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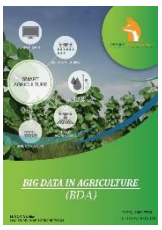

RESEARCH ARTICLE

COMPARATIVE STUDIES ON BIOMASS AND YIELD RESPONSE OF SORGHUM CULTIVARS UNDER VARIOUS POPULATION DENSITIES IN ANAMBRA STATE

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ABSTRACT

Field experiments were conducted at ChukwuemekaOdumegwuOjukwu University, Igbariam research field in 2019 and 2020 cropping seasons. The objectives were to evaluate the biomass and grain yield of six sorghum cultivars (CSR01, Samsorg11, Samsorg40, Samsorg44, Samsorg45 and Samsorg46) under four plant densities (941760, 1333000, 2182000 and 5714000 plants/ha) constituted the treatments which were laid out in a randomized complete block design (RCBD) with three replications. Data collected were subjected to analysis of variance (ANOVA) and significant mean were separated using Fisher's Least Significant Difference (LSD). The tested parameters were fresh, dry matter (biomass) and grain yield of all the investigated cultivars. Cultivars CSR01 and Samsorg11 (748.20 and 697.14 respectively) were the most productive in respect to biomass yield while cultivar Samsorg40 was least productive. For grain yield, cultivars samsorg11 and CSR01 were significantly the best. Biomass and grain yield increased with increase in Plant density. Plant density 1333000 plant/ha and 2182000 plant/ha were the best since they produced the largest biomass and grain yield. A sharp reduction was observed from the result as density increased to 5714000 plants/ha. Therefore, these integrated treatments were recommended for maximum biomass and yield. Extreme plant density reduced dry matter and grain yield due to plant competition for resources.

KEYWORDS

Population density, yield, sorghum, biomass, growth.

1. INTRODUCTION

Sorghum (*Sorghum bicolor*L.Moench) is one of the resilient crops which grow well under environmental stresses such as drought. It is well adapted to the tropics, having more water use efficiency compared to maize (Almodares, 2009). Sorghum provides substantial amount of fodder of outstanding quality for livestock. It produce a tonnage of dry matter having digestible nutrients carbohydrate (50 %), crude protein (8 %), fat (2.5 %) and nitrogen free extracts (45 %) (Azam et al., 2010). It can be used fresh as well as can be stored in form of silage and hay for future use. It is now one among the leading potential crops for bio-fuel production (Pulidindi et al., 2014). In Nigeria, sorghum is used for traditional and industrial purposes. The traditional uses include a variety of traditional foods, beverages and drinks while its non-food traditional uses include: thatching of roofs and fencing of compounds. Sorghum consumption for food is mainly in the form of flour or paste (Ayub et al., 2012). As a C4 plant, it shows an impressive absorption of CO_2 during its fast growth in 4–5 months (Yu et al., 2014).

Today, sorghum is extensively exploited because of its biomass which has proven to be a promising feedstock, for bio-fuel in three categories (starch-based, saccharide-based and cellulose-based). Lignocellulosic sorghum consists of cultivars developed specifically for second generation ethanol and for electricity cogeneration (Bekheet et al., 2017). In general, genetic improvement of crops is basically aimed to enable crop to survive in vagary of environmental conditions and induce significant changes in morphological and yield traits. For sorghum, interaction between genotype and environment has been reported as an important factor while selecting variety. Specifically, research are now related to crop production system aimed to establish the ideal plant population per hectare (Mohammed and Mohamed, 2009). Thus, it is necessary to define the spacing and seedling density for commercial cultivars. Plant population density is defined as the number of plant per unit area which can be measured in hectares, tons, or meters (Cox, 1996).

