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ANALYSIS OF RAINFALL ONSET AND CESSATION IN THE SUDANO-SAHELIAN ECOLOGICAL ZONE, NIGERIA

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ABSTRACT

The study investigated the actual onset and cessation date of rainfall in the Sudano Sahelian Ecological Zone (SSEZ), Nigeria. Thirty-Seven (37) years (1981-2018) rainfall data from Climate Research Unit (CRU) for the study areas was utilised. The Inter-Seasonal Rainfall Monitoring Index (IRMI) was used for the analysis. Onset of rainfall was taken as the pentad within which the index is greater than or equal to 1(≥1) for the first time. Generally, result showed high variability in the amount of rainfall received across the study area. The lowest average annual rainfall was detected in Nguru at 536 mm while the highest was in Yelwa at 1090.65 mm. The Average Length of Raining Season (LRS) was between 120-140 days across the study locations. The result of average onset period for each stations showed slight variability. The study established that the average rainfall onset date for Bauchi was 20th May; Gusau, Kano and Katsina was 21st May. Maiduguri, Nguru and Sokoto was 24th, 25th and 26th of May respectively, while Yelwa was on the 13th of May. The average rainfall onset date across the study area was on the 28th pentad which corresponds with 21st May of every year. Further result showed that early cessation of rainfall was detected for Katsina in 1985, 1989, 1991, 1993, 2005, 2006, 2007, 2010, 2011, 2013, 2014, 2017 and 2018. Similarly, early cessation period for Maiduguri was in 1981, 1987, 1989, 1994 1996, 2000, 2002, 2005. 2007, 2013, 2014 and 2017 respectively. Result for Kano station showed that the early cessation date was 2nd October, 2017. Early cessation period for Nguru station was in 1983,1984,1985,1991, 1996, 2001, 2007, 2009 and 2014 respectively. Further, the Sokoto station detected early cessation period in 1984 while Yelwa station detected 1981 and 2005 respectively. The average cessation date across the station was on the 57th pentad which corresponds with 27th October. The study established that rainfall in the region is highly variable with asymmetric changes and a multiplying effects on the ecosystem and livelihood. The study recommends continuous monitoring of the rainfall pattern of the study area for effective agricultural production planning.

Keywords: Rainfall, Onset, Cessation, IRMI, Sudano Sahelian Ecological Zone, Nigeria.

INTRODUCTION.

In tropical country like Nigeria, rainfall varies spatially as the rain-belt follows the relative northward and southward movements of the sun. In this tropical situation of a marked seasonal rainfall regime, variability of the onset and cessation

of rain is highly significant, and its estimation and prediction are necessary. A delay of 1 or 2 weeks in the onset is sufficient to destroy the hopes of a normal harvest (Odekunle, 2004; Jacquin *et al*., 2010)) and in return have adverse effects on vegetation dynamics. A false start of planting, encouraged by a false start of rainfall, may be followed by prolonged dry spells whose duration of 2 weeks or more may be critical to plant germination and/or growth (Omobowale, 2014). For instance, in 1973, the onset was earlier in Nigeria, which encouraged early planting and animal migration. However, this was a false onset, resulting in both crop and animal loss (Odekunle *et al*., 2008)

Although, similar studies exist such as; Amekudzi *et al*. 2015; Hachigonta *et al*. 2008; Ibrahim *et al.* 2017; Jiang *et al*. 2011; Oladipo and Kyari 1993 and Tadross *et al*. 2005 on the onset and cessation of rains, but substantial number of them were limited in scope and methodology. The present study investigated the onset and cessation date of rain in the study area using the IRMI method developed by Usman and Abdulkadir 2012.

MATERIALS AND METHODS.

Study Area Description

The Sudano-Sahelian Ecological Zone (SSEZ) is located in Northern Nigeria between latitude 10^0N and 14^0N and longitude 4^0E and 14^0E. This is the largest ecological zone in Nigeria because it occupies almost one-third of the total land area of the country. It stretches from the Sokoto plains through the northern section of the high plains down to the Chad Basins (Odekunle *et al.*, 2008). The average annual rainfall in this zone varies from less than 500 mm in the extreme north-eastern part to 1000 mm in the southern sub-region (Abaje *et al*., 2011) in only about five months in the year, especially between May and September (Ati *et al*., 2007). The rainfall intensity is very high between the months of July and August. The pattern of rainfall in the zone is highly variable in spatial and temporal dimensions with inter-annual variability of between 15 and 20% (Oladipo and Kyari 1993).

Data Used.

Daily rainfall data for Thirty-seven years (1981-2018) from Climate Research Unit (CRU) was used. Table 1, depict the data type, source and resolution.

Data Analysis

The Intra Seasonal Rainfall Monitoring Index (IRMI) developed by Usman and Abdulkadir (2012) was used for the analysis, the IRMI is an effective tool for determining the actual onset date of the summer monsoon rains. IRMI is computed on a pentad by pentad basis from the beginning of May using the following equation:

$$IRMI = \frac{(C_{pt})^2}{(hpt \times Nb \times 100)} \quad (1)$$

Where: C_{pt} = cumulative pentad rainfall since May 1

hpt = is the highest pentad total rainfall since May 1

Nb = is number of breaks in rainfall (pentads with less than 5 mm of rainfall)

100 = working factor

IRMI model was used to determine the effective onset of the rain at the individual synoptic station.

RESULTS AND DISCUSSIONS.

Figure 2 depict the annual rainfall distributions in the study area. Result showed that areas marked with red colour had poor rainfall distribution of between (465.14 to 574.15 mm, 574.15 to 683.16 mm and 683.16

to 901.17 mm) respectively, the stations include; Maiduguri, Nguru, and part of Kano. Further, stations with medium rainfall distribution were depicted in lemon green colour with rainfall amount of between (901.17 to 1,010.18 mm, 1,010.18 to 1,119.19 mm and 1,119.19 to 1,228.19 mm), areas in this region are Bauchi and part of Yelwa, also areas with high amount of annual rainfall were depicted in blue and can be found in Yelwa with rainfall amount of between (1, 228. 19 to 1, 337. 20 mm and 1, 337.20 to 1446. 21 mm). Generally, the study revealed that the lowest amount of rainfall was recorded in Nguru at 536.01 mm while the highest was in Yelwa at 1,090.65 mm. This finding implies that the amount of rainfall received across the study area would not be sufficient to support agricultural production. Therefore, crop farmers in this region must result to the use of irrigation facilities as strategy to adapt to the changing rainfall regime.

Table 2 depict the analysis of rainfall onset dates in the study area. Generally, result showed wide variability in onset dates across the study locations (SSEZ). The average onset period for each synoptic stations showed a slight variability, the onset date for Bauchi was 20th May, Gusau was 21st May, Kano detected 21st of May, Katsina has 21st of May, Maiduguri was 24th of May, Nguru was 25th of May, Sokoto detected 26th of May while for Yelwa it was 13th of May, respectively. The average rainfall onset recorded in this region was on the 28th pentad which corresponded with 21th May of every year. The onset dates were derived using the IRMI which implies that the "actual" or "real" onset of rains was taken as the pentad within which the index is greater than or equal to 1 ($\geq$1), for the first time.

Table 3 depicts the analysis of rainfall cessation date across the study area. Result showed that early cessation date was detected for Katsina in 1985, 1989, 1991, 1993, 2005, 2006, 2007, 2010, 2011, 2013, 2014, 2017 and 2018 while Maiduguri had early cessation in 1981, 1987, 1989, 1994 1996, 2000, 2002, 2005. 2007, 2013, 2014 and 2017. Early cessation for Kano was in 2017 (2nd-Oct), and Nguru was in 1983, 1984, 1985, 1991, 1996, 2001, 2007, 2009, 2014. Early cessation was detected for Sokoto in 1984 and while for Yelwa it was in 1981, and 2005. Further result showed that the average cessation date is across the study area was on the 57th pentad which corresponded with 27th October. These results revealed that most part of study area recorded early cessation of rains during the study period, the findings underscore the need for continuous advocacy and encouragement to the farmers by the extension agent to adopt improved crop varieties that are high yielding and early maturing so as to safeguard against total crop failure.

Table 4 showed break in rainfall distribution during the study period. A break is when the pentad value is less than 5 (<5), when there is a drop in pentad for two consecutively time, then a break is observed. A prolong break may result to a dry spell and when it last for too long it may result to a drought; this implies that there will be a prolong period of absent of rainfall with resultant effect on the productivity of crops generally. From the analysis the average annual rainfall in the study area varies from less than 500 mm in the extreme north-eastern part to 1000 mm in the southern sub-region. The rainfall is usually for a period Five (5) months (May to September). The rainfall intensity was high between the months of July and August. The pattern of rainfall was highly variable in spatial and temporal dimensions with inter-annual variability of between 15 and 20%.

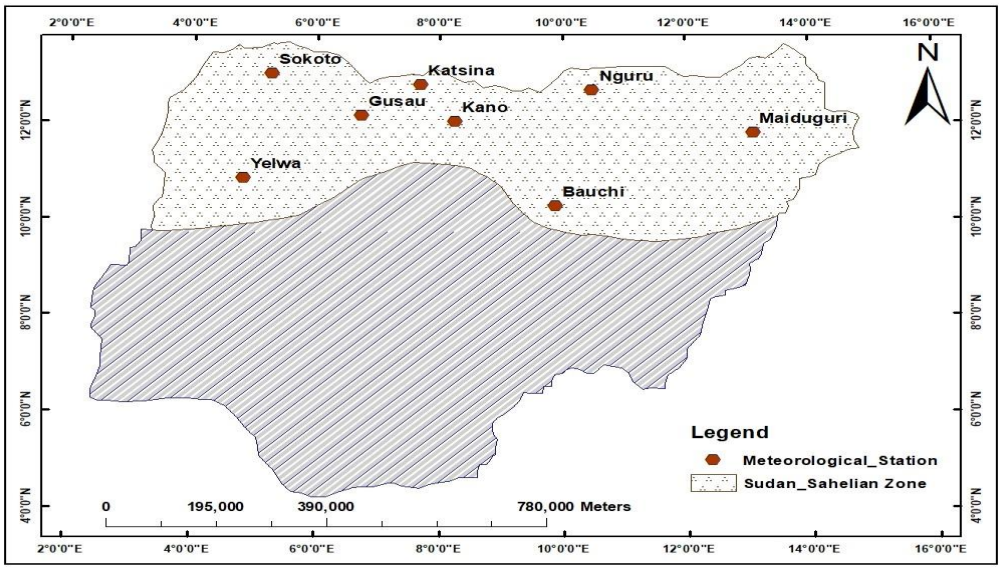

Figure 1: Study Area (Sudano-Sahelian Ecological Zone of Nigeria)
Source: Authors Work

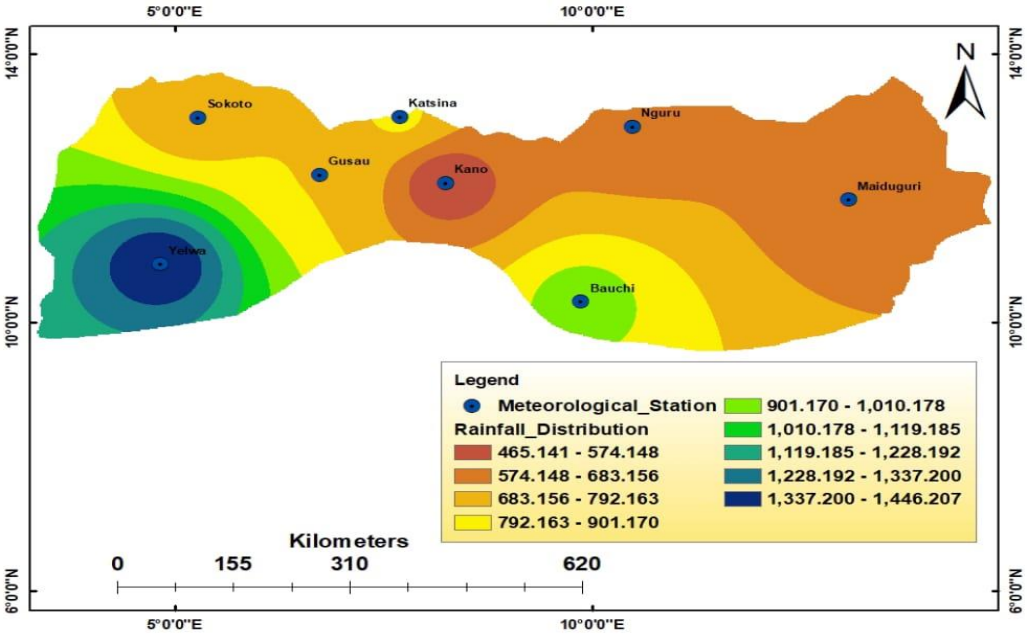

Figure 2: Thematic Map of Annual Average Rainfall Distributions in the Study Area

Table 1: Type and Source of Data Used

S/N	Type of Data	Source	Duration and Resolution
1	Satellite-derived Rainfall Data.	Climate Research Unit (CRU).	Gridded data at 0.5meter resolution, 1981-2018 (37Years) converted in to pentad.

