

Adaptation Strategy to Climate Change and Variability for Sorghum (*Sorghum bicolor* L. Moench) Production in Forest-Savannah Agro-Ecological Zone of Nigeria

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Abstract

Climate change and variability have far reaching consequences on smallholder farmers in developing countries. Timely planting is critical for maximizing yield of sorghum (*Sorghum bicolor* L. Moench). In order to determine the optimum planting date for good growth and yield of sorghum, three planting dates were selected at two weeks interval. This research was conducted during the growing season of 2021 at the Laboratory for Genecology and sustainable food systems (GeoLab), Federal University of Technology Akure (7°15'N, 5°15'E) and Institute of Agricultural Research and Training (I.A.R&T.) Ibadan (7°22'N; 3°30'E), both within the forest-Savannah eco-climatic zone, Nigeria. The varieties of sorghum used are, Samsorg-44, Deko and Zauna-Inuwa. Planting spacing used was 75cm by 30cm. Variables measured include plant height, number of leaves, leaf area, number of grains/head, grain weight/head and grain yield. The three planting dates selected for are 28th June (d1), 12th of July (d2) and 26th of July (d3). The experiment was laid out with split plot design with variety of the crop as main plot and days of planting as sub-plot treatment. Generally, the plant growth and yield parameters decreased with delayed planting irrespective of location and variety of sorghum planted. Yield obtained for Samsorg-44, Improved Deco and Zauna-Inuwa planted in Akure are 2.23 tons/ha, 2.74 tons/ha and 3.8 ton/ha respectively, while 1.96 tons/ha, 2.36 tons/ha and 3.12 tons/ha respectively were recorded in Ibadan. While recommending planting is best done at the onset of rains in forest-savannah agro-ecology of Nigeria, planting should not be delayed beyond mid-July.

Keywords: Climate change, climate variability, food production system, adaptation strategy, optimum planting date.

Introduction

Food production systems in various countries are threatened by climate variability and change. Intergovernmental Panel on Climate Change (2007) defined climate change as a change in the state of the climate that can be identified (i.e using statistical tests) by changes in mean and or the variability of its properties and that persist for an extended period, typically decades or longer. Climate variability refers to the climatic parameter of a region varying from its long-term mean (F.A.O, 2007). Recently, studies on impact of climate change in Nigeria have shown that rainfall and temperature are the most critical variables of measurements relevant to food production system (Odjugo, 2011). However, rainfall is the most important climatic element as far as food production systems is concern (Ziervogel et al, 2006). In the last few decades, rainfall has been shown to have exhibited the highest variability in Nigeria (Oyekale, 2009). Studies have shown irregularities in rainfall distribution pattern in forest- savannah agroecology zone of Nigeria (Odjugo, 2005; Afangideh et al, 2010; Obot et al, 2010; Odjugo, 2011; Ezemonye and Emeribe, 2011). It is clear that climate change will bring about substantial losses especially

to poor resource farmers whose their source of livelihood is derived from crop production, hence the necessity for this study.

Sorghum (*Sorghum bicolor* (L.) Moench) is an important food crop in Africa and is the fifth most important cereal crop grown in the world. Sorghum is locally called guinea-corn or dawa Nigeria is the second largest producer of sorghum, grown on about 5.9 million ha with current annual production estimated to be about 6.7 million tonnes. It is mostly grown for domestic consumption and the excess sold to generate income. Major problem facing sorghum production is the variable rainfall that leads to wild fluctuations in production. A majority of the domestic produce is used for household consumption by many rural communities. It finds uses in the production of beverage, malt, sorghum meal, and livestock feed, among others. Whole grain is ground into flour used to make traditional foods. A gradual increase in demand for pre-processed sorghum convenience foods as well as for industrial sorghum products has been observed. Sorghum is also processed into malt for malted drinks and foods, high quality flours, and as a raw material for the poultry and fish feed industries. Sorghum is also processed into cake, biscuits, sweets and other confectionaries.