It is believed that increasing plant density may increase juice extraction percentage and biomass yield of sorghum (Bekheet et al., 2017). Plant density of about 166,000 plants ha^{-1} was initially reported to give the highest values of plant height and stalk yield, while later report showed that plant density of about 83,000 plants ha^{-1} gives highest stalk diameter, leaf area, total soluble solids percentage, sucrose percentage, purity percentage and sugar yield (Abo and Abo, 2001; Bekheet et al., 2017). Hamid and Nasab showed that various cultivars of sorghum vary also in stalk height, diameter and syrup production and yield quality (Hamid and Nasab, 2001). In Nigeria, information concerning the relationship between sorghum biomass yield and population density is scanty. There is strong need for research on the yield-density relationship of sorghum cultivars for which this study attempted to explore by comparing the biomass and yield of selected cultivars of sorghum under four plant population densities.

2. MATERIALS AND METHODS

The experiment was carried out at the Teaching and Research Farm of the Department of Crop Science and Horticulture, Chukwuemeka Odumegwu Ojukwu University, Igbariam, Anambra State which lies between latitude

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16° 75'N and longitude 13° 35'E and altitude 169 m above sea level. The area experienced bimodal rainfall pattern that peaked in June and subsequently decreased with a daily temperature range of 20°C – 30°C. The study was laid out in a 6 x 4 factorial experiment in a Randomized Complete Block Design (RCBD) replicated three times. The Sorghum seeds were obtained from the Seed Production Unit of Institute for Agricultural Research, Ibadan.

The land used for this experiment was cleared manually and tilled very well into fine tilt. Planting was done on ridges, two seeds per hole with planting depth of 2cm. Four plants were randomly selected, marked and used for collection of data in each plot. Hoe weeding was done twice during the growing period of the sorghum cultivars at four and seven weeks after plant (4 & 7 WAP). Fertilizer used was NPK 20.10.10 was applied in one dose at recommended rate of 60kg N, 30kg P_2O_5, and 30kg K_2O per hectare at three WAP.

2.1 Data Collection

- Above Ground biomass Fresh Weight: For each treatment combination, unmarked plant was uprooted and their vegetative parts weighed using an electronic weighing balance. This reading was taken at an interval of two weeks from fourth week after planting until maturity.
- Grain yield/plant, grain yield/hectare and number of Cobs/plants were also collected and recorded accordingly.

2.2 Data Analysis

Data collected was subjected to analysis of variance (ANOVA) using Genstat Release 10.3 statistical. While the means were separated using the Fisher's Least Significant Difference (LSD) at 5% probability level.

Table 1: Physical and Chemical Properties of Soil of the Experimental Site

Parameters	Value
Clay	230 (g/kg)
Silt	210g (g/kg)
Fine sand	420 (g/kg)
Coarse sand	160 (g/kg)
Textural class	Sandy clay loam
Bulk Density	1.39gm-3
Total porosity	48.92 (%)
Moisture Content	20.52 (%)
Dispersion Ratio	0.87 (%)
Aggregate Stability	17.02 (%)
Hydraulic conductivity	4.59 (cmhr-1)
pH (H_2O 1:1)	5.98
Oxygen Content	0.76 (%)
Nitrogen	0.055 (%)
Available Phosphorus	3.89mgkg-1
Ca^{2+}	1.5(cmolkg-1)
Mg^{2+}	1.3 (cmolkg-1)
Na^{+}	0.24 (cmolkg-1)
K^{+}	0.26 (cmolkg-1)
EC	4.99 (cmolkg-1)
B S	87 (%)

Source: Agricultural Development Programme (ADP) Soil Laboratory Unit.

Table 2: Effect of Cultivars and Plant Densities on Whole Fresh Weight of Sorghum for Two Cropping Years at 6, 8 and 10 Weeks after Planting (WAP)