Table 2: Rainfall Onset in the Sudano-Sahelian Ecological Zone of Nigeria

Year	Bauchi	Gusau	Kano	Katsina	Maiduguri	Nguru	Sokoto	Yelwa
1981	24-Jun	15-May	5-May	10-May	15-May	10-May	15-May	10-May
1982	10-May	20-May	25-May	5-May	15-May	15-May	10-May	5-May
1983	10-May	20-May	15-May	10-May	20-May	10-May	10-May	15-May
1984	5-May	15-May	25-May	15-May	10-May	4-Jun	25-May	20-May
1985	5-May	20-May	25-May	20-May	15-May	15-May	30-May	10-May
1986	24-Jun	25-May	30-May	5-May	15-May	30-May	4-Jun	15-May
1987	20-May	25-May	4-Jun	15-May	20-May	15-May	15-May	15-May
1988	15-May	30-May	30-May	30-May	30-May	30-May	10-May	30-May
1989	10-May	20-May	25-May	15-May	25-May	4-Jun	20-May	25-May
1990	5-May	10-May	10-May	25-May	30-May	20-May	4-Jun	5-May
1991	10-May	10-May	10-May	25-May	20-May	30-May	25-May	5-May
1992	10-May	15-May	15-May	20-May	25-May	4-Jun	30-May	10-May
1993	5-May	25-May	25-May	25-May	20-May	30-May	10-May	10-May
1994	10-May	25-May	4-Jun	20-May	20-May	30-May	4-Jun	15-May
1995	4-Jun	20-May	25-May	30-May	15-May	4-Jun	30-May	15-May
1996	20-May	25-May	30-May	10-May	20-May	30-May	4-Jun	15-May
1997	25-May	15-May	20-May	30-May	20-May	25-May	30-May	10-May
1998	20-May	10-May	30-May	4-Jun	15-May	25-May	15-May	5-May
1999	10-May	25-May	25-May	15-May	20-May	30-May	4-Jun	15-May
2000	14-Jun	30-May	15-May	30-May	20-May	30-May	30-May	10-May
2001	15-May	4-Jun	4-Jun	30-May	20-May	4-Jun	30-May	5-May
2002	4-Jun	10-May	30-May	30-May	25-May	25-May	4-Jun	5-May
2003	30-May	25-May	10-May	5-May	25-May	30-May	15-May	15-May
2004	30-May	25-May	30-May	15-May	30-May	25-May	15-May	25-May
2005	20-May	10-May	4-Jun	4-Jun	4-Jun	20-May	30-May	10-May
2006	10-May	5-May	25-May	30-May	30-May	25-May	4-Jun	15-May
2007	15-May	4-Jun	15-May	15-May	20-May	25-May	30-May	10-May
2008	15-May	20-May	25-May	4-Jun	25-May	30-May	25-May	20-May
2009	25-May	30-May	30-May	10-May	30-May	25-May	4-Jun	20-May
2010	20-May	25-May	20-May	20-Jan	4-Jun	30-May	30-May	10-May
2011	25-May	25-May	5-May	10-May	30-May	25-May	25-May	10-May
2012	20-May	20-May	15-May	15-May	25-May	5-May	30-May	10-May
2013	4-Jun	15-May	30-May	25-May	4-Jun	10-May	4-Jun	20-May
2014	30-May	30-May	10-May	10-May	30-May	20-May	25-May	25-May
2015	15-May	4-Jun	15-May	4-Jun	30-May	30-May	30-May	10-May
2016	30-May	4-Jun	15-May	15-May	4-Jun	25-May	4-Jun	20-May
2017	10-May	30-May	20-May	25-Jun	30-May	25-May	30-May	10-May
2018	5-May	25-May	10-May	15-Jun	4-Jun	30-May	20-May	5-May

Table 3: Rainfall Cessation in the Sudano-Sahelian Ecological Zone of Nigeria

Year	Bauchi	Gusau	Kano	Katsina	Maiduguri	Nguru	Sokoto	Yelwa
1981	17-Oct	27-Oct	27-Oct	7-Oct	2-Oct	27-Oct	7-Oct	2-Oct
1982	22-Oct	27-Oct	22-Oct	12-Oct	17-Oct	12-Oct	7-Oct	7-Oct
1983	12-Oct	27-Oct	27-Oct	7-Oct	7-Oct	2-Oct	12-Oct	7-Oct
1984	27-Oct	27-Oct	27-Oct	17-Oct	22 cot	2-Oct	2-Oct	12-Oct
1985	27-Oct	27-Oct	27-Oct	2-Oct	27-Oct	2-Oct	12-Oct	17-Oct
1986	27-Oct	27-Oct	27-Oct	7-Oct	2-Oct	7-Oct	27 cot	12-Oct
1987	22-Oct	27-Oct	27-Oct	12-Oct	12-Oct	27-Oct	22-Oct	7-Oct
1988	27-Oct	27-Oct	27-Oct	2-Oct	22 cot	22-Oct	27-Oct	12-Oct
1989	27-Oct	27-Oct	27-Oct	7-Oct	2-Oct	7-Oct	22-Oct	22-Oct
1990	27-Oct	27-Oct	27-Oct	22-Oct	7-Oct	12-Oct	27-Oct	22-Oct
1991	22-Oct	22-Oct	27-Oct	2-Oct	12-Oct	2-Oct	27-Oct	27-Oct
1992	27-Oct	27-Oct	27-Oct	7-Oct	7-Oct	7-Oct	27-Oct	27-Oct
1993	17-Oct	27-Oct	27-Oct	2-Oct	2-Oct	12-Oct	27-Oct	22-Oct
1994	27-Oct	27-Oct	27-Oct	17-Oct	2-Oct	22-Oct	22-Oct	22-Oct
1995	22-Oct	27-Oct	27-Oct	22-Oct	7-Oct	7-Oct	27-Oct	22-Oct
1996	22-Oct	27-Oct	27-Oct	7-Oct	2-Oct	2-Oct	27-Oct	22-Oct
1997	27-Oct	27-Oct	27-Oct	12-Oct	12-Oct	7-Oct	27-Oct	27-Oct
1998	27-Oct	27-Oct	27-Oct	17-Oct	22-Oct	22-Oct	27-Oct	17-Oct
1999	27-Oct	27-Oct	27-Oct	17-Oct	17-Oct	7-Oct	27-Oct	22-Oct
2000	27-Oct	17-Oct	27-Oct	17-Oct	2-Oct	7-Oct	27-Oct	27-Oct
2001	27-Oct	27-Oct	27-Oct	17-Oct	22-Oct	2-Oct	27-Oct	22-Oct
2002	22-Oct	27-Oct	17-Oct	27-Oct	2-Oct	12-Oct	27-Oct	17-Oct
2003	27-Oct	27-Oct	27-Oct	12-Oct	7-Oct	27-Oct	27-Oct	22-Oct
2004	27-Oct	27-Oct	27-Oct	12-Oct	7-Oct	12-Oct	27-Oct	7-Oct
2005	27-Oct	22-Oct	27-Oct	2-Oct	2-Oct	17-Oct	22-Oct	2-Oct
2006	27-Oct	22-Oct	27-Oct	2-Oct	7-Oct	12-Oct	22-Oct	7-Oct
2007	27-Oct	27-Oct	27-Oct	2-Oct	2-Oct	2-Oct	27-Oct	27-Oct
2008	27-Oct	27-Oct	27-Oct	7-Oct	7-Oct	27-Oct	27-Oct	27-Oct
2009	22-Oct	27-Oct	27-Oct	7-Oct	7-Oct	2-Oct	27-Oct	22-Oct
2010	22-Oct	27-Oct	27-Oct	2-Oct	7-Oct	12-Oct	22-Oct	27-Oct
2011	27-Oct	27-Oct	27-Oct	2-Oct	7-Oct	17-Oct	27-Oct	27-Oct
2012	17-Oct	27-Oct	27-Oct	7-Oct	12-Oct	12-Oct	22-Oct	27-Oct
2013	27-Oct	27-Oct	27-Oct	2-Oct	2-Oct	22-Oct	27-Oct	27-Oct
2014	27-Oct	27-Oct	27-Oct	2-Oct	2-Oct	2-Oct	27-Oct	27-Oct
2015	27-Oct	27-Oct	22-Oct	2-Oct	7-Oct	12-Oct	17-Oct	17-Oct
2016	27-Oct	27-Oct	17-Oct	17-Oct	7-Oct	7-Oct	22-Oct	12-Oct
2017	27-Oct	27-Oct	2-Oct	2-Oct	2-Oct	17-Oct	22-Oct	22-Oct
2018	27-Oct	27-Oct	7-Oct	2-Oct	7-Oct	22-Oct	17-Oct	22-Oct

Table 4: Break in Rainfall in the Sudano-Sahelian Ecological Zone of Nigeria.

Year	Bauchi	Gusau	Kano	Katsina	Maiduguri	Nguru	Sokoto	Yelwa
1981	36	39	44	43	44	49	51	38
1982	32	37	48	47	47	48	52	30
1983	41	43	48	47	46	50	48	39
1984	34	36	40	41	48	47	48	34
1985	34	43	45	46	42	48	54	39
1986	31	38	41	45	48	49	48	38
1987	39	45	46	48	45	48	52	43
1988	34	41	43	43	44	46	47	37
1989	35	38	39	43	45	49	49	35
1990	36	40	41	43	42	48	49	36
1991	34	38	41	44	43	50	45	33
1992	37	39	40	41	44	45	45	36
1993	35	40	43	46	44	50	49	37
1994	30	35	40	41	45	46	46	32
1995	35	38	41	43	42	46	49	34
1996	34	40	38	41	39	43	46	37
1997	33	36	40	41	46	44	46	32
1998	37	37	41	41	48	48	45	32
1999	49	45	51	47	53	49	47	39
2000	38	42	44	43	48	49	45	36
2001	39	41	44	43	49	46	49	38
2002	41	38	46	44	47	50	48	34
2003	41	40	43	45	52	47	48	32
2004	42	44	51	46	47	52	48	36
2005	42	46	52	50	48	50	49	33
2006	49	47	55	50	45	52	49	38
2007	41	38	44	46	44	47	51	34
2008	41	43	46	43	46	48	46	37
2009	44	43	48	47	44	49	48	33
2010	41	38	45	43	44	46	44	33
2011	41	44	46	45	43	47	50	35
2012	35	36	39	40	48	43	44	33
2013	45	48	51	48	41	52	48	36
2014	43	41	50	49	52	52	53	35
2015	47	46	51	46	47	53	49	37
2016	39	44	50	45	46	51	47	36
2017	40	42	48	47	47	51	49	36
2018	42	41	52	44	48	50	45	33

CONCLUSION

The study revealed that there existed a high inter-annual variability in rainfall over the study area which in turn had pronounced effect on the onset and cessation dates of rainfall in the zone. The study showed that the pattern of rainfall was highly variable in spatial and temporal dimensions with inter-annual variability of between 15 and 20%. The Average Length of Raining Season (LRS) was between 120-140 days, while the average onset and cessation period for each synoptic stations shows slight variability. The study established the actual onset and cessation dates of rainfall in the ecological zone and recommended continuous monitoring of the rainfall pattern of the study area for effective agricultural production planning.

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ANALYSIS OF THE PROFITABILITY OF DRY SEASON INTERCROPPED AND SOLE CROP (*CORCHORUS OLITORIUS-AMARANTHUS CRUENTUS*) FARMING AT FEDERAL UNIVERSITY OF AGRICULTURE, ABEOKUTA, OGUN STATE, NIGERIA

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ABSTRACT

Decision to invest is guided by expectation of a positive return on investment, security, among other factors. This study determined the profitability of three different cropping enterprises at Federal University of Agriculture, Abeokuta, Nigeria. Results of the gross margin analysis showed that both the intercropped and sole amaranthus enterprises were profitable. The computed gross margins were; ₦579, 916.67/ha, ₦179, 916.67/ha and (₦500, 083.33/ha) for intercropped, Amaranthus and Corchorus respectively. The intercropped enterprise had a Benefit Cost Ratio, Rate of Return and Gross Ratio of 1.53, 0.52 and 0.65 respectively, while sole amaranthus enterprise had a Benefit Cost Ratio, Rate of Return and Gross Ratio of 1.15, 0.15 and 0.87 respectively. The result indicates that the two enterprises were profitable in the study area. However, losses were incurred for the sole Corchorus enterprise. The study therefore concluded that both the intercropped and sole amaranthus enterprises were profitable in the study area, but there was a significant difference in the profitability between the two systems, as the amaranthus/corchorus intercrop was more profitable. The intercropped enterprise is therefore recommended for the farmers' promotion since it is more profitable and provides a variety of income generation for the thereby ensuring food security and income security.

Keywords: Amaranthus, corchorus, dry season, intercropping, sole cropping, profitability

INTRODUCTION.

The production of vegetables is an important component of the farming system in Nigeria. (Ibrahim and Omtosho, 2011). Vegetables play a significant role in supplying the essential minerals, vitamins and fibre not present in large quantities in starchy staple foods. The significance of vegetables makes the production an all season crops. However, its production is hindered in the developing economy because of the high dependence on rainfall. Ojo *et al*. (2011) asserted that vegetable production is done mainly during the rainy (major cropping) season in South-western Nigeria. Hence, a majority of vegetable producers utilizes wetlands (usually called *Fadama*) - supplemented with a simple irrigation system to raise vegetables. Production of vegetables during the dry seasons has been a source of employment and income to the farmers for decades. This is

because during the dry season there is usually the scarcity of this important farm product thereby leading to a high price due to short supply (Mohammed, 2002; Okunola, 2009; Ibekwe and Adesope, 2010).

There are various leafy vegetables grown in West Africa, Nigeria, inclusive among which are Amaranth– *Amaranthus cruentus* L.; bitter leaf – *Vernonia amygdalina* Del.; lettuce – *Lactuca sativa* L., spinach – *Basella alba* L., etc. Of these leafy vegetables, amaranth is the most widely grown in Nigeria. It is a staple vegetable plant grown for its leafy material used in Nigerian dishes such as soup, stew, salad porridge and as garnish (Abdullahi *et al.,* 2019). It is also considered as one of the most important green leafy vegetables of the tropics, because it provides minerals and vitamins (especially vitamin A) which are highly beneficial for the maintenance of good health and prevention of diseases (Nnamani *et al*., 2007; Onyango *et al.,* 2008)**.** However, the major limitation to the growth of this crop all the year round is rainfall (Akinbile and Yusoff, 2011).

