recorded in plant height, leaf area index and dry matter accumulation $plant^{-1}$ at various growth stages of sorghum with different genotypes. With respect to plant height, SPV 2530 attained significantly higher plant height at 30, 60 DAS and harvest compare to the CSV 19SS and CSV 24SS genotypes (Table 1). Further, SPV 2530 proved to be significantly superior in terms of leaf area index over rest of the both of the genotypes at 30 and 60 DAS. This variation in growth parameters between varieties might be because of their difference in genetic makeup. Since all the genotypes were grown under identical agronomical and external environmental conditions, the considerable variations in growth parameters could be ascribed to their genetic capabilities to exploit available resources for their growth and development. The variation in plant height might be the resultant of inherent variations and vigour and the variation in leaf area index might be due to differential leaf production capacity as well as size of leaves of the genotypes. The behavioural variability of these genotypes could also be described exclusively by their genetic combination ((Trivedi, 2011, Dhaker *et al.*, 2014, Mishra *et al.*, 2015 and Kishor, 2017) [14, 6, 9, 10, 8].

Results showed in Table 2 revealed that CSV 24SS accumulated significantly higher dry matter $plant^{-1}$ at 60 DAS and harvesting stage performed better than CSV 19SS and SPV 2530. At harvest CSV 24SS produced significantly higher dry matter over rest of the genotypes. The dry matter accumulation $plant^{-1}$ in CSV 24SS at harvest was higher by CSV 19SS (5.68%) and SPV 2530(15.74%). Dry matter production efficiency of cultivar determines their potential to produce biological yield (Curtis *et al.*, 1969) [5]. The variation in dry matter accumulation $plant^{-1}$ might be attributed to the variation in genetic combination of the genotypes. Kishor *et al.* (2017) [8] also reported variation in dry matter accumulation $plant^{-1}$ at different growth stages in sorghum genotypes.

Effect on Yield

The higher grain yield is recorded in genotype CSV 24SS, stover yield and biological yield were maximum recorded in CSV 19SS (Table 2). Further, CSV 24SS recorded. These appeared to be the result of considerable increment in several yield components, which was brought about because of adoption of genotype.

Effect of Fertility Levels on Growth Attributes

The results revealed that different fertility levels show that significant influence on growth attributes *viz* plant height, dry matter accumulation and leaf area index. In Table 1, application of 125% RDF (80 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1}) recorded significant maximum plant height at 30 DAS, 60 DAS and at harvest (107.28 cm, 237.06 cm and 360.28 cm, respectively). Which was found superior from 75% RDF and 100% RDF. The absolute effect of increasing fertility levels on growth attributes of the crop analyzed in this investigation was mainly because of increasing of plant available nutrient status in rhizosphere of the plant. In general, over all increased development and growth of sorghum plants because of higher rate of fertility levels could be approved to the in here role of N, P and K containing fertilizers in bring about certain advantageous modifications in soil environment as well as in plant surroundings. In plant nitrogen plays a major role in synthesis of chlorophyll compound, proteins and other compounds of impressive physiological importance. Besides these, it has been extensively disclosed that identical nutrient application, environmental factors, especially N performs an important regulative functional role in plant metabolic activity through biosynthesis of phytohormones and their transport to sites of action, which generally act as stimulant for certain steps of growth and development (Beringer, 1980) [2]. The most essential function of P in plants is transfer of energy and energy storage. Phosphorus application increase different metabolic activity and physiological processes, thus known as "energy currency" which is subsequently used for reproductive and vegetative growth through phosphorylation (Brady, 1996 and Tisdale, 2002) [3, 13]. A part from this, P is an essential element in ribonucleic acid (RNA), deoxyribonucleic acid (DNA), phosphoproteins, phospholipids, phytin and coenzymes. Thus, it has more concern for vigorous growth and development of reproductive parts. Also, phosphorus is related with increasing root growth and fruit set and seed progress. The extensively root system facilitate in exploiting the higher nutrients and water from soils. K is required in charge balance, water relations and osmotic pressure in cells and across membranes. Improved physiological role of K^+ ion in the formation of carbohydrate in the plant is contributed to K fertilization. Although potassium is not directly concerned with CO_2, it is required for the photosynthetic transfer of radiant energy into chemical energy through production of ATP and translocation of photosynthates (carbohydrates) from leaves to storage organs. Increased supply with potassium helps in leaf area expansion in cereal crops. This increased leaf area in many cases may be the prime cause of increased photosynthetic activity of the plant finally increasing metabolic activity per unit area. Also, K is essential role in nitrogen metabolism. It acts as a bio catalytic plant element and regulates nitrogen uptake by plant system. K fertilizer increase vegetative vigour more than reproductive growth which is improved by phosphate application (Raheja, 1996 and Brady and Weil, 2002) [4].