Year 1

Plant densities/ha	Sorghum cultivars						
	CSR01	Samsorg11	Samsorg40	Samsorg44	Samsorg45	Samsorg46	Mean
At 6WAP							
941760	83.12	84.78	59.39	67.19	58.76	75.55	72.46
1333000	81.96	81.49	82.46	59.80	73.96	89.50	77.39
2182000	81.39	79.18	86.21	81.18	77.21	89.30	80.81
5714000	69.15	81.71	81.51	78.13	65.92	73.67	73.67
Mean	**78.90**	**81.79**	**77.40**	**71.58**	**68.96**	**82.00**	**82.00**
At 8WAP							
941760	220.33	357.23	349.73	203.67	285.48	299.98	272.24
1333000	347.73	223.67	340.00	335.67	372.33	265.33	292.05
2182000	303.79	260.33	267.79	213.48	282.79	314.33	273.80
5714000	304.29	254.23	249.48	293.29	277.73	253.29	269.41
Mean	**294.04**	**273.86**	**301.75**	**261.53**	**304.58**	**283.23**	**276.88**
At 10WAP							
941760	713.00	746.70	550.70	282.33	721.24	374.74	516.66
1333000	660.20	788.00	867.00	843.67	365.00	819.33	678.90
2182000	803.56	778.67	856.56	587.74	818.06	892.67	711.51
5714000	816.06	403.20	313.24	462.06	736.20	683.56	571.03
Mean	**748.20**	**697.14**	**646.88**	**543.95**	**660.12**	**692.58**	**619.53**
Whole Fresh Weight At							
	6WAP			**8WAP**		**10WAP**	
LSD 0.05 for 2 Sorghum cultivars	0.729			1.678		1.424	
LSD 0.05 for 2 Plant densities	0.516			1.186		1.007	
LSD 0.05 for 2 Cultivars x Densities	1.459			3.355		2.8482.852	

Note: WAP= weeks after planting, NS= not significant, *= significantly different

Year 2							
Plant densities/ha	**Sorghum cultivars**						
	CSR01,	**Samsorg11,**	**Samsorg40,**	**Samsorg44,**	**Samsorg45**	**Samsorg46**	**Mean**
At 6WAP							
941760	82.99	84.94	59.27	67.19	58.81	75.39	72.44
1333000	81.91	81.49	82.46	59.80	73.96	89.50	77.39
2182000	81.06	79.18	85.35	81.50	76.68	89.30	80.73
5714000	69.90	81.79	81.68	77.85	66.24	72.76	73.58
Mean	**78.71**	**81.82**	**77.19**	**71.59**	**68.92**	**81.74**	**76.03**
At 8WAP							
941760	220.33	355.67	349.33	203.67	283.67	300.33	271.71
1333000	345.67	223.67	340.00	335.67	371.67	264.67	291.62
2182000	303.33	261.33	269.00	212.33	282.67	314.33	273.92
5714000	303.67	254.00	248.33	292.67	277.67	253.00	269.17
Mean	**293.25**	**273.67**	**301.67**	**261.08**	**303.92**	**283.08**	**276.60**
At 10WAP							
941760	713.00	747.00	550.30	282.33	721.00	375.00	516.60
1333000	660.30	788.00	867.00	843.70	365.00	819.33	678.90
2182000	804.00	778.70	856.30	588.00	817.70	892.70	711.50
5714000	815.30	403.30	313.30	521.70	736.00	683.30	578.50
Mean	**748.20**	**697.20**	**646.80**	**558.90**	**659.90**	**692.60**	**621.40**
Whole Fresh Weight At							
	6WAP			**8WAP**		**10WAP**	
LSD 0.05 for 2 Sorghum cultivars	0.579			1.014		14.960	
LSD 0.05 for 2 Plant densities	0.410			1.717		10.580	
LSD 0.05 for 2 Cultivars x Densities	1.159			2.028		29.920	

Note: WAP= weeks after planting, NS= not significant, *= significantly different

Table 3: Effect of Cultivars and Plant Densities on Leaf Fresh Weight of Sorghum for Two Cropping Years at 6, 8 and 10 Weeks After Planting (WAP).