Corchorus olitorius (Jute mallow) is a popular tropical leafy vegetable crop in Africa, Asia, some parts of the Middle East and Latin America (Odofin *et al.,* 2011). Jute leaves provide many health benefits, and different literatures observed that leaves of jute mallow are rich of calcium which helps to protect the teeth and jaw and for strong bone, copper that diminishes heart diseases, vitamin B9 that is essential for reducing the occurrence of cancer in the human body (Islam *et al.,* 2013). The antioxidants in saluyot leaves may sharpen vision, fight arthritis and improve fertility (Watkins, 2017).

Intercropping, which is also referred to as multi-cropping is a centuries-old agricultural practice that involves the growing of multiple crop species in close proximity such that they coexist for a significant part of their life cycle (Brooker *et al.,* 2014; Gitri *et al*., 2020). In tropical areas particularly in Africa, intercropping has been practiced for over a millennium, and it is still gaining popularity among the smallholder farmers (Mucheru-Muna *et al*., 2010; Gou *et al*., 2016; Gitari *et al*., 2018a; and 2019b; Nyawade *et al*., 2019a; and b). According to Javanmard *et al*. (2009), intercropping is popular because of its advantages over sole cropping which include security of returns and higher profitability due to higher combined returns per unit area of land**.**

Intercropping corchorus/amaranthus is a farming practice gaining momentum among peasant farmers in Nigeria, with the choice being motivated by the economic objective of producing maximum output to earn a positive economic return (Akinkuoroye, 2019).

Studies have examined the profitability and production constraints in the sole vegetable production of dry season amaranth (Emokaro *et al*., 2007; Onyango *et al.,* 2008; Owombo *et al*., 2012; Shuaib *et al*., 2017). Also, recent study by Akinkuoroye (2019) worked on vegetable based intercropping systems of celosia, amaranthus and corchorus production. However, these studies did not reveal the economic viability particularly in amaranthus/corchorus combination. There is, therefore, the need to examine the differences in profitability of *corchorus/amaranthus* intercrop and sole crops in the study area. Knowledge of this research will help farmers to obtain empirical information about their profitability in order to make a pre-informed farming decision on vegetable production.

MATERIALS AND METHOD

Study Area

The work was carried out at the vegetable plot farm of the Institute of Food Security, Environmental Resources and Agricultural

Research (IFSERAR), Federal University of Agriculture, Abeokuta. ((07^0 15'N 03^0 25'E) in the forest savannah transition zone of South West Nigeria in the late dry season of year 2020. The soils of the experimental site were sandy loam with low organic matter content. The land was cleared and seed beds were prepared with hoes. The plot size for the experimental area was 93m^2. The experiment consists of three cropping systems which were: amaranthus-corchorus (intercropped), amaranthus (sole) and corchorus (sole) cropping systems. In each cropping system, there were 4 replicates making a total of 12 plots. Each replicate of the intercropped and sole crop has a plot size of 3.0 x 2.0 m^2.

Data Collection

The data collected were; cost of fixed assets, cost of variable inputs, yields and prices of outputs.

Analytical Technique

The data was analysed using budgetary technique which was used to determine the profitability of the three vegetable production enterprises. Gross margin analysis is one of the budgetary techniques and it basically measures the difference between total returns and total variable costs. For the purpose of arriving at fixed costs of the production enterprise for a given year, the straight line depreciation method was taken into consideration and the expected life span of the different fixed cost items. Using the straight line method, the annual depreciation expenses were calculated on the fixed costs, which were then used to get the net farm profit.

The Gross margin analysis was derived by the equation:

$GMI = \Sigma TR - \Sigma TVC$

$TR = Py \cdot Yi$

$TVC = Pxi \cdot X$

$TC = TVC + TFC$

Where;

GM = Gross Margin (₦)

TR = Total Revenue (₦)

TVC = Total Variable Cost (₦)

Py = Unit Price of Output Produced (₦)

Y = Quantity of Output (kg)

Pxi = Unit Price of Variable input i used (₦)

Xi = Quantity of Variable Input i (kg)

Also, the performance and economic worth of the production enterprise was determined by the use of the following profitability ratios:

1. Benefit Cost Ratio (BCR) = TR/TC
2. Rate of Return ROR = NR/TC
3. Gross ratio GR = TC/TR

Depreciation: Depreciation values of fixed items such as; shovel, pan, hose, weighing scale, hoe, tank, water pumping machine and generator were used for the calculation. Straight Line Method (SLM), which assumed salvage value of zero, was used and the items are expected to spend a minimum of 3-30 **y**ears. The formula is specified as:

$$D = \frac{P_o - S}{n}$$

Where,

D = Annual depreciation

P_o = Original Price/Cost

S = Salvage Value

n = Expected no of Years or Useful Life Span (year)

RESULTS AND DISCUSSION

A. Production Cost of *Corchorus olitorius-Amaranthus cruentus* Intercrop and Sole Crops.

The results of the analysis in Table 1 showed the total cost of fixed assets and variable inputs used for the total experimental plot during the production cycle. A large proportion of the variable costs were attributable to the labor input, which accounted for more than 50%. This identifies

labor as the single most costly input in operating an irrigated dry season farms in the study area. This situation is not unexpected, since all farm operations including land clearing, planting, weeding, watering, spraying, manuring and harvesting were accomplished through manual labor. For fixed asset, the total fixed cost in the production cycle was ₦393, 500 while that of variable inputs was ₦1, 020,083.33k. The huge cost of the total variable cost of production was due to the high cost of labour used for watering, weeding and spraying during the production cycle. This was because the vegetables were planted during the dry season and water was not readily available at the study area, hence the need for irrigation which was done at intervals on a daily basis at a cost. Also, incidence of weed infestation, pest and diseases also attributed to the high cost of labour for weeding and spraying. This corroborates the finding of Chukwuji (2008), who reported that labour constituted the single most important cost item on the average. Furthermore, the cost of fuel used in pumping water in the study area was also high.

B. Gross Returns per Hectare of *Corchorus-Amarantus* intercrop and Sole Cropping Systems.

Table 2, presents the gross revenue of the individual cropping systems per hectare**.** The table reveals that on per hectare basis, the intercrop combination of corchorus-amaranthus had the highest revenue of ₦1,600,000/ha compared to the revenue both from sole corchorus and sole amaranthus which was ₦520,000/ha and ₦1,200,000/ha respectively. This implies that of the three vegetable production systems, the intercrop had the highest return during the period of experiment.

C. Cost and Returns per Hectare of *Corchorus-Amarantus* (intercropped), *Corchorus* (sole) and *Amarantus* (sole) Cropping Systems.

Table 3 presents summary of the costs and returns to dry season vegetable production for each enterprise in the study area expressed in ₦/ha. The gross margin, benefit cost ratio, rate of returns and gross ratios were computed for each cropping system (enterprise) expressed in ₦/ha. The result revealed that *corchorus-Amarantus* (intercropped) and *Amarantus* (sole) Cropping Systems were profitable with the intercropped system having the highest gross margin of ₦579,916.67k/ha while amaranthus (sole) had a gross margin of ₦179,916.67/ha. *Corchorus* (sole) had a negative gross margin of 500,083.33. This means that the intercropped system was the most profitable enterprise in the study area. However, the profitability of this enterprise was due to its high yield of 8000kg/ha compared with the output from sole amaranthus which yielded 6000kg/ha. This is in tandem with the position of Abdulsalam *et al.* (2012), whose results showed that mixed cropping was profitable compared to the sole enterprises. On the other hand, sole corchorus was not a profitable enterprise as revealed by the result during the production cycle. This study agrees with the finding of Ibrahim (2000) who found out that dry season vegetable farming of sole tomato was also not profitable in the study area. The production recorded an average loss of ₦1, 898.00/ha for farmers in Galmi District, Niger Republic. He attributed loss incurred to the high cost of inputs and labor coupled with low produce price at harvest.

Table 3 also captured benefit cost ratio (BCR) for the three enterprises and the results shows that intercropped and sole amaranthus had a BCR of 1.53 and 1.15 respectively. As

a rule of thumb, project with benefit cost ratio greater than one, equal to one or less than one indicates profit, break-even or loss respectively. Since the ratios were greater than one, it showed profit and indicated that the enterprises were profitable and worth venturing into in dry season. This was compared with the sole corchorus whose BCR was (0.49). Since this production system shows a negative BCR, this indicates loss in profit. However, this loss could be as a result of weed infestation which arose on the early stage of the crops during the course of production but were controlled manually in the third week. These weeds competed with the sole corchorus most especially which in turn affected its productivity. However, this loss in the production systems was significant in the first production cycle and possibly be transformed into positive BCR in the subsequent years if adequate protocols are adhered to leading to higher yield and good pricing per kilogram.

The Rate of Return (ROR) provides a measure of financial performance of the enterprise employed expressed in percentage (i.e. profit/ ₦ invested). Results of the analysis revealed that the rate of returns for the intercropped system was the highest with a ROR of 0.52 which implies that for every ₦1.00 invested in this production, the enterprise yields ₦52.00 as gain. Also for the sole amaranthus production, the ROR was 0.15 in the study area. This also implies that for every ₦1.00 invested, ₦15.00 was gained by the farmer. However, the ROR for sole corchorus was (0.50). This means that for every ₦1.00 invested, ₦50.00 was lost by the vegetable farmer. This is synonymous with the findings of (Tsoho and Salau, 2012) who observed that sole tomato had a negative average rate of returns of -29.40%. This suggest that on the average a loss of 29k will be incurred on every naira invested in the cultivation of dry season tomato in the area.

The Gross ratio of the intercropping system and sole amaranthus vegetable production in the study area was 0.65 and 0.87 respectively. This implied that from every ₦1.00 returns to the enterprise, ₦65.00 was spent on intercropping while ₦87.00 was being spent on sole amaranthus vegetable production. This finding is in line with the findings of Olukosi and Erhabor (2008) who stated that a gross ratio of less than one is desirable for any farm business. Therefore, based on the information in table 3, it is obvious that dry season intercrop and sole amaranthus farming was a profitable venture in the study area.

CONCLUSION AND RECOMMENDATIONS.

The results of the study revealed that both the intercropped and sole amaranthus enterprises were profitable during the production cycle in the study area, but there was a notable difference in the profitability of the various enterprises practiced, with amaranthus/corchorus intercropped yielding more profitable. Based on the findings of the study it is recommended that as sustainability mechanism especially in small-scale farming, diversification is an instrument for ensuring continuity in business and on the strength of the results generated, intercroped yielded higher return on investment and hence needs to be promoted in the farming communities. Also, it is central to adequately provide extension services that will help the farmers in the adoption and utilization of new and promising production techniques that will ensure greater productivity which will lead to higher revenues.

Table 1: Production Cost of Amaranthus/Corchorus (Intercropped), Corchorus (Sole) and Amaranthus (Sole) Cropping Enterprises per hectare.

Farm Operation (Fixed items)	Amount (₦)	Expected Useful life (years)	Depreciation Cost (₦)
Land Purchase	120,000	30	-
Shovel	1500	3	500
Bowl	500	3	167
Pan	1000	3	333
Weighing Scale (20kg)	6000	5	1200
Hoe	1500	3	500
Overhead tank 500Ltr	18000	5	3600
Pumping machine 0.75hp	25000	5	5000
Generator 2.5kva	80000	5	16000
Well	140,000	30	
Total Fixed Cost	393,500		27,500
			-
Variable Items			Amount (₦)
Land clearing, Seed bed preparation, manuring and planting			220,000
Watering, Weeding and Spraying			510,753
Cost of Bio pesticide (1) & (2)			67,000
Cost of Fuel (petrol)			71,398
Cost of Manure with Transportation			22,000
Cost of Seeds			26,000
Cost of Harvesting			84,000
Total Variable Cost			1,020,083.33

Source: Field experiment, 2020

Table 2: Gross Returns per Hectare of *Corchorus-Amarantus* intercropped and Sole Cropping Systems.

Cropping systems	Output (kg/ha)	Average market price (₦/kg)	Total Revenue(₦)
Corchorus/Amaranthus (intercropped)	8000	200	1,600,000
Corchorus (sole)	2600	200	520,000
Amaranthus (sole)	6000	200	1,200,000

Source: Field experiment, 2020

Table 3: Cost and Returns per Hectare of *Corchorus-Amarantus* Intercropped, Amaranthus (sole) and Corchorus (sole) Cropping Systems

Items (₦/ha)	Amaranthus-Chochorus (₦/ha)	Amaranthus (sole) (₦/ha)	Corchorus (sole) (₦/ha)
Gross returns	1,600,000	1,200,000	520,000
Total variable cost	1,020,083.33	1,020,083.33	1,020,083.33
Gross margin	579,916.67	179,916.67	(500,083.33)
Benefit cost ratio	1.53	1.15	(0.49)
Rate of return	0.52	0.15	(0.50)
Gross ratio	0.65	0.87	(2.01)

Source: Field experiment, 2020

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BACTERIOLOGICAL ASSESSMENT OF FOUR SOURCES OF BOREHOLE WATER IN YOBE STATE UNIVERSITY CAMPUS, DAMATURU, YOBE STATE.