Fertility levels with 125% RDF resulted maximum plant heights of sorghum than 100% RDF {(80 kg N + 40 kg P_2O_5 + 40 kg K_2O) ha^{-1}} and 75% RDF at various stages of growth (Table 1). This increase in height might be attributed to improved nutritional status of plant resulting in greater synthesis of amino acids and proteins and other growth promoting substances which in turn increase meristematic activity and increase cell division and their elongation. The findings of this investigation corroborate with those observed by, Mishra *et al*. (2015) [9, 10] and Patil *et al*. (2018) [11]

The leaf area index and leaf: stem ratio was also maximum with application of 125% RDF at different crop growth stages (Table 1). Increased K application increases the leaf surface area in cereals and also N enhances leaf number and leaf growth. These might be the reasons for higher leaf area index. Similar finding has also been reported by Kishor (2017) [8].

Fertility levels with 125% RDF accumulated the highest dry matter plant^{-1} at various growth stages. At harvesting dry matter accumulation plant^{-1} was higher with application of 125% RDF (158.11 g plant^{-1}) which was significantly higher over 100 and 75% RDF by 6.0 and 9.27%, respectively (Table 2). The improvement in morphological parameters of plant might have resulted in improved capture and usage of solar radiation providing desirable bases for enhanced photosynthesis and finally higher dry matter production of individual plants. The experimental evidence on higher biomass accumulation precisely explains the potential of fertilizer in exploitation of favorable environment towards formation of increased photosynthates by the virtue of modifying most important photosynthetic components. These results are in close conformity with the observations reported by Kishor *et al*. (2017) [8] and Patil *et al*. (2018) [11].

Effect on Yield

A perusal of data (Table 2) reveal that application of 100% and 125% RDF significantly increased grain yield over 75% RDF. However, highest grain yield was observed in 125% RDF (5263 kg ha^{-1}). Stover yield data indicate that application of 125% RDF significantly increase Stover yield to the tune of 7.26 and 2.33 per cent over 75% and 100% RDF respectively. Biological yield data reveal that application of 100% RDF and 125% RDF observed significantly higher biological yield by 15.31 and 5.20 per cent over 75% RDF respectively.

Table 1: Effect of sorghum genotypes and fertility levels on plant height and leaf area index

Treatments	Plant height (cm)			LAI	
	30 DAS	60 DAS	at Harvest	30 DAS	60 DAS
Genotypes					
SPV 2530	109.89	246.23	401.23	2.51	4.58
CSV 19SS	105.22	223.23	335.23	2.42	4.37
CSV 24SS	96.33	213.68	299.68	1.97	4.51
S. Em. ±	1.86	4.76	8.25	0.05	0.05
C. D. (P = 0.05)	5.58	14.29	24.76	0.15	0.16
Fertility Levels					
75% RDF	98.56	213.59	327.92	1.90	4.44
100% RDF	105.61	232.50	347.94	2.31	4.72
125% RDF	107.28	237.06	360.28	2.69	4.30
S. Em. ±	1.86	4.76	8.25	0.05	0.05
C. D. (P = 0.05)	5.58	14.29	24.76	0.15	0.16

Table 2: Effect of sorghum genotypes and fertility levels on plant dry matter accumulation and yield

Treatments	Dry matter accumulation (g plant^{-1})			Yield (kg ha^{-1})		
	30 DAS	60 DAS	at Harvest	Grain	Stover	Biological
Genotypes						
SPV 2530	9.71	84.88	138.95	4481.86	12471.48	16953.34
CSV 19SS	9.26	90.44	152.18	4373.68	12721.02	17094.70
CSV 24SS	10.76	96.77	160.83	4831.17	11054.02	15885.19
S. Em. ±	0.39	3.18	3.67	125.57	228.62	270.97
C. D. (P=0.05)	1.17	9.56	11.03	376.47	685.42	812.38
Fertility Levels						
75% RDF	8.59	83.76	144.69	3752.70	11614.61	15367.30
100% RDF	9.94	91.76	149.16	4670.84	12173.70	16844.54
125% RDF	11.20	96.58	158.11	5263.17	12458.21	17721.38
S. Em. ±	0.39	3.18	3.67	125.57	228.62	270.97
C. D. (P=0.05)	1.17	9.56	11.03	376.47	685.42	812.38

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