Year 1							
Plant densities/ha	**Sorghum cultivars**						
	CSR01,	**Samsorg11,**	**Samsorg40,**	**Samsorg44,**	**Samsorg45,**	**Samsorg46,**	**Mean**
At 6WAP							
941760	49.82	55.13	30.78	33.87	38.79	38.84	41.32
1333000	51.47	43.03	44.60	30.14	35.10	43.24	40.96
2182000	50.09	32.45	39.34	52.68	29.98	49.21	42.45
5714000	42.17	50.04	40.49	41.20	40.13	40.89	43.05
Mean	**48.39**	**45.16**	**38.80**	**39.47**	**36.00**	**43.04**	**41.95**
At 8WAP							
941760	98.67	151.95	144.45	101.00	149.95	119.95	121.55
1333000	147.95	109.33	160.33	150.67	222.00	101.00	134.99
2182000	140.10	99.00	120.10	97.95	110.10	141.00	117.57
5714000	140.10	117.95	100.95	115.10	135.45	110.10	119.93
Mean	**131.71**	**119.56**	**131.46**	**116.18**	**154.38**	**118.01**	**123.51**
At 10WAP							
941760	95.67	147.03	141.03	97.00	146.38	116.38	118.03
1333000	144.53	105.33	157.00	147.67	119.67	97.67	119.48
2182000	137.59	94.67	118.59	94.38	106.59	137.67	114.17
5714000	136.59	116.53	98.38	113.09	133.53	106.59	117.64
Mean	**128.59**	**115.89**	**128.75**	**113.03**	**126.54**	**114.58**	**117.33**
Leaf Fresh Weight At							
	6WAP			**8WAP**		**10WAP**	
LSD 0.05 for 2 Sorghum cultivars	0.512			0.598		0.328	
LSD 0.05 for 2 Plant densities	0.362			0.423		0.476	
LSD 0.05 for 2 Cultivars x Densities	1.025			1.196		1.345	

Note: WAP= weeks after planting, NS= not significant, *= significantly different

Year 2							
Plant densities/ha	**Sorghum cultivars**						
	CSR01,	**Samsorg11,**	**Samsorg40,**	**Samsorg44,**	**Samsorg45,**	**Samsorg46,**	**Mean**
At 6WAP							
941760	49.82	55.23	30.87	33.78	38.97	39.07	41.39
1333000	51.49	43.03	44.20	30.14	35.10	43.24	40.92
2182000	50.00	32.34	38.44	52.83	29.86	49.21	42.42
5714000	42.06	50.07	40.57	41.08	40.23	41.04	43.04
Mean	**48.34**	**45.17**	**38.52**	**39.45**	**36.04**	**43.14**	**41.94**
At 8WAP							
941760	49.82	55.23	30.87	33.78	38.97	39.07	41.39
1333000	51.49	43.03	44.20	30.14	35.10	43.24	40.92
2182000	50.00	32.34	38.44	52.83	29.86	49.21	42.42
5714000	42.06	50.07	40.57	41.08	40.23	41.04	43.04
Mean	**48.34**	**45.17**	**38.52**	**39.45**	**36.04**	**43.14**	**41.94**
At 10WAP							
941760	95.67	147.33	141.00	97.00	146.33	116.33	118.04
1333000	144.67	105.33	157.00	147.67	119.67	97.33	119.42
2182000	137.00	94.67	118.33	94.00	106.33	137.00	113.88
5714000	136.33	116.67	98.00	113.00	133.33	106.67	117.58
Mean	**128.42**	**116.00**	**128.58**	**112.92**	**126.42**	**114.33**	**117.23**
Leave Fresh weight at							
	6WAP			**8WAP**		**10WAP**	
LSD 0.05 for 2 Sorghum cultivars	0.345			0.534		0.543	
LSD 0.05 for 2 Plant densities	0.244			0.377		0.384	
LSD 0.05 for 2 Cultivars x Densities	1.689			1.068		1.085	

Note: WAP= weeks after planting, NS= not significant, *= significantly different

Table 4: Effect of Cultivars and Plant Densities on Number of Seeds / Plant of Sorghum for Two Cropping Years.