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ABSTRACT

Bacteriological assessment of four different borehole water sources in Yobe State University were conducted during the 2017/2018 academic session using standard laboratory analysis. The results showed two organisms; Salmonella and E. coli at significant levels ($p<0.005$) from the samples collected. The treatment combination of each sample collected A, B, C and D had a dilution factor of 10^{-3}, $10^{-5,}$ and 10^{-7}. The result of plate counts showed that all water samples had colony counts below 10cfu/ml, which showed that all samples collected in Yobe State University campus met the World Health Organization (WHO) standard requirement for drinking water under its water standard guideline (2006), approved colony count of 1 – 10cfu/100ml of drinking water is acceptable. The data collected were subjected to analysis of variance (ANOVA), using Statistical package (SAS version 8.0) to elucidate the valid information from the outcome of the research, showing significant differences using the least significant difference (LSD.

Key: Sample, infectious, borehole, significant, Bacteria, Data, and E. coli

INTRODUCTION.

Life on earth is entirely and exclusively dependent on water. As an essential prerequisite of agriculture and industrial production, water serves as the source of food needed for the survival of life. Even though water covers more than 70% of the earth, only 1% of the earth's water is available for drinking and our society continues to pollute it (Okapor, 2005).

It is well established that a large number of infectious diseases are transmitted primarily through water supplies contaminated with human and animal excreta particularly feces (Colombati, 2009).

The bacteria family (*Enterobacteriaceae)* comprise the general commonly referred to as coliform and fecal bacteria. These bacteria are naturally intestinal, as normal flora of man and other animals, but with greater potential inhabiting any other part of the body as *saprophytes*, obligate or *opportunistic* pathogens (Getnet, 2008).

Insufficient treatment of water and contamination of the water by various pathogenic microorganisms can be potential causes of water-borne diseases of diverse symptoms. Symptoms of these illnesses range from fever and malaise to gastrointestinal symptoms such as diarrhea and stomach aches. Water-borne diseases

usually occur when sanitation and living conditions are generally poor in addition to lack of safe water sources (WHO, 2009).

This study accessed the bacterial load presence in different sources of borehole water on the Yobe State University campus.

METHODOLOGY.

Sample Collection: Study Samples were collected insterile (in sterile) containers from four (4) different locations on the Yobe State University campus. Sample A was collected from the new hostel borehole, while sample B was taken from the old hostel and staff quarters borehole. Samples C and D were respectively collected from the Yobe State University Sachet water borehole and the YSU farm borehole and immediately transferred to the research laboratory.

Preparation of Growth Media: All media used for the culture and isolation namely; Nutrient agar, MacConkey broth, and Eosin methylene blue agar (TM media, India)) were prepared according to the manufacturer's instruction. About 100ml of water sample was filtered with aid of a membrane filter using a vacuum. The membrane was removed aseptically and placed on Nutrient agar (NA) as a basal medium and MacConkeyagar as a differential medium to determine enteric bacteria. All the plates were incubated at37°C for 24 hrs. Coliform colonies (indicating faecal contamination) growing on the surface of the membrane were recorded as a presumptive test results.

Presumptive colonies were confirmed by gram staining, microscopy, and biochemical (Indole, Methyl-red, Vogues Proskauer, Citrate utilization Catalase and Oxidase) tests, nitrate reduction, sugar fermentation, and motility test. Each plate was graded as positive or negative. Bacteria isolates were further characterized according to Bergey's Manual of Systemic Determinative Bacteriology (Holtet al., 2002).

Treatments and Experimental Design: The treatments consisted of four water samples (A, B, C, and D) and three dilution factors (10^{-3}, $10^{-5,}$ and 10^{-7}) which were combined factorially and laid out in a completely randomized design (CRD). The treatments were allocated randomly.

Treatment Combinations

Dilution factor	Water sampling sites			
	A	B	C	D
10^{-3}	A10^{-3}	B10^{-3}	C10^{-3}	D10^{-3}
10^{-5}	A10^{-5}	B10^{-5}	C10^{-5}	D10^{-5}
10^{-7}	A10^{-7}	B10^{-7}	C10^{-7}	D10^{-7}

Data Collection: Data were collected based on the number of colonies, colony colors, gram staining. Morphological characteristics based on gram reaction, production of gas in the Mac broth, and suspected organisms.

Data Analysis: The data collected were subjected to analysis of variance (ANOVA), using the SAS Version 8.0 statistical software to elucidate the valid information from the outcome of the research and the means that showed significant difference were separated using the least significant difference (LSD).

RESULTS AND DISCUSSIONS.

The Results on the influence of water samples and dilution factors in laboratory assessment of borehole water in Yobe State University Damaturu during the 2017/2018 Academic session revealed that New hostel borehole (Sample A) was significant at (P<005) and therefore suspected to be contaminated by *Salmonellae* species while

in the case of Samples B, C and D, E. coli was significantly (P<005) suspected.

Results on the presence of suspected organisms in the water samples collected in Yobe State University Damaturu during the 2017/2018 Academic session show that New hostel borehole water (Sample A) was significantly (P<005) suspected to be affected by *Salmonellae spp* while the other samples (B, C, and D) Was found to be significantly (P<005) suspected to be affected by *Escherichia coli* respectively.

Results on the presence of colonies in mass on the samples collected in Yobe State University Damaturu during the 2017/2018 Academic session show that water samples were not significantly (P >005) affected by the number of colonies at the different sampling sites while the dilution was found to be significantly (P <005) affected by the number of colonies at the different sampling sites. Sample A differs significantly (P <005) from the other samples as it contains a higher number of colonies compared to the rest, table 3.

The assessment of bacterial contamination of different sources of borehole water in this study shows that new hostel borehole (Sample A) was found to be significantly (P<005) affected by *Salmonellae* species while Samples B, C, and D were significantly (P<005) affected by *Escherichia coli*, respectively table 1.

It was also observed from the result obtained in this study that the influence of water samples and dilution factors in laboratory assessment of borehole water in Yobe State University Damaturu, during the 2017/2018 Academic session was high because two bacterial species (*Salmonella*spp and *Escherichia coli*) were found, and this is due to lack of treatment of the water before passing for public use. Contamination may also occur as a result of breakages of the pipes which causes leakages and subsequent penetration of the fecal bacteria into the water pipes which supplies the general public.

Table 1: Presumptive test of cultural characteristics, Gram's and Shapes of the coliforms suspected with the influence of samples and dilution.

Treatment Sample	AEMB	GR	MBGR	PAMB	PGMB	SO
A	Brownish	-	4.6667[a]	+	+	*Salmonellae*
B	Green metalic sheen	-	4.3333[a]	+	+	*E.coli*
C	Green metalic sheen	-	5.3333[a]	+	+	*E.coli*
D	Green metalic sheen	-	5.3333[a]	+	+	*E.coli*
Significance	*	NS	NS	NS	NS	NS
S.E±	-	-	0.7454	-	-	-
Dilution factor						
10^{-3}	19.250[a]	-	5.0000[a]	+	+	9.7500a
10^{-5}	19.250[a]	-	5.0000[a]	+	+	9.7500a
10^{-7}	19.250[a]	-	4.7500[a]	+	+	9.7500a
Sig.	NS	NS	NS	NS	NS	NS
SE±	3.8891	-	0.6972	-	-	0.3536

KEY: AEMB = Appearance on Eosin Methylene Blue GR = Gram reactionSO = Suspected organismsPAMB= Production of acid in MacConkey brothMBGR= Morphological characteristics base on gram reactionSE = Standard ErrorNS = Not significantPGMB= Production of gas in macconkey broth*= Significant.

Table 2: Confirmatory of Bacterial Isolates from Water Samples.

Confirmatory Test	A	B	C	D
Indole	-	+	+	+
Methyl Red	+	+	+	+
Vogue Proskeaur	-	-	-	-
Citrate utilization	-	-	-	-
Catalase	+	-	-	-
Coagulase	-	-	-	-
Oxidase	-	-	-	-
Motility	+	+	+	+
Nitrate reduction	+	+	+	+
Mannitol fermentation	+	+	+	+
Lactose Fermentation	-	+	+	+
Confirmed Organism	Salmonella typhi	E. coli	E. coli	E. coli

KEY: A = New hostel borehole B = Old hostel and staff quarters borehole C = Yobe State University sachet water industry borehole D = Yobe State University farm borehole.

Table 3; Shows the presence of colonies in mass in the samples collected in Yobe State University Damaturu during the 2018/2017 Academic session.

SAMPLE SOURCE	BACTERIAL SPECIES	NUMBER OF COLONIES
A	*Salmonellae*	0.0338^{a}
B	*E.Coli*	0.2148^{a}
C	*E.Coli*	0.2427^{a}
D	*E.Coli*	0.3342^{a}
Significant	*	NS
S.E		0.3274
Dilution factors		
10^{-3}		$0.615O^{a}$
$1o^{-5}$		0.00414^{b}
10^{-7}		0.0000304^{b}
Significant		*
S.E		0.1541

KEY: A = New hostel borehole
B = Old hostel and staff quarters borehole
C = Yobe State University sachet water industry borehole
D = Yobe State University farm borehole
SE= Standard Error
NS= Not significant

According to (WHO, 2010) water has long been considered a vehicle for transmission of diseases like cholera, typhoid fever, etc. However, no source of water (was) 100 percent free of contamination by micro-organisms despite the effective treatment method employed. As it was seen from the result obtained for the bacteriological analysis of the water in this study; that the suspected organism from the new hostel borehole (sample A) was found to be *Salmonellae* Spp while in the other sampling sites (B, C, and D) was *E.coli*. This was similar to the work of the Centre for disease control (1990), that the greatest danger to individuals' health from water pollution derives from enteric pathogens which results predominantly in health hazards and could

result in amoebic dysentery, typhoid, cholera, diarrhea, etc. This finding is also in agreement with the work of Krenkel and Novotny (1980) that in developing countries like Nigeria waterborne disease is still a cause of some ten million deaths per year and five hundred million cases of illness.

Geldrich(2005) under WHO (2004-2006) guidelines for the construction of dams disregard these types of setting as far as the potable water supply is concerned. This could be said to be partly responsible for the dissemination of the microbial pathogen. Moreover (Moringo *et al*; 2005) reported that 65 to 85% of waterborne disease is associated with public and private water contamination. The high count of the organisms in water may be explained as proffered by N. T (Dabo, 2006), by the fact that they are autochthonous to the animal intestinal tract, yet, capable of free-living and so proliferate in water under normal environmental conditions. This may explain partly why the incidence of a recent enterobacterial infection was observed to be very high all over in the developing country. More so the contamination may be due to pipe damages such as breakages during fittings and construction or due aging which leads to leakages and seepage with the resultant admixture of their content with toilet water, sewage water, soil, and vegetable nearby. Observations have shown that these greatly introduced highly turbid (dark or brown) unhealthy water to consumers- whose more than half of its population do not bother to boil or filter before use. It was therefore not surprising to deduce that majority of the water supplied contains fecal bacteria as also provided by Exner and Martins (2007).

The high number of these pathogens in the water samples from the study areas needs public health attention. The high prevalence of pathogens in this study is in agreement with the findings of Obi and Okocha (2007) and Amajor *et al.* (2012), the presence of fecal bacteria in all of the sampling sites is unacceptable from the public health point of view. These organisms could be pathogenic. Therefore, there is a need for caution when using this contaminated borehole water source for any purpose. Also, the result of the finding is in agreement with the findings Agbabiaka and Sule (2010) obtain some numbers of Coliforms in Ilorin (Nigeria) metropolis borehole water samples. Most of the samples were contaminated with both fecal and non-fecal coliform bacteria.

The boreholes have only one species of bacteria and not a combination of them, this is based on the fact that the boreholes were dug down to the aquifer level beyond the level at which most of the enteric pathogen survives.

The outcomes of the findings of this research reveal that both the dilution factor 10^{-3}, $10^{-5,}$ and 10^{-7} were all contaminated with the fecal bacteria but were considered slightly safe for human consumption since the values reported were within the ranges of 9.75 which were slightly lower than the values reported for being not safe for human consumption which is 10cfu/100mls (WHO2004). Moreover, corrective measures need to be taken to eliminate the bacterial load for it to be rated safe for domestic usage.

The result reveals *Salmonella* spp and *E. coli* were the major organisms that were obtained after the isolation and this is as a result of proper maintenance (through repairmen of leakages that can allow bacterial access into the pipes) and a high-water table that reaches the aquifer level and thus limits the number of the microorganism present in the water.

The result on the number of colonies shows that numbers of colonies were not significantly ($P > 005$) different from one another for sampling sites while for the

dilution factor 10^{-3} was significantly (P < 005) different from 10^{-5} and 10^{-7} this shows that the number of colonies was the same for all the sampling sites where for the dilution factor 10^{-3} produces a higher number of colonies as compared to 10^{-5} and 10^{-7} respectively. The high number of these pathogens in the water samples from the study areas needs public attention. The high prevalence of pathogens in this study is in the agreement with findings of Obi and Okocha (2007). The presence of these organisms in the sampling sites is unacceptable from the public health point of view. These organisms could be pathogenic. Therefore, there is a need for caution when using these contaminated borehole water for any purpose.

The result on the presence of suspected organisms in the water samples collected in Yobe State University Damaturu during the 2017/2018 Academic session is presented in table 2.

Result on the presence of suspected organisms in the water samples collected in Yobe State University Damaturu during the 2017/2018 Academic session shows that New hostel borehole water (Sample A) was significantly (P<005) suspected to be affected by *Salmonellae spp* while the other samples (B, C, and D) Was found to be significantly (P<005) suspected to be affected by *Escherichia coli* respectively table 2.

It was also discovered from this study that the influence of water samples and dilution factors in laboratory assessment of borehole water in Yobe State University Damaturu, during the 2017/2018 Academic session was high because two microorganisms were found, the microorganisms were *Salmonella* spp and *Escherichia coli* and this is due to lack of treatment of the water before passing for public use, contamination may also occur as a result of breakages of the pipes which causes leakages and subsequent penetration of the fecal bacteria into the water pipes which supplies the general public. According to (WHO, 2010) water has long been considered a vehicle for transmission of diseases like cholera, typhoid fever, etc.