Several studies have assessed the grain yield of sorghum to planting dates. Inconsistencies in their reports, climate change phenomenon and necessity to have adequate information for the forest-savanna agro-ecology are part of the aim of carrying out this study. M'Khaitir and Vanderlip, (2002) reported that planting dates had no consistent effect on grain yield of sorghum in a study carried out in Kansas. Martin and Vanderlip, (2002) also conducted a research in Kansas and found out an optimal planting period 25th May to 5th June for good yield of sorghum. Also, Burke, et al (2002) reported that grain yield of sorghum planted in Nebraska was consistently 8% greater, when planted in early to mid may.

While farmers are often flexible in dealing with rainfall and year-to-year variability, there is nevertheless a high degree of adaptation to the local climate in the form of established infrastructure, local farming practice and individual experience. Climate change can therefore be expected to impact on agriculture, potentially threatening established aspects of farming systems but also providing opportunities for improvements. Therefore, the objective of this study is to determination of optimum planting date of sorghum as an adaptation strategy to the impact of climate change and variability on food production in the forest-savanna agro-ecology of Nigeria.

Materials and Methods

Study Area

This research was conducted during the growing season of 2021 at Agro-meteorology research farm of the Federal University of Technology Akure, Nigeria (70 15'N, 5015'E) and project farm of the Institute of Agricultural Research and Training (I.A.R&T.) Ibadan, Nigeria (7022'N; 3030'E). Both stations are within the forest-Savannah eco-climatic zone of Nigeria. The forest-Savannah eco-climatic zone of Nigeria covers a total land area of about 115,000 sq. km. Rainfall in the zone can be described as humid to sub-humid tropical with distinct dry and wet season. There are two rainfall peaks in June and September with dry spell in August (August break) which produces the bimodal rainfall pattern. It is characterized by minimal fluctuations, usually less than 5oC throughout the year. The mean monthly temperature ranges between 28oC and 35oC for the period of 10 years, while the mean monthly minimum temperature ranged between 22.6oC and 26.7oC. February and March have the highest evaporation rate, and it is as high as 6.9 mm. The least evaporation rate (1.6 mm) is recorded in June/July. The relative humidity ranges from 64.5% in February to 91% in June.

Soil sampling was carried out before land preparation to quantify the baseline nutrient status of the soil before the trial. The result of the pre-planting soil analysis indicates soil pH of 4.76 and 5.12 for Akure and Ibadan respectively. The percentage organic matter and organic carbon of the soils in Akure and Ibadan are 13.2%, 1.28% and 8.9%, 1.04% respectively. The exchangeable bases Ca (1.50 cmol kg⁻¹) and cation exchange capacity (3.26 cmol kg⁻¹) was found in Akure soil, while Ca (1.52 cmol kg⁻¹) and cation exchange capacity (4.02 cmol kg⁻¹). The textural class of the soil in both sites is sandy-loam (Table1).

Table 1: Result of Preliminary Soil Analysis

s/n	Parameters	Quantity (Akure)	Quantity (Ibadan)
1	pH	4.76	5.12
2	% Organic Carbon	13.2	8.90
3	% Organic matter	1.28	1.04
4	Ca (cmol/kg)	1.50	1.52
5	Mg (cmol/kg)	1.00	2.04
6	K (cmol/kg)	0.24	0.42
7	C.E.C (cmol/kg)	3.26	4.02
8	% Sand	0.72	0.77
9	% Silt	0.18	0.15
10	% Clay	0.10	0.08
11	Textural class	Sandy loam	Sandy loam

Treatment, Experimental Design and Data Analysis

The treatments will consist of 3 varieties of sorghum. The experiment was laid out in split plot design with varieties of crops as the main plot and dates of planting as subplot treatments. The treatments combinations were replicated 3 times in each location.

Prior to planting, soil samples shall be obtained at each location from 0-100 cm depth at 20 cm interval to determine basic physical and chemical characteristics of the soils (Tables 1). Minimum tillage was employed as a means of soil-water conservation. The varieties of sorghum used are, Samsorg-44, Deko and Zauna-Inuwa. Planting spacing used was 75cm by 30cm. Variables measured include plant height, number of leaves, leaf area, number of grains/head, grain weight/head and grain yield. Three seeds per hole were planted which was later be thinned to two per stand at one week after planting. Weeding was carried out manually using hoe two weeks after planting and subsequently at two weeks interval. Spraying with insecticides at the rate of 4ml per liter of water was carried out at two weeks after planting and at two weeks intervals to prevent the attack of army worm on the crops. NPK (15:15:15) fertilizer was applied at sowing at a rate of 40kg/ha and 30 kg/ha of Urea at 40 days after planting. The data sets were subjected to descriptive statistics as well as analysis of variance irrespective of the year of planting. Means of the different treatment were separated using Duncan Multiple Range Test (DMTR) (SAS 2002).