Year 1							
Plant densities/ha	**Sorghum cultivars**						
	CSR01,	**Samsorg11,**	**Samsorg40,**	**Samsorg44,**	**Samsorg45**	**Samsorg46**	**Mean**
941760	2001	2029	1988	3000	1401	2022	2060
1333000	3000	3000	3001	2999	2983	2000	2873
2182000	2050	2038	2051	2042	2051	2042	2047
5714000	2001	3000	2000	2019	2032	1999	2131
Mean	**2263**	**2517**	**2260**	**2515**	**2117**	**2016**	**2278**
LSD 0.05 for 2 Sorghum cultivars	150.100						
LSD 0.05 for 2 Plant densities	106.200						
LSD 0.05 for 2 Cultivars x Densities	300.300						

Note: WAP= weeks after planting, NS= not significant, *= significantly different

Year 2							
Plant densities/ha	**Sorghum cultivars**						
	CSR01,	**Samsorg11,**	**Samsorg40,**	**Samsorg44,**	**Samsorg45,**	**Samsorg46,**	**Mean**
941760	2001	2029	1988	3000	1401	2022	2060
1333000	3000	3000	3001	2999	2983	2000	2873
2182000	2050	2038	2051	2042	2051	2042	2047
5714000	2001	3000	2000	2019	2032	1999	2131
Mean	**2263**	**2517**	**2260**	**2515**	**2117**	**2016**	**2278**
LSD 0.05 for 2 Sorghum cultivars	2.582						
LSD 0.05 for 2 Plant densities	1.826						
LSD 0.05 for 2 Cultivars x Densities	5.165						

Note: WAP= weeks after planting, NS= not significant, *= significantly different

Table 5: Effect of Cultivars and Plant Densities on Cob Yield (g) of Sorghum for Two Cropping Years.

Year 1							
Plant densities/ha	**Sorghum cultivars**						
	CSR01,	**Samsorg11,**	**Samsorg40,**	**Samsorg44,**	**Samsorg45**	**Samsorg46**	**Mean**
941760	80.40	84.40	34.00	51.20	51.60	80.40	67.90
1333000	86.30	88.00	47.90	62.90	62.90	82.60	74.70
2182000	81.90	86.70	54.20	61.40	61.70	81.70	73.80
5714000	68.20	72.80	33.90	31.80	60.20	68.20	57.40
Mean	**79.20**	**83.00**	**42.50**	**51.80**	**59.10**	**78.20**	**68.50**
LDS 0.05 for 2 Sorghum cultivars				8.430			
LSD 0.05 for 2 Plant densities				5.960			
LSD 0.05 for 2 Cultivars x Densities				16.850			

Note: WAP= weeks after planting, NS= not significant, *= significantly different

Year 2							
Plant densities/ha	**Sorghum cultivars**						
	CSR01,	**Samsorg11,**	**Samsorg40,**	**Samsorg44,**	**Samsorg45,**	**Samsorg46,**	**Mean**
941760	80.40	84.40	34.00	51.20	51.60	80.40	67.90
1333000	86.30	88.00	47.90	62.90	62.90	82.60	74.70
2182000	81.90	86.70	54.20	61.40	61.70	81.70	73.80
5714000	68.20	72.80	33.90	31.80	60.20	68.20	57.40
Mean	**79.20**	**83.00**	**42.50**	**51.80**	**59.10**	**78.20**	**68.50**
LSD 0.05 for 2 Sorghum cultivars				0.091			
LSD 0.05 for 2 Plant densities				0.064			
LSD 0.05 for 2 Cultivars x Densities				0.181			

Note: WAP= weeks after planting, NS= not significant, *= significantly different

4. Discussion

Table 2 shows that the whole fresh weight of sorghum was affected by cultivars, plant densities and the interaction at 6, 8 and 10 WAP in the two cropping years. At 6WAP, cultivar Samsorg46 produced the highest whole fresh weight at plant density 1333000 plants/ ha which was significantly different (P>0.05) from other cultivars and plant densities except at plant density 2182000 plants/ha. At 8WAP, whole fresh weight was heaviest at plant density 1333000 plants/ha with cultivar Samsorg45 which was significantly heavier than fresh weight produced by other cultivars and plant densities. Cultivar Samsorg46 produced the heaviest whole fresh weight at plant density 218200 plants/ha which differed significantly (P>0.05) from other cultivars and plant densities at 10 WAP. However, on average cultivar CSR01 produced the highest whole fresh weight at 10 WAP.