The high number of these pathogens in the water samples from the study areas suggests the need for essential health educations. The high prevalence of pathogens in this study is in agreement with the findings of Obi and Okocha (2007) and Amajor *et al.,* (2012), the presence of fecal bacteria in all of the sampling sites is unacceptable from the public health point of view. These organisms could be pathogenic. Therefore, there is a need for caution when using this contaminated borehole water source for any purpose. Also, the result of the finding is in agreement with the findings Agbabiaka and Sule (2010) obtain some numbers of Coliforms in Ilorin (Nigeria) metropolis borehole water samples. Most of the samples were contaminated with both fecal and non-fecal coliform bacteria.

The boreholes have only one species of bacteria and not a combination of them. This is based on the fact that the boreholes were dug down to the aquifer level beyond the level at which most of the enteric pathogen survives. The soil temperature obtainable in that region is also above the thresh-hold level for their survival. Borehole A had *Salmonella* species which may be attributed to the leakages on the pipes which bring impurities into the water before passing for public consumption while boreholes B, C, and D had *Escherichia coli* and this could be due to the contamination by feces of the defecating students near and around the boreholes which brings contaminations by the enteric pathogens.

The outcomes of the findings of this research reveal that both the dilution factor 10^{-3}, $10^{-5,}$ and 10^{-7} were all contaminated with the fecal bacteria but were considered slightly safe for human consumption since the values reported were within the ranges of 9.75 which were slightly lower than the values reported for being not safe for human consumption which is 10cfu/100mls (WHO2004). Moreover, corrective measures need to be taken to eliminate the bacterial load for it to be rated safe for domestic usage.

The result reveals *Salmonella* spp and *E. coli* were the major organisms that were obtained after the isolation and this is as a result of proper maintenance (through repair of leakages that can allow bacterial access into the pipes) and a high water table that reaches the aquifer level and thus limits the number of the microorganism present in the water.

The result on the number of colonies shows that numbers of colonies were not significantly (P > 005) different from one another for sampling sites while for the dilution factor 10^{-3} was significantly (P < 005) different from 10^{-5} and 10^{-7} this shows that the number of colonies was the same for all the sampling sites where for the dilution factor 10^{-3} produces a higher number of colonies as compared to 10^{-5} and 10^{-7} respectively. The high number of these pathogens in the water samples from the study areas needs public attention. The presence of these organisms in the sampling sites is unacceptable from the public health point of view. These organisms could be pathogenic. Therefore, there is a need for caution when using these contaminated borehole water for any purpose.

According to USEPA standard, water samples in which coliforms are accepted should be considered unacceptable for drinking water as they are regarded as the principal indicators of water pollution (United state environmental protection agency USEPA, (1976).

These are pathogenic organisms mainly of fecal origin. Any water source used for drinking or cleaning purposes should not contain any organism of fecal origin Boundet (1977). The presence of enteric coliform especially Escherichia coli makes the water samples unsuitable for human consumption according to the guidelines set by WHO for the evaluation of the bacteriological quality of drinking water. WHO (1996), Apart from environmental hygiene and population density the presence of *Salmonella* spp in the water sampling sites in the sites in this study may also be attributed to drainage and flooding from contaminated surface water in un-protected/broken pipes. Findings from this study highlight the non-conformity of study samples with WHO standard recommendation for safe portable water Lechebaliar *et al.* (1987). A situation where high counts of enteric pathogens are isolated from sources of water consumed by humans is a serious problem that calls for vigilance on the part of authorities as it signals possible future outbreaks of water-borne diseases. Such disease outbreaks may spread widely within the state and even possibly extend to neighboring states.

The reason for the gross contamination of the water from the sampling sites by the pathogens as observed in this study may be due to breakage and leaking pipes which allowed the easy entrance of particles from the surroundings. It may also be due to poor sanitary conditions around the area where such boreholes are located.

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CHALLENGES CONFRONTING CITRUS (*Citrus sinensis*) PRODUCTION IN NORTH-CENTRAL AND SOUTH-WESTERN NIGERIA.

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ABSTRACT.

Citrus is one of the most important fruit crops in Nigeria. In order to maximally utilize the comparative advantage of the country in the commodity value chain, there is the need to identify major challenges of citrus farmers in selected zones of Nigeria. The North Central (NC) and South West (SW) zones of Nigeria, from which the bulk of citrus in the country is produced, were purposively selected. Primary data was collected from 302 respondents using structured questionnaire. Data were analyzed using descriptive statistics. Result revealed that most of the respondents were male (59.6%), married (88.7%) and within 31-40 years (25.8%) and were literate with 39.7% and 24.5% having secondary and tertiary education. Majority (41.7%) of the respondents had 1-10 years' experience in citrus production. Prevalent farming systems practiced were mixed farming (63.2%) and mixed cropping (25.8%). Pests and disease problems (88.1%), inaccessibility to procurement of fertilizers (84.4%) and high cost of agrochemicals (83.4%) were ranked the major challenges among the farmers. Critical areas of information needs were on safe use of agrochemicals (65.6%), storage of fruits (63.6%) and health and nutrition benefits of Citrus (60.6%). The most important training needs were on credit and loan procurement (76.2%), storage of fruits (74.5%) and access to marketing channels (71.9%). Easy access to inputs, frequent training of farmers to build their capacity and provision of location specific processing and storage facilities are recommended.

Keywords: Citrus, Producers, Constraints, Information and Training needs.

INTRODUCTION.

Citrus (*Citrus sinensis*) production takes place across the tropical and sub-tropical countries of the world; however, Brazil, China and United States are the topmost producers (Spreen, 2008). Global production of Citrus fruits in thousands metric tonnes in 2019 by region was 79,544.48, 28, 393.35, 20,937.18, 10,586.9, 10,093.92, 72309.85, 640.61, 551.98 for Asia, South America, Africa, Europe, Central America, Northern America, Caribbean and Oceania respectively (Statista, 2021). Within Africa, large scale production of citrus occurs on the Mediterranean coast, South Africa, Zimbabwe, Mozambique and Swaziland. South Africa was adjudged to be 8th top producer of orange and 5th processor and exporter of lemon and lime. The 2007 Food and Agriculture Organization report rated Nigeria as the 9th Citrus producing country

with annual average production capacity of about 3, 325, 000 tonnes (Olife, *et al.,* 2015). Citrus got adapted to Nigerian ecology after its introduction to the country by missionaries and colonial masters and it is mainly planted for fresh juice consumption (Olife, *et al*., 2015). Citrus is mostly grown in the North Central part of the country using wide spacing to accommodate intercrop with arable crops such as maize (*Scientific name?*), guinea corn (*Scientific name?*) and soya beans (*Scientific name?*). In this zone, cattle is allowed to graze crop residues of arable crops after harvesting and also consume small to medium sized citrus fruits that dropped from trees. This helps to prevent rottenness of such fruits and breeding of pests.

The most important factor in the choice of site for citrus production is free drainage of water. Citrus can be grown on a wide range of soil types but sandy loam soil is the most ideal, Citrus does not like shade therefore land should be cleared of all trees stumps and appropriately ploughed before orchard establishment (NIHORT, 2019). Planting of budded seedlings is highly essential because they are true-to-type, mature faster and are less susceptible to diseases (NIHORT, 2019; IITA, 2018). Most citrus production is accounted for by oranges (*Scientific name?*), but significant quantities of grapefruits (*Scientific name?*), lemons (*Scientific name?*) and limes (*Scientific name?*) are also grown (Olife *et al* 2015). Citrus fruit ranks first internationally in trade value among all fruits (Norberg, 2008; UNCTAD, 2009). Sweet oranges are the major fruit grown and represent approximately 70 percent of the citrus output (FAOSTAT, 2007).

Looking critically at citrus production in Nigeria, production is still mostly at small scale level while most orchards in the country were raised from seeds and are also growing old thus citrus production in terms of yield is still below expectation. This study therefore seeks to identify major challenges confronting citrus farmers in Nigeria. The specific objectives of the study were to: determine the socio-economic characteristics of citrus farmers, identify challenges encountered in production and ascertain information and training needs of citrus farmers.

METHODOLOGY.

The North Central (NC) and South West (SW) zones of Nigeria that produce bulk of the citrus in the country were purposively selected. Respondents were contacted through the Agricultural Development Programme (ADP) in the selected zones thus, selection was from available farmers under the auspices of the state ADPs in the selected zones. Areas covered in the NC were Benue Sate (Tarka and Ushongo); and Nasarawa State (Eggon, Oba, Obi and Akwanga) while in the SW, Oyo (Afijio) and Ogun States (Yewa, Sagamu, Remo North, Ikenne and Ilaro) were covered. Structured questionnaire was used to collect information from respondents. A total of 302 respondents were interviewed for this study (comprising 222 and 66 respondents from the NC and SW zones respectively). Greater proportion of the respondents was from the NC zone due to the fact that citrus is one of the most important horticultural crops in the zone and quite a number of farmers have citrus orchard. Data were analyzed using descriptive statistic and rank order.

RESULTS AND DISCUSSION.

Socioeconomic Characteristics of Respondents.

Most of the respondents were male (59.6%) and married (88.7%) with family size of 1-10 (60.6%). This showed dominance of the male folks in citrus production (Table 1). Having more male in Citrus production in the zone was also reported by Olajide-Taiwo et al. 2009 and Alabi et al, 2011. Age distribution of the respondents showed that most of them were within 31-40 years (25.8%). This is an indication that the producers were young and active. Most of the farmers were literate with 39.7% and 24.5% having secondary and tertiary level of education. The level of education may improve their level of adoption and awareness on innovation in agricultural production. Greater proportion (87.4%) of the respondents had Citrus farm size of 1-10 acres. This indicated that most of the Citrus farmers were small holders. Majority (41.72%) of the respondents had 1-10 years' experience in citrus production followed by 11-20 years (29.5%). Greater proportion (72.5%) of were members of association and the major business of the association being cooperative society (39.7%), farmers association (25.4%) and religious group (3.3%) (Table 1).

Mixed farming is the prevalent farming system employed by the sampled farmers (63.2%), followed by mixed cropping (25.2%) with few (0.3%) practicing intercropping system. However, Okafor (2020) affirmed that intercropping is a common practice in citrus production in Nigeria, this is carried out to generate extra income by farmers before economic yield and maturity are attained. Intercropping was not common among the sampled farmers in this study probably because they were involved in mixed farming and mixed cropping which are able to also alleviate the chance of possible risk in farming. Most farmers in Nigeria are involved in planting more than one crop and also practice rearing of animals. This is employed to guard against risks which is prevalent in agricultural production, diversify the economic base of the farmers and provide additional source of income for farmers. Other notable crops cultivated by the farmers include cassava (48.68%), soya beans (37.75%), corn (23.48%) and tomato (12.25%) (Table 2) while common animals reared were goat (68.21%), chicken (51.2%), pig (23.51%) and sheep (15.0%) (Table 3). This is a confirmation of mixed farming practices among the farmers.

Table 1: Socioeconomic characteristics of respondents (n = 302)

Items	Variables	Frequency	Percentage
Sex Distribution	Female	122	40.4
	Male	180	59.6
Marital status	Married	268	88.7
	Single	23	7.6
	Widowed	3	1.0
	No response	8	2.6
Family size	1-10	183	60.6
	11-20	67	22.2
	21-30	13	4.3
	31-40	3	1.0
	41-50	1	0.3

Items	Variables	Frequency	Percentage
	51-60	0	0
	61-70	1	0.3
	71-80	1	0.3
	No response	33	10.9
Age (years)	<20	11	3.6
	21-30	51	16.9
	31-40	78	25.8
	41-50	63	20.9
	51-60	54	17.9
	61-70	f21	7.0
	71-80	16	5.3
	>81	3	1.0
	No response	5	1.7
Education	No formal education	25	8.3
	Primary	62	20.5
	Secondary	120	39.7
	Tertiary	74	24.5
	Others	5	1.7
	No response	16	5.3
Experience	1-10	126	41.7
	11-20	89	29.5
	21-30	37	12.3
	31-40	19	6.3
	41-50	12	4.0
	51-60	0	0
	No response	19	6.3
Citrus farm size (ha)	1-10	264	87.4
	11-20	9	3.0
	21-30	0	0
	31-40	0	0
	41-50	0	0
	51-60	0	0
	61-70	0	0
	71-80	0	0
	>80	8	2.6
	No response	21	7.0
Farming system	sole cropping	9	3.0
	mixed cropping	78	25.8
	mixed farming	191	63.2

Items	Variables	Frequency	Percentage
	Intercropping integrated	1	0.3
	farming	2	0.7
	no response	21	7.0
Membership of association	Yes	219	72.5
	No	83	27.5
Business of the group	Cooperative Society	120	39.7
	Farmers Association	77	25.5
	Religious group	10	3.3
	Others	9	3.0
	No response	86	28.5

Table 2: Other common crops grown by respondents

Crops	Frequency	Percentage
Banana	5	1.65
Cassava	147	48.6
Cocoa	8	2.65
Groundnut	27	8.94
Guinea corn	11	3.64
Melon	3	0.99
Onion	4	1.32
Oil Palm	13	4.30
Pineapple	21	6.9
Plantain	15	4.9
Rice	79	26.1
Soy beans	114	37.7
Tomato	37	12.2
Beans	31	10.2
Cashew	39	12.9
Coconut	2	0.6
Kola	5	1.6
Pepper	21	6.9

Table 3: Common livestock reared by citrus farmers.