Results and Discussions

The results of plant height, number of leaves and leaf area of the trials in Akure and Ibadan are presented in table 2. The average number of days from seed emergence to maturity of sorghum varieties is about 80 days. Cultivar differences were noticed in the growth characteristics of the varieties used. Deko (V2) had higher vegetative growth than Samsorg-44 (V1) and Zauna-Inuwa (V3). The results showed that there was no significant difference in the growth performances of each of the varieties in the first four weeks of planting. The significance in the effects of planting dates on growth of sorghum was noticed at four weeks after planting. Generally, the highest vegetative growth characteristics were recorded on sorghum

planted on the first day while the lowest on the ones planted on the third day. The highest number of leaves was found on sorghum planted on first day and lowest on those planted last. Similarly, the tallest plants were found on Deko while Samsorg-44 and Zauna-Inuwa showed similar heights. These results are in conformity with the findings of Rizzard et al (2004), cha and chol (2005). who reported that growth of sorghum reduced with delayed planting.

Table 2: Growth performance of three selected varieties of sorghum at different dates in Akure and Ibadan

Var. * Day and Location	No. of leaves					Plant height (cm)					Leaf area (cm ²)				
	WAP					WAP					WAP				
	4	6	8	10	12	4	6	8	10	12	4	6	8	10	12
V1*D1L1	6.3	9.8	16.2	19.4	20.2	71.8	246.2	297.4	346.23	392.5	4215	8408	9264	10842	12798
V1*D2L1	6.0	9.6	15.0	18.2	19.8	68.3	231.8	281.4	35.4	390.9	3697	7524	8425	10136	12537
V1*D3L1	6.0	9.7	14.0	18.0	19.2	65.2	224.6	269.2	326.1	380.4	3025	6842	7246	9864	11468
V1*D1 L2	6.0	9.4	15.8	19.6	19.2	68.4	238.1	286.4	324.2	386.8	3976	8022	8680	9624	12147
V1*D2 L2	6.0	9.6	15.2	17.8	18.8	60.8	222.5	274.5	315.4	347.5	3542	7408	8047	9007	10431
V1*D3 L2	6.0	9.7	13.8	16.4	18.0	58.4	199.5	268.1	292.8	302.3	2988	7022	7824	8643	10002
V2*D1 L1	6.7	10.2	16.4	19.8	20.6	84.1	266.4	301.8	382.4	429.1	5462	8405	10051	13657	15628
V2*D2 L1	6.0	10.1	15.2	18.6	20.0	78.8	252.8	295.4	364.7	409.3	4210	7276	9848	12768	14632
V2*D3 L1	5.7	10.0	15.0	16.2	19.8	73.5	244.3	286.2	352.1	400.8	3218	6815	8467	10246	13763
V2*D1 L2	6.5	9.8	16.0	19.6	19.8	78.2	272.5	311.7	374.9	405.6	5046	8626	9824	12147	14346
V2*D2 L2	6.2	9.4	14.8	19.0	19.8	68.9	245.1	272.8	342.3	396.1	4147	7897	9248	11224	13827
V2*D3 L2	6.0	9.0	13.0	17.2	19.0	66.2	214.4	254.5	289.4	382.5	3646	7072	8622	10196	12246
V3*D1 L1	6.0	9.7	15.0	18.0	19.2	63.4	238.4	274.5	319.7	378.2	4126	7992	9275	10042	11924
V3*D2 L1	6.0	9.5	14.0	17.0	19.0	54.4	224.6	262.4	296.2	356.4	3524	8627	9024	9672	10246
V3*D3 L1	6.0	9.4	13.0	16.0	19.0	43.5	186.5	201.4	215.8	241.3	3012	6841	8215	8468	10041
V3*D1 L2	6.0	9.0	14.8	18.2	18.8	62.4	225.4	248.9	305.8	352.5	3996	7268	8763	9366	10966
V3*D2 L2	6.0	8.6	13.2	16.8	17.4	60.2	218.5	232.5	292.5	298.1	3422	7022	8210	9045	9864
V3*D3 L2	6.0	7.2	12.8	14.4	16.2	50.0	199.2	215.4	263.5	276.2	2907	6742	7621	8612	9248
LSD	0.03	0.24	0.68	1.47	3.48	8.24	13.84	24.68	18.93	34.21	50.50	46.46			
SEM	0.15	0.36	1.12	3.34	4.67	5.62	17.65	17.96	15.65	19.89	28.79	23.90			