Table 3 showed that sorghum cultivars, plant densities and interaction significantly affected leaf fresh weight (P>0.05) at 6, 8 and 10 WAP in the two cropping years. At 6WAP, cultivar Samsorg11 produced the highest leaf fresh weight at plant density 941760 plants/ha. Though on the average, cultivar CSR01 and plant density 5714000 plants/ha recorded the highest leaf fresh weight of 48.39g and 43.05g in the first year, then 48.34 and 43.04 in the second year of planting. Cultivar Samsorg45 recorded the highest leaf fresh weight at plant density 1333000 plants/ha which was significantly heavier than that produced by other cultivars and plant densities at 8WAP. Similarly, at 10WAP cultivar Samsorg40 produced the highest leaf fresh weight at plant density 1333000 plants/ha.

Table 4 shows the number of sorghum seeds per plant and grain yield which was significantly affected by cultivars, plant densities and interaction at LSD (P>0.05) in the two cropping years (Tang et al., 2017). Cultivar Samsorg40 produced the highest number of seeds/plant at plant density 1333000 plants/ha which was statistically significant from the number of seeds/plant produced by other cultivars and plant densities. Although, on the average, cultivar Samsorg11 produced the highest number of seeds/plant. However, the highest and lowest grain yield (g) were as well produced by Samsorg11 and Samsorg44 at plant density 1333000 plants/ha and 5714000 plants/ha respectively (Wondimu et al., 2004).

Tables 5 showed that the cob yield/ha of sorghum were significantly affected by cultivars and plant densities in the first year. However, plant densities and interaction of densities and cultivars had no effect on grain yield per hectare in the second year of cropping. Cultivar Samsorg45 produced the highest grain yield/ha while cultivars SamsorgCSR01, Samsorg11 and Samsorg17 produced the lowest yield/ha at plant density 5714000 plants /ha.

5. Conclusion

Sorghum crop is currently viewed as an ideal feedstock crop for non food (bio-fuel) generation due to its high biomass yield. In Nigeria, sorghum crop is also one of the most important cereals that serve as food in a country that grows at an alarming rate. Results of the two years experiment were very similar. The little differences seen could be as result of little variation in the environmental factors between the two years. The interaction of cultivars and plant densities in both years had a significant influence on the biomass and grain yield. Cultivar CSR01 and Samsorg40 had the broadest leaf area at plant density 2182000 plants/ha in the years of study. On yield, cultivar Samsorg11 produced the highest number of seeds and grain yield at plant density 1333000 plants/ha. This could be as a result of increase in plant density from 941760 plants/ha to 1333000 plants/ha. This agrees with the study report of that grain and Stover yields at harvest increased in linear responses to increase in plant population density of sorghum.

Two years cropping season 2017 and 2018 studies were used to evaluate eight cultivars of sorghum for biomass and grain yield under four plant population densities at the tropical rainforest zone of Igbariam. Out of the six cultivars namely local cultivar, cultivars Samsorg11, Samsorg17, Samsorg40, Samsorg44, Samsorg45, and Samsorg46 verify the six already mentioned which were used in the two years, cultivars CSR01 and Samsorg11 (748.20 and 697.14 respectively) performed best in growth parameters and in dry matter accumulation while cultivar Samsorg11 had the highest yield determined with the high number of seeds per plant. On the other hand, high yield both biomass and grain yield showed sere seen at plant densities 1333000 plants/ha and 2182000 plants/ha. At the interaction, plant dry matter and grain yield increased with increase in plant population density. All the cultivars especially CSR01, Samsorg40, Samsorg11 for dry matter and Samsorg11 (83.00g) for gain yield showed an increase as the plant density from 941760 plants/ha to 2182000 plants/ha. However, a reduction in dry matter and grain yield were observed with further increase in plant density from 2182000 plans/ha to 5714000 plants/ha.