Animals	Frequency	Percentage
Chicken	155	51.32
Cattle	5	1.65
Dog	4	1.32
Duck	3	0.99
Goat	206	68.21
Grass cutter, geese, rabbit, fish	7	2.3
Pig	71	23.51
Sheep	15	4.96
Turkey	9	2.98
Sheep	59	19.53

Challenges of Citrus Producers in Nigeria.

The diverse challenges faced by Citrus producers can be categorized into factors of production/input, post-harvest handling and human/natural factors. Considering factors of production and input, challenges of high priority include inaccessibility to fertilizer procurement (84.4%), high cost of farm chemicals (83.4%) and high labour cost (82.5%). The topmost post-harvest challenges among the producers are high transport cost (80.5%), inadequate storage facilities (79.5%) and inadequate post-harvest handling practices (74.8%). Human and natural factors affecting Citrus producers mostly are pests and diseases infestation (88.1%)> climate change (71.9%) > failure in harvest (69.9%) ranked in that order. Other challenges affecting majority of the respondents are pilfering (63.3%), glut (60.3%) and inadequate extension service delivery (59.3%). The challenges of post-harvest losses could be due to inadequate post-harvest technologies in the country. Value addition is germane to prevention of post-harvest losses in most horticultural produce. Processing of agro raw materials into various innovative products promotes market acceptability and give the products high economic value which consequently brings higher income to the producer (Onwualu, 2009a; Olife, et al., 2013a, b). Processing also expands the horizon of human participation in the production process and therefore creates awareness for employment generation in the downstream activities such as packaging, marketing, retail and exports (Onwualu, 2009b). Citrus pulp after extraction of juice from the fruits can serve as livestock feed and the rind acid (oil) is an expensive commodity in the international market (Olife *et al*., 2015). Despite the huge advantages in value addition, Adeyemi (2005) affirmed that citrus processing is very low in Nigeria, most of the juice industry in Nigeria depend on importation of citrus juice concentrate as source of raw materials. Commercial cultivation of citrus along sides with other fruit crops for large scale processing into various fruit products is inadequate in Nigeria.

Constraints to citrus production reported by Oyedele and Yahaya (2010), included irregular fruit bearing, fluctuating weather, inadequate farm labour and pest problems which was ranked as the most limiting by

87.5% of sampled respondents. Olajide-Taiwo et al (2011) also observed disease infestation, pest infestation and susceptibility to drought among others as the most pressing risk factors in Citrus production in the North Central zone of the country. The challenges in citrus production are serious threat that could hamper efficiency of Citrus production in the country if not well addressed.

Information and training needs of Citrus producers.

Information needed most by the Citrus farmers were safe use of agrochemicals (65.6%), Storage of fruits (63.6%) as well as health and nutrition benefits of Citrus (60.6%). The most important training needs among respondents are on credit and loan procurement (76.2%), storage of fruits (74.5%) and accessing of marketing channels (71.9%). Availability of credit to farmers if properly channeled can encourage purchase of processing and storage equipment thus reducing the challenge of post-harvest losses. Accessibility to market and market information will enhance farmers income while reducing the negative impact of middle men. Other areas of important information needs are credit/loan procurement, accessing marketing channels and processing among 58.6%, 54.3%, and 52.3% of the respondents respectively (Table 5). The least area of information needs were is harvesting (29.5%), land preparation and planting (30.8%) and weather information (34.4%).

Table 4: Challenges of Citrus producers

				Severity		
		Yes Freq (%)	Rank	Very severe	Severe	Not severe
A	**Inputs/Factors of production**					
i.	Cost of planting materials	221(73.2)	4	88(29.1)	35(11.6)	8(2.6)
Ii	Timely availability of improved seeds	185(61.3)	7	56 (18.5)	69(22.8)	30(9.9)
Iii	Non-availability of improved planting materials	212(70.2)	6	67(22.2)	88(29.1)	26(8.6)
Iv	High cost of farm chemical	252(83.4)	2	119(39.4)	78(25.8)	14(4.6)
v.	Limited productive land	164(54.3)	8	50(16.6)	59(19.5)	22(7.3)
Vi	Adulteration of farm chemicals	215(71.2)	5	87(28.8)	75(24.8)	15(5.0)
vii	Inaccessibility to fertilizer procurement	255(84.4)	1	108(35.8)	78(25.8)	16(5.3)
viii	High labour cost	249(82.5)	3	106(35.1)	79(26.2)	8(2.6)
B	**Transportation and post-harvest challenges**					
i.	High transportation cost	243(80.5)	1	108(35.8)	76(25.2)	12(4.0)
ii.	Bad road network	224(74.2)		9712(32.1)	79(26.2)	1712(5.6)
Iii	Inadequate post- harvest handling	226(74.8)	3	75(24.8)	90(29.8)	21(7.0)
Iv	Inadequate storage facilities	240(79.5)	2	116(38.4)	62(20.5)	22(7.3)
V	Inadequate market information	220(72.8)	5	86(28.5)	87(28.8)	14(4.6)
C	**Human and natural factors**					
I	Glut	182(60.3)	5	63(20.9)	60(19.9)	23(7.6)
Ii	Pilfering	191(63.3)	4	47(15.6)	55(18.2)	36(11.9)
Iii	Harvest failure	211(69.9)	3	86(28.5)	51(16.9)	38(12.6)
Iv	Climate change	217(71.9)	2	66(21.9)	69(22.8)	31(10.3)
v.	Extension services	179(59.3)	6	83(27.5)	70(23.2)	15(5.0)
vi.	Pest and diseases infestation	266(88.1)	1	137(45.4)	73(24.2)	9(3.6)

Table 5: Information and training needs of Citrus producers

		Information needs		Training needs	
	Information and training needs	Frequency (%)	Ranking	Frequency (%)	Ranking
1.	Storage of fruits	192 (63.6)	2	225(74.5)	2
2.	Nursery preparation techniques	117(38.7)	8	193(63.9)	9
3.	Land preparation and planting	93(30.8)	10	198(65.6)	8
4.	Weed management	134(44.4)	7	207(68.5)	7
5.	Weather information	104(34.4)	9	208(68.9)	6
6.	Safe use of agrochemicals	198(65.6)	1	212(70.2)	5
7.	Harvesting	89(29.5)	11	182(60.3)	11
8.	Processing	158(52.3)	6	187(61.9)	10
9.	Marketing channels	164(54.3)	5	217(71.9)	4
10.	Credit/Loan	177(58.6)	4	230(76.2)	1
11.	Health and nutrition	183(60.6)	3	221(73.2)	3

CONCLUSION AND RECOMMENDATION

Greater proportion of the respondents were male, literate, married, within the active age group and had 1-10 years' experience in citrus production. Mixed farming and mixed cropping are the prevalent farming systems among the farmers. Pests and disease infestation, inaccessibility to procurement of fertilizers and high cost of agrochemicals were the prominent challenges among the farmers. Information mostly needed was on safe use of agrochemicals, storage of fruits as well as health and nutrition benefits of Citrus. The most important training needs are on credit and loan procurement, storage of fruits and accessing of marketing channels. Input should be made available and affordable for farmers, Provision of location specific processing and storage facilities, frequent training to build capacity of farmers as well as construction of rural road network are recommended. This will enhance the contribution of the commodity to food security, sustainable livelihood and the nation's economy at large.

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GROWTH ATTRIBUTES AND WOOD YIELD OF THREE KENAF (*HIBISCUS CANNABINUS* L.) VARIETIES AS INFLUENCED BY THE APPLICATION OF DIFFERENT RATE OF POULTRY MANURE.

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ABSTRACT

Field trials were conducted during the 2017 wet season at the Research farms of the Institute for Agricultural Research, Samaru and Kadawa to study the wood yield response of three Kenaf (*Hibiscus cannabinus* L.) varieties (Ifeken 400, Ifeken D1 400 and Girin danani) under four rate of poultry manure (0, 2, 4 and 6 t ha^{-1}) factorially combined and laid in a Randomized Complete Block Design (RCBD) and replicated three times. Plots treated with 6 t ha^{-1} poultry manure produced taller plants with more leaves, higher shoot dry weight and wood yield. Girin danani produced taller plants, more number of leaves, higher shoot dry weight and wood yield than Ifeken 400 and Ifeken D1 400 in both locations.Based on the results obtained from this trial, the application of 6 t ha^{-1} poultry manure resulted in better growth and higher wood yield with all the varieties while Girin Danani yield better than the other two varieties in both locations.

Keywords: Growth attributes, Poultry manure, Kenaf and Varieties.

INTRODUCTION.

Kenaf (*Hibiscus cannabinus* L.) is a fast growing annual crop of the Malvaceae family known for both its economic and nutritional importance. Kenaf is believed to have its origin in Africa (Western Sudan), occurring as early as 4000 BC, where diversified forms of its species are widely grown (Mostofa *et al,* 2013, Dempsey, 1975, Kobayashi *et al*., 2003 and Cheng *et al*., 2004).It is an erect annual shrub 1-4 meters height, with well-developed tap roots, straight and slender stems. It has cream-colored, large flowers characterized by a reddish purple throat. The seeds are cylindrical or kidney-shaped pubescent, grey in colour and ranged between 35,000 to 40,000 per kg. (Purseglove, 1974 and Dempsey, 1975). Kenaf is the most economically important fiber crop after cotton and jute. Kenaf is traditionally grown in East Central Africa, western Asia and in several southern states of America for fibre and seed oil production. It is also an excellent forage crop (Muchow and Wood, 1980) containing 18-30 % crude leaf protein and stalk protein 5.8-12.1 % (Ogbonnaya *et al.,* 1997). Kenaf fibre is comparable to jute in lustre, although it is coarse, less supple and resistant to rottening. The cordage fiber is used in sacks, mats, carpets, ropes roofing and canvass. The stalk is used as paper pulp and the seeds contain about 20% oil which is extracted and used as lubricant and for illumination, soaps, paints and varnishes (Purseglove, 1968).The leaf contains about 25 % crude protein (Killinger,1965) and is used in human diets and animal feeds. Investigation has indicated that Nigerian savannah soils are largely deficient in major essential nutrients like

nitrogen, phosphorus and potassium. Making it necessary to supply and enrich the soil with applied nutrients using inorganic and organic sources such as poultry, cow and goat manure. The use of inorganic fertilizer is constrained by factors such as unavailability of the right type, at the right time, and at affordable cost, as well inadequate credit facilities for the farm inputs (Chude, 1999). Hence organic manure is a better alternative and a necessary option for improved crop production especially in the Northern Guinea and Sudan Savannah of Nigeria. Poultry manure is relatively cheap, readily available to small holder farmers and improve soil physical properties compared to inorganic fertilizers, similarly the increasing demand for poultry manure was due to its health benefits and risk-free characteristics especially in vegetables and fruits production. Poultry manure has been found to have higher nutrients concentration (Iken and Amusa, 2004). Although in Nigeria research work on poultry manure recommendation for kenaf production is not available, however improve and high yielding kenaf varieties have been developed such as Ifeken 400 and Ifeken D1 400. Based on this, the present study was undertaken with the aim to determine the most wood producing kenaf variety and response of the Kenaf varieties to poultry manure rate in Samaru and Kadawa.

MATERIALS AND METHODS

The experiment was conducted at the Institute for Agricultural Research (I.A.R) Farm, Samaru, (Latitude 11^0 11N Longitude $07^{'}$ 38 E, 686m) above sea level in Kaduna State and at Kadawa, (Latitude 11^0 39 N Longitude $08^{'}$ 27 E, 500m) above sea level in Kano State, in the northern Guinea and Sudan savannah ecological zones of Nigeria, respectively during the 2017 wet season (Kowal and Knabe, 1972). The treatments consisted of four rate of poultry manure (0, 2, 4 and 6 tons ha^{-1}) and three varieties of kenaf (Ifeken 400, Ifeken D1 400, and Girin danani). The treatments were factorially combined and laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The gross plot size was 4 m x 3 m (12 m^2) while the net plot was 2 m x 3 m (6 m^2).Data was collected on plant height, number of leaves, shoot dry weight and wood yield. The data collected were subjected to statistical analysis of variance (F-test) as described by (Snedecor and Cochran, 1967) to test significance of treatment effects. The treatment means were separated using Least Significant Difference (LSD) at 5% level of probability.

RESULTS AND DISCUSSION

Plant height (cm)

There was significant difference between varieties at 3 and 6 WAS at Samaru only. At 3 WAS, Girin danani significantly produced taller plants, than Ifeken D1 400 and Ifeken 400 which were statistically similar. At 6 WAS, Ifeken 400 produced significantly tall plants with Girin danani and both significantly produced taller plants than Ifeken D1 400. At Kadawa, no significant difference was observed between varieties on plant height of kenaf at all sampling periods. Application of poultry manure significantly influenced plant height of kenaf at 3 WAS and 6 WAS at Samaru and at 3 and 12 WAS at Kadawa. Where the application of 6 t ha^{-1} poultry manure produced taller plants than other rates of application. The interaction between varieties and poultry manure rate on the height of kenaf was not significant throughout the period of study.

Number of Leaves

Crop variety influenced leaves numbers at 3 WAS in Samaru. Ifeken D1 400 and Girin danani significantly produced higher number of leaves than Ifeken 400. Application of poultry manure had significant effect on the number of leaves of kenaf at 3 and 6 WAS in Samaru and

at 12 WAS in Kadawa. At 3 WAS in Samaru, application of 4 and 6 t ha^{-1} poultry manure produced similar and higher number of leaves than the lower rates, which were also similar. At 6 WAS in this location, the application of 4 t ha^{-1} of poultry manure significantly produced higher number of leaves than lower rates, but was statistically at par with the application of 6 t ha^{-1}. At 12 WAS in Kadawa, application of 6 t ha^{-1} poultry manure produced higher number of leaves than 2 t ha^{-1}, but was statistically at par with application of 4 and 0 t ha^{-1}, while the least number of leaves was obtained by the application of 2 t ha^{-1} which differed significantly with 0 t ha^{-1}.