V1- Samsorg-44, V2- Deko, V3- Zauna-Inuwa, D1- 28th June, D2- 12th of July, D3- 26th of July, L1-Akure, L2- Ibadan, WAP- Weeks After Planting

Table 3 shows the results of yield performance of three varieties selected of sorghum at different dates during in Akure and Ibadan. The results showed that planting dates had significant effects on yield of sorghum. The yield characteristics of sorghum decreased with delayed planting irrespective of variety of sorghum and location of trials. Probably due to the differences in soil nutrients status, the yield characteristics of sorghum planted in Akure were higher than that planted in Ibadan. The panicle length decreased with delayed planting in all the varieties of sorghum. The results further showed that planting dates has no significance on 1000 grain weight. The heaviest grains were found on variety 2 with varieties 1 and 3 having similar weights which might be due to higher vegetative growth leading to better grain filling. Grain yield (kg ha^{-1}) was significantly affected by planting dates. Grain yield reduction was noted with delay in planting dates irrespective of the variety and location of trials. Crops sown on day 1 recorded maximum grain yield followed by crops sown on day 2 while minimum grain yield was observed in crops sown on day 3. These results are in agreement with results of Moser, et al (2008), Weitzman, (2007) Macdonald, et al (2005), Perdicoulis, A. and J. Glasson. (2006) and Mani, et al (2008) who reported that yield of sorghum decreased with delay in planting dates.

Table 3: Yield performance of three varieties selected of sorghum at different dates during in Akure and Ibadan

Var. * Day and Location	Panicle length (cm)	1000 grain weight (g)	Grain yield (kg/ha)
V ₁ *D ₁ L ₁	35 35.3	30.4 30.41	2188
V ₁ *D ₂ L ₁	34. 34.8	30.24	2050
V ₁ *D ₃ L ₁	32.9	30.20	1815
V ₁ *D ₁ L ₂	25.2	30.20	2047
V ₁ *D ₂ L ₂	23.6	30.10	1986
V ₁ *D ₃ L ₂	20.2	30.20	1792
V ₂ *D ₁ L ₁	50.3	32.46	2746
V ₂ *D ₂ L ₁	48.8	32.42	2500
V ₂ *D ₃ L ₁	48.2	32.40	2448
V ₂ *D ₁ L ₂	48.4	33.20	2627
V ₂ *D ₂ L ₂	44.8	30.60	2361
V ₂ *D ₃ L ₂	40.1	30.60	2005
V ₃ *D ₁ L ₁	32.9	30.42	1983
V ₃ *D ₂ L ₁	31.4	29.96	1762
V ₃ *D ₃ L ₁	30.6	30.02	1698
V ₃ *D ₁ L ₂	32.6	30.20	1904
V ₃ *D ₂ L ₂	30.1	29.80	1821
V ₃ *D ₃ L ₂	22.4	30.00	1706
LSD	0.98	1.85	
SEM	1.02	2.02	

Conclusions and Recommendations

Results of this study decidedly reinforce the positions that sorghum growth and yield vary in response to variations in planting dates. The study shows that forest-savanna agro-ecological zone of Nigeria is a potentially viable region for the production of sorghum considering the favorable nature of the climate and soil. Reduced yield of sorghum may be as a result deterioration of environmental factors (temperature, radiation, water availability soil e.t.c.) suggesting farmers suggestion on delayed planting. Early planting is hereby recommended for sorghum production in forest-savanna agro-ecological zone of Nigeria as it was significantly superior in the growth and yield components.

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