Recommendations

Result of the two years studies showed that the plant density of 2182000

plants/ha and 1333000plants/ha would be recommended to obtain high biomass and grain yield in sorghum.

REFERENCES

Abo El-Wafa, A.M., and Abo El-Hamd, A.S., 2001. Evaluation of some sweet sorghum varieties under different plant populations in Upper Egypt. Minia Journal ofAgricultural ResearchDevelopment, 21, Pp. 475-492.

Almodares, A., 2009. Production of bioethanol from sweet sorghum: A review: African Journal ofAgriculturalResearch, 4, Pp. 772–780.

Ayuba, M., Khalid, M., Tariq, M., Elahi, M., and Nadeem, M.A., 2012. Comparisonof sorghum genotypes for forage production and quality. The Journal of Animal and Plant Sciences, 22 (3), Pp. 733-737.

Azam, A., Khan, A.G., Nadeem, M.A., and Muhammad, D., 2010. Influence of maize and cowpea intercropping on fodder production characteristics of silage. Asian-Australian Journal of Animal Science, 13 (6), Pp. 781-784.

Bekheet, M.A., Abdullah, S.S., Ismail, A.E., 2017. Effects of plant density and weed control on sweet sorghum sugar, forage yields and associated weeds. Assiut JournalofAgriculturalScience, 37, Pp. 21-40.

Bongiorno, V.A., Rhoden, S.A., Garcia, A., Polonio, J.C., Azevedo, J.L., Pereira, J.O., Pamphile, J.A., 2016. Genetic diversity of endophytic fungi from Coffea arabica cv. IAPAR-59 in organic crops. Annals of Microbiology, 66 (2), Pp. 855-865.

Cox, W.J., 1996. Whole-plant physiological and yield responses of maize to plant density. Agronomy Journal, 88, Pp. 489-496.

Hamid, A., and Nasab, A.D.M., 2001. The effect of various plant densities and N levels on phenology of two medium maturity corn hybrids. Iran Journal of Agricultural Science, 32, Pp. 857-874.

Mensah, K.B., Oosthuizen, F., Bonsu, A.B., 2018. Cancer awareness among community pharmacists: a systematic review. BMC Cancer, 18 (1), Pp. 299.

Mohammed, I.M., and Mohamed, M.A., 2009. Evaluation of newly developed sweet sorghum (Sorghum bicolorL.) genotypes for some forage attributes. American-Eurasian Journal Agricultural Environmental Science, 6 (4), Pp. 434-440.

Mori, E., Iwata, H., Maehara, K., Sakajo, A., Tamakoshi, K., 2018. Relationship between the mode of conception and depressive symptoms during the first 6 months post-partum in Japan. Reproductive Medicine and Biology. Available at: https://onlinelibrary.wiley.com/doi/abs/10.1002/rmb2.12101

Pulidindi, I.N., Kimchi, B.B., Gedanken, A., 2014. Can cellulose be a sustainable feedstock for bioethanol production? Renewable. Energy, 71, Pp. 77–80.

Shuhua, L., 2007. The night of MidAutumn Festival. In. Lau JSM, Goldblatt H (Eds.), The Columbia Anthology of Modern Chinese Literature. New York, NY: Columbia University Press. Pp. 95-102.

Tang, C., Sun, C., Fengchen, F.D., Ameen, A., Fu, T., Xie, G.H., 2017. Effect of plant density on sweet sorghum and biomass on semi arid marginal land. Sugar Technology Research, 10, Pp. 364 - 376.

Yu, M., Li, J., Chang, S., Du, R., Li, S., Zhang, L., Fan, G., Yan, Z., Cui, T., Cong, G., 2014. Optimization of ethanol production from NaOH-pretreated solid state fermented sweet sorghum. bagasse Energy, 7, Pp. 4054-4067.