Shoot Dry Weight

No significance difference between varieties was recorded at all sampling periods at both locations. The application of poultry manure significantly influenced shoot dry weight of kenaf at 9 WAS at Samaru while the application of 4t ha^{-1} poultry manure produced a significantly higher shoot dry weight compared to 0 t ha^{-1}; but statistically at par with plots applied with 2 and 6 t ha^{-1}. The least shoot dry weight was recorded on plots applied with 0 t ha^{-1}. There was a significant difference on the application of poultry manure on the shoot dry weight of kenaf at all sampling periods in Kadawa. At 3 WAS, the application of 2 t ha^{-1} poultry manure produced significantly higher shoot dry weight than plots applied with 0 t ha^{-1}; but statistically differed with plots applied with 4 and 6 t ha^{-1} poultry manure. However at 6, 9 and 12 WAS, shoot dry weight of kenaf generally increased with increasing rate of poultry manure from 2 to 6 t ha^{-1}. Shoot dry weight was significantly higher in plots applied with 6 t ha^{-1} poultry manure than on those with 0 t ha^{-1}. There was no significant difference on shoot dry weight from plots applied with 6 t ha^{-1} poultry manure and those applied with 2 and 4 t ha^{-1}. The lowest shoot dry weight was recorded on plots applied with 0 t ha^{-1}.The interaction between varieties and poultry manure rates on shoots dry weight of kenaf was significant at 9 and 12 WAS in Samaru is presented in (Table 4). At 9 WAS, the combination of poultry manure rate and varieties, recorded a significantly higher shoot dry weight with Ifeken 400 and 2 t ha^{-1} poultry manure; and was statistically similar with the variety Girin danani applied with poultry manure at 2 and 4 t ha^{-1} of poultry manure .The lowest shoot dry weight was recorded with Ifeken D1 400 applied with 2t ha^{-1} poultry manure. At 12 WAS, Ifeken 400 applied with 2 t ha^{-1} of poultry manure produced the highest shoot dry weight; but differed significantly with Girin danani applied with poultry manure at 2 and 4 t ha^{-1} and Ifeken D1 400 at 0 t ha^{-1}. The lowest shoot dry weight was recorded with Ifeken 400 at 0 t ha^{-1}.

Wood Yield

The wood yield differed significantly between varieties at both locations (Table 5). Girin Danani produced higher wood yield ha^{-1} compared with other varieties tested. Similarly, the application of poultry manure significantly influenced wood yield at both locations. At Samaru, application of 6 t ha^{-1} poultry manure significantly recorded the highest wood yield compared with other treatments. Poultry manure applied at 2 t ha^{-1} significantly recorded higher kenaf wood yield than plots applied with 4 t ha^{-1} while plots applied with 2 t ha^{-1} of poultry manure recorded statistically the same kenaf core yield with those treated with 0 t ha^{-1}. At Kadawa, there was a significant increase in the wood yield of kenaf with increasing poultry manure rate from 2 to 6 t ha^{-1}.

The positive response of growth components such as plant height, number of leaves and shoot dry weight to poultry manure application from 2 to 6 t ha^{-1} at both locations could be attributed to the beneficial role of manure in providing soil nitrogen, phosphorus, potassium and other

essential nutrients which in turn improved growth and development of the plants during the trial. This is in consonance with the findings of Adekunle *et al*., (2014) who reported that the application of manure from 10-20 t ha^{-1} significantly increase the growth attributes of kenaf. Wood yield ha^{-1} was observed to increase significantly with the application of 6 t ha^{-1} of poultry manure at both locations. This could be due to the appreciable amount of essential nutrients in the poultry manure (N,P,K,Ca and Mg) and the favorable weather conditions during the 2017 wet season that favored the quick decomposition of the manure. This result conforms to earlier findings by Atif *et al*. (2015) who reported a higher yield of jute mallow when poultry manure was applied. The significant differences recorded among the three kenaf varieties in terms of their growth and yield such as plant height, number of leaves, shoot dry weight and wood yield of kenaf is attributed to differences in the genetic composition of the varieties used. This is in line with the study of Akinfasoye *et al*. (1997) who reported that the differences in yield parameters of crops are attributed to the cultivars grown and their genetic make-up.

Girin danani produced higher wood yield than Ifeken 400 and Ifeken D1 400 at both locations. Apart from the genetic composition of the variety which plays an important role in the potential yield of the crop, the differences in the rate of nutrient absorption and utilization among the three varieties and environmental variations could greatly influence the yield of kenaf. This result agrees with the finding of Williams (2004) who observed differences in yield of kenaf varieties due to different genetic make-up of these varieties.

CONCLUSION.

Results obtained from this trial showed that the application of 6 t ha^{-1} poultry manure resulted in better growth and higher yield with all the varieties while Girin Danani out yielded the other two varieties in both locations.

Table 1: Effects of Varieties and Poultry Manure Rate on the Height of Kenaf at Samaru and Kadawa during the 2017 Wet Season

Table 1: Effects of Varieties and Poultry Manure Rate on the Height of Kenaf at Samaru and Kadawa during the 2017 Wet Season

	Plant Height (cm)							
	Samaru				Kadawa			
Treatment	3 WAS	6 WAS	9 WAS	12 WAS	3 WAS	6 WAS	9 WAS	12 WAS
Variety (V)								
Ifeken 400	41.47b	140.41a	168.05	180.02	48.28	151.59	174.92	201.02
Ifeken D1 400	41.56b	137.12b	164.15	178.40	45.92	151.91	176.52	202.72
Girin danani	43.78a	138.73ab	162.88	175.55	45.03	152.71	174.68	198.11
SE±	0.681	0.980	3.375	4.490	1.231	3.983	3.888	4.463
Poultry manure(t ha^{-1})								
0	36.57b	132.82c	160.42	172.80	39.31c	141.92b	162.73c	178.24b
2	43.87a	138.18b	161.73	174.00	45.62b	156.81a	171.22bc	186.08b
4	43.82a	140.45ab	165.42	177.74	47.97b	154.37ab	182.11ab	216.86a
6	44.82a	143.56a	172.53	187.39	52.74a	155.17ab	185.44a	221.28a
SE±	0.787	1.132	3.897	5.185	1.422	4.599	4.490	5.154
Interaction								
V x M	NS	NS	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatment followed by different letter (s) are significantly different at 5% level using DMRT. WAS = Weeks after sowing NS = Not significant ** = significant at 1%

Table 2: Effects of Varieties and Poultry Manure Rate on the Nnumber of Leaves of Kenaf at Samaru and Kadawa during the 2017 Wet Season

	Number of Leaves							
	Samaru				Kadawa			
Treatment	3 WAS	6 WAS	9 WAS	12 WAS	3 WAS	6 WAS	9 WAS	12 WAS
Variety (V)								
Ifeken 400	18.76b	23.01	26.58	30.55	18.75	22.99	27.10	31.38
Ifeken D1 400	20.97a	23.17	26.28	30.78	19.20	23.09	27.25	31.48
Girin danani	20.06a	22.67	25.85	30.75	18.64	23.51	26.65	30.87
SE±	0.393	0.467	0.518	0.676	0.573	0.611	0.677	0.707
Poultry manure(t ha^{1})								
0	18.69b	22.47b	26.34	30.65	17.96	22.69	26.49	30.31ab
2	19.18b	21.86b	25.01	29.31	18.91	22.54	25.69	29.87b
4	20.84a	24.13a	26.90	31.67	18.69	23.35	27.73	32.05ab
6	21.03a	23.33ab	26.70	31.16	19.91	24.21	28.11	32.73a
SE±	0.456	0.540	0.599	0.781	0.661	0.705	0.782	0.817
Interaction								
V x M	NS	NS	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatment followed by different letter (s) are significantly different at 5% level using DMRT.
WAS = Weeks after Sowing NS = Not significant

Table 3: Effects of Varieties and Poultry Manure Rate on the Shoot Dry Weight of Kenaf at Samaru and Kadawa during the 2017 Wet Season.

	Shoot Dry Weight (g)							
	Samaru				Kadawa			
Treatment	3WAS	6WAS	9WAS	12WAS	3WAS	6WAS	9WAS	12WAS
Variety								
Ifeken 400	11.24	15.95	23.94	25.68	11.48	14.99	18.96	23.69
Ifeken D1 400	11.56	16.12	20.99	24.43	11.30	15.24	18.21	22.63
Girin danani	10.98	16.82	23.25	25.58	11.30	14.75	18.78	23.69
SE±	0.549	0.859	0.698	0.815	0.168	0.427	0.474	0.993
Poultry manure(t ha^{-1})								
0	10.87	14.82	20.35b	23.89	10.94b	12.47c	15.33c	20.37b
2	11.14	17.20	23.29a	26.86	11.61a	14.11bc	18.97b	22.85ab
4	11.84	17.03	23.35a	26.12	11.39ab	15.29b	19.52ab	24.38a
6	11.19	16.13	22.51ab	23.97	11.51ab	18.11a	20.72a	25.81a
SE±	0.634	0.992	0.806	0.942	0.194	0.569	0.548	1.147
Interaction								
V x M	NS	NS	**	**	NS	NS	NS	NS

Means in a column of any set of treatment followed by different letter (s) are significantly different at 5% level using DMRT.
WAS = Weeks after Sowing
** = significant at 1%
NS = Not significant

Table 4: Interaction between Varieties and Poultry Manure Rate on Shoot Dry Weight of Kenaf at 9 and 12 WAS at Samaru during the 2017 Wet Season.

	9 WAS			
Treatment	Poultry manure (t ha^{-1})			
Variety (V)	0	2	4	6
Ifeken 400	19.41cd	27.35a	22.87bc	22.84bc
Ifeken D1 400	22.33bc	15.97d	23.37bc	22.29bc
Girin danani	19.31cd	26.45ab	23.92a-c	22.42bc
SE±		1.398		
	12 WAS			
Treatment	Poultry Manure (t ha^{-1})			
Variety (V)	0	2	4	6
Ifeken 400	21.39d	31.63a	26.86bc	23.59b-d
Ifeken D1 400	26.93a-c	21.92cd	25.31b-d	23.58b-d
Girin danani	23.34b-d	27.20ab	26.98ab	24.76b-d
SE±		1.631		

Means followed by the same letters do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT)

Table 5: Effects of Varieties and Poultry Manure Rate on Wood Yield of Kenaf at Samaru and Kadawa during the 2017 Wet Season.

	Wood Yield per hectare (kg ha^{-1})	
Treatment	Samaru	Kadawa
Variety (V)		
Ifeken 400	97.8b	134.8c
Ifeken D1 400	120.0a	142.4b
Girin danani	120.3a	151.6a
SE±	0.597	0.762
Poultry manure(t ha^{-1})		
0	101.0bc	108.5d
2	117.4b	135.9c
4	92.6c	152.1b
6	139.9a	175.3a
SE±	0.690	0.879
Interaction		
V x M	NS	NS

Means in a column of any set of treatment followed by different letter (s) are significantly different at 5% level using DMRT.
** = Significant at 1%

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INFLUENCE OF SOKOTO ROCK PHOSPHATE AND POULTRY DROPPINGS ON SOIL NUTRIENT STATUS AND PERFORMANCE OF GROUNDNUT (*ARACHIS HYPOGAEA* L.) IN SOKOTO, SUDAN SAVANNA, NIGERIA

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ABSTRACT.

Field experiment was conducted during 2016 and 2017 rainy seasons at the Centre for Agricultural and Pastoral Research (CAPAR) (Dabagi farm) of Usmanu Danfodiyo University, Sokoto to investigate the influence of Sokoto rock phosphate and poultry droppings on soil nutrient status and performance of groundnut (*Arachis hypogaea* L.) in Sokoto, Sudan savanna of Nigeria. The experiment comprised nine treatments which were laid out in a Randomized Complete Block Design (RCBD) replicated three times. Soil samples were collected and analyzed for pH, organic carbon, total nitrogen, available phosphorus, exchangeable bases and CEC. Crop growth and yield data on number of leaves per plant, number of branches per plant, number of pods per plant and seed yield were also collected. The data generated were analyzed using analysis of variance (ANOVA) at 5% level of probability and the means were separated using Duncan's Multiple Range Test (DMRT). The result of the study indicates a significant difference ($P<0.05$) on soil pH, organic carbon, total nitrogen, available phosphorus, exchangeable calcium, magnesium, potassium (only in 2016), sodium (only in 2017) and CEC. Rock phosphate at 60 kg/ha plus poultry dropping at 4 t ha^{-1} recorded the best performance of all the parameters assessed, and therefore is recommended for better performance of the crop in the study area.

Keywords: Poultry droppings, Sokoto Rock Phosphate, Groundnut, Nutrient status.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the cash crops produced in Nigeria (Audu *et al*., 2017) and Sokoto is one of the major producers of the crop in the country (NAERL, 2011). The crop is an important diet for rural and urban population, particularly children because of its high content of protein and carbohydrate. It contains 26-28% protein, 11-27% carbohydrate and 48-50% oil, mineral and vitamins (Mukhtar, 2009). Despite the immense importance of groundnut as a source of protein for both human and animal diet and also a source of cooking oil,

the yield per hectare of the crop has been on decline over the years in Nigeria (Audu *et al*., 2017). The decrease in the yields could be attributed to either inherent low level of phosphorus or depletion of phosphorus through cultivation (Buah and Mwinka'ara, 2009).

Rock phosphate (RP) is the raw material used to make phosphate fertilizer. It can also be used directly as a fertilizer material, although the release of P is often slow, due to its low solubility (Kofi *et al*., 2016). Rock phosphate contains free carbonate such as calcite ($CaCO_3$) and dolomite $CaMg(CO_3)_2$ that provides Ca and Mg to acid soils which rises the soil pH (Chien and Menon, 1995). Phosphorus (P) is an essential element for plant growth. It is the second in importance after nitrogen, and one of the plant nutrient elements that is needed in large amount. Adequate phosphorus nutrition enhances many aspect of plant physiology, including fundamental process of photosynthesis, nitrogen fixation, flowering, fruiting, maturation and root growth (Brady and Weil, 1999). In Nigeria, P deficiency is a common phenomenon in soils as a result of either inherent low levels of P or depletion of P through cultivation (Haruna and Aliyu, 2011) consequently leading to sharp decrease in the yield of agricultural crops (Akinrinde *et al.*, 2005). In some cases, the P deficiency in soils of savanna zone of West Africa becomes acute and crop growth may cease as soon as the stored P in their seed is exhausted (Mokwunye and Batiano, 2002). The requirement of phosphorus in nodulating legumes is higher compared to non-nodulating crops as it plays a significant role in nodule formation and fixation of atmospheric nitrogen (Brady and Weil, 2002). In Nigeria, scarcity and high cost of chemical fertilizers coupled with adverse effect of environmental impacts associated with the use of phosphate fertilizers has compelled Nigerian farmers to seek an alternative means of enhancing the growth and yield performance of their crops. Hence, in the recent time, attention has been focused on direct application of rock phosphate to agricultural soils for enhancing food production by local farmers due to its numerous advantages: Relatively cheap, affordable, readily available and environmentally friendly (Kolo, 2014).

Poultry Droppings.

Poultry droppings occupied a place of pride as it is rich in nutrients than the other manures (Mohammad Amunullah *et al*., 2007). Singh and Amberger (1990); Akande *et al.* (2008) stated that incorporation of agricultural wastes like poultry droppings and cow dung with rock phosphate significantly improved the release of phosphorus and performance of crops. Misra *et al*. (2002) also said that incorporating rock phosphate into compost materials has been an effective method of improving soil phosphorous and nitrogen to crops. High soil organic matter can promote dissolution of rock phosphate by forming complex with Ca^{2+} ions and therefore the need to use poultry droppings to enhance solubility of rock phosphate in soil is essential.

The objective of this study is to assess the effect of Sokoto rock phosphate amended with poultry droppings on soil physical and chemical properties and performance of groundnut.

MATERIALS AND METHODS.

Study Area.

The research was conducted at the Centre for Agricultural and Pastoral Research (CAPAR) (Dabagi of Usmanu Danfodiyo University, Sokoto in 2016 and 2017 cropping seasons. The area is geographically located on latitude $12^0$45.78'N and longitude $5^0$25.58'E about 33 km south east of Sokoto town (Muhammed *et*

al., 2016). Maximum day time temperature ranges from 25 - 46^0C and minimum temperature is between 19 - 26^0C. The annual rainfall data in 2016 and 2017 cropping seasons were 663.42 and 606.18 mm respectively (SERC, 2017).

Soil Sampling and Analysis.

Soil samples were collected from the experimental field at the depth of 0 – 15 cm before and after the experiment. The samples were analyzed for pH, organic carbon, total nitrogen, available phosphorus, exchangeable bases (Ca, Mg, K and Na) and cation exchange capacity (CEC) by 1:1 soil-water ratio using a glass electrode pH meter as described by Udo *et al*. (2009), wet oxidation method of Walkely-Black method (Nelson and Sommers, 1982), micro Kjeldahl method (Bremner, 1965), Bray No.1 method (Bray and Kurtz, 1995), atomic absorption spectrophotometer and flame photometer respectively. Rock Phosphate was sourced from Dange Shuni Local Government Area of Sokoto State. It was cleaned, ground and analyzed for phosphorus, calcium and magnesium contents. Poultry droppings were obtained from Sarkin Gobir, Adiya Farms, Sokoto. The treatments consisted of factorial combination of three levels of rock phosphate (0, 60 and 80 kg/ha) and three levels of poultry droppings (0, 2 and 4 t/ha) laid-out in a Randomized Complete Block Design (RCBD) replicated three times.

The Treatments:

RP_0PD_0 = Rock Phosphate 0 kg/ha plus Poultry Dropping 0 t/ha

RP_0PD_2 = Rock Phosphate 0 kg/ha plus Poultry Dropping 2 t/ha

RP_0PD_4 = Rock Phosphate 0 kg/ha plus Poultry Dropping 4 t/ha

$RP_{60}PD_0$ = Rock Phosphate 60 kg/ha plus Poultry Dropping 0 t/ha

$RP_{60}PD_2$ = Rock Phosphate 60 kg/ha plus Poultry Dropping 2 t/ha

$RP_{60}PD_4$ = Rock Phosphate 60 kg/ha plus Poultry Dropping 4 t/ha

$RP_{80}PD_0$ = Rock Phosphate 80 kg/ha plus Poultry Dropping 0 t/ha

RP_{80} PD_2 = Rock Phosphate 80 kg/ha plus Poultry Dropping 2 t/ha

$RP_{80}PD_4$ = Rock Phosphate 80 kg/ha plus Poultry Dropping 4 t/ha

The site for the experiment was prepared into three blocks. Within each block, 9 plots of 15 m^2 gross plot were constructed with a net plot of 7.5 m^2 for each. The gross plots were separated from one another by 0.5 m and 1 m among the blocks. Improved groundnut variety (Samnut 24) was used as a test crop, which was sourced from Sokoto Agricultural Development Project (SADP).

Rock phosphate and poultry droppings was applied basally and subsequently worked into the soil to facilitate greater dissolution. Harvesting was done at maturity (12 weeks after planting), when the pods were fully developed.

Data Collection.

Data were collected on number of leaves, number of branches and number of pods from five randomly selected tagged plants in each net plot at 3, 6, 9 and 12 weeks after planting. Number of leaves per stand was taken by counting the number of leaves, number of branches per stand was by counting the number of branches, number of pods per stand was determined by counting the number of pods at harvest. Seed yield (kg/ha) was taken from the harvested plant from the net plot after shelling and weighing the seeds.

Data Analysis.

The data collected were subjected to analysis of variance (ANOVA) using SAS computer package (SAS 9.1, 2010) and Duncan's New

Multiple Range Test (DMRT) was used to separate the treatment means at 5% level of probability (P = 0.05).

RESULTS AND DISCUSSION.

The results of the chemical composition of the soil, poultry dropping and rock phosphate in both cropping seasons (2016 and 2017).

The results of the chemical composition of the soils in the two cropping seasons (2016 and 2017) are presented in Table 1. The results revealed that the soils of the experimental site were strongly acidic, low in organic carbon, available phosphorus and calcium, low to medium in cation exchange capacity, medium in exchangeable magnesium, potassium and sodium, and high in total nitrogen based on the standard ratings of Esu (1991) and Chude *et al.* (2011).

The results of chemical composition of rock phosphate and poultry droppings used in the experiment are shown in Table 2. The result indicates that, the rock phosphate was high in available phosphorus, medium in calcium and low in magnesium, while the poultry droppings were strongly alkaline in pH, low in calcium, medium in available phosphorus, high in organic carbon, total nitrogen, cation exchange capacity, magnesium, potassium as well as sodium.

Table 1: Chemical properties of the soils before the experiment.

Parameter	2016	2017
pH (H_2O)	5.2	5.4
Organic carbon (g/kg)	6.60	6.18
Total N (g/kg)	0.98	1.02
Available P (mg/kg)	0.83	0.89
Cation Exchange Capacity (cmol/kg)	5.02	6.00
Ca (cmol/kg)	0.80	0.89
Mg (cmol/kg)	0.65	0.69
K (cmol/kg)	0.23	0.27
Na (cmol/kg)	0.15	0.19

Table 2: Chemical composition of rock phosphate and poultry droppings used for the experiment.

Chemical Composition	2016	2017
Rock Phosphate		
Phosphorus (mg/kg)	300.00	300.00
Calcium (cmol/kg)	3.59	3.65
Magnesium (cmol/kg)	0.12	0.17
Poultry Droppings		
pH (H_2O)	8.6	8.7
Organic carbon (g/kg)	24.8	26.17
Total N (g/kg)	4.31	4.79
Available P (mg/kg)	10.8	10.3
Ca (cmol/kg)	0.60	0.65
Mg (cmol/kg)	1.10	1.15
K (cmol/kg)	5.80	4.30
Na (cmol/kg)	1.49	1.56
CEC (cmol/kg)	19.50	20.90

Effect of the Treatments on the Chemical Properties of the Soil

The effects of the levels of rock phosphate and poultry droppings and their combinations on the soil chemical properties are shown in Table 3 and 4. The results indicate that, the treatments had significant ($P<0.05$) effect on almost all the chemical properties in both 2016 and 2017 cropping seasons. This could be attributed to low fertility level of the experimental site as the initial values of the soil chemical parameters (Table 1) were low. Therefore application of rock phosphate and poultry droppings improved the fertility status of the soils. Singh and Amberger (1990); Akande *et al.* (2008) stated that incorporation of agricultural wastes like poultry droppings and cow dung with rock phosphate significantly improved the release of phosphorus and performance of crops.

According to FAO (2004), low concentration of phosphorus, calcium and high organic matter content accelerate the dissolution of rock phosphate. Decomposition of the poultry droppings could also increase solubility of rock phosphate and improved nutrient status of the soil.

With regard to the significant increase in soil pH observed for the plots that received rock phosphate as compared to the plots with sole application of poultry droppings and control in 2016 and some treatments in 2017 cropping seasons might be due to the release of either calcium or magnesium from rock phosphate that led to rise in soil pH. In support of this, Chien and Menon (1995) found that rock phosphate contains free carbonate such as calcite $(CaCO_3)_2$ and dolomite $CaMg(CO_3)_2$ that provides Ca and Mg to acid soils which rises the soil pH.

An increase in soil organic carbon observed in plots treated with poultry droppings than untreated plots could be a result of the addition of organic matter through the application of poultry droppings that increased organic carbon content of the soils. Gosh *et al.* (2004) reported that poultry manure improves organic carbon, nitrogen content, porosity and microbial activity of the soil. Poultry droppings levels also significantly ($P<0.05$) influenced the amount of organic carbon obtained in 2016 and 2017 trials, the values obtained ranged from 5.13-9.83 g/kg which rated low in organic carbon. This is in line with the work of Sharu *et al*. (2013) who found low level of organic carbon in hot-semi arid climate of Nigeria, and further stated that it could be attributed to rapid decomposition of organic materials due to high temperature and sparse vegetation in the zone.

A significant increase in total N in 2016 was observed in treatments with poultry droppings as compared to those treatments without. Also in 2017 cropping season, treatments with high rate of poultry droppings significantly ($P<0.05$) increased total N contents of the soils which could be attributed to the release of nitrogen through mineralization of poultry droppings. Veeramani *et al.* (2012) reported that poultry manure is an excellent organic material, as it contains high nitrogen, phosphorus, potassium and other nutrients.

A significant improvement in soil available phosphorus observed for all the plots as relative to control plots in both 2016 and 2017 cropping seasons might be due to the release of P from rock phosphate and poultry droppings. In support of this, Ortega and Rojas (1999) found that phosphorus availability in soil was increased by phosphorus application as single superphosphate (SSP), Triple superphosphate (TSP) or rock phosphate. In addition, Audu *et al*. (2013) reported that, increase in the rate of application of Sokoto rock phosphate progressively increased the growth and yield performance of cowpea and soil available phosphorus in Sudan savanna of Nigeria. On the other hand, Ayuba *et al*. (2005) observed that, cow dung and poultry manure increased soil pH, organic matter, nitrogen, available phosphorus and exchangeable calcium, magnesium and potassium when compared to

control. Similarly, application of poultry manure, cattle manure and pig manure in rock phosphate amended soils improved the dissolution of phosphorus from rock phosphate, with poultry manure being much more effective. The dissolution increased with the increase in quantity of manure applied as stated by Kofi *et al*. (2016).

Table 3: Effect of rock phosphate and poultry droppings on soil pH, organic carbon, total nitrogen and available phosphorus in 2016 and 2017 growing seasons at CAPAR farm of Usmanu Danfodiyo University, Sokoto.

Treatment	pH(H_2O)		OC (g/kg)		Total N (g/kg)		Av.P (mg/kg)	
	2016	2017	2016	2017	2016	2017	2016	2017
RP_0PD_0	5.0^{e}	5.6^{ab}	5.30^{d}	5.13^{f}	0.71^{e}	0.89^{c}	0.70^{e}	0.82^{e}
RP_0PD_2	4.9^{e}	5.4^{bc}	7.13^{b}	7.03^{c}	0.99^{bc}	1.05^{c}	0.75^{de}	0.85^{de}
RP_0PD_4	5.0^{e}	57^{ab}	8.53^{a}	9.83^{a}	1.03^{ab}	2.16^{a}	0.78^{d}	0.93^{cd}
$RP_{60}PD_0$	5.4^{d}	5.7^{ab}	5.83^{cd}	5.43^{ef}	0.73^{e}	0.90^{c}	0.85^{c}	0.93^{cd}
$RP_{60}PD_2$	5.8^{b}	5.8^{ab}	7.20^{b}	8.46^{b}	0.97^{c}	1.05^{c}	0.92^{ab}	1.03^{ab}
$RP_{60}PD_4$	6.3^{a}	6.0^{a}	8.70^{a}	9.53^{a}	1.05^{a}	2.06^{a}	0.94^{a}	1.08^{a}
$RP_{80}PD_0$	5.6^{c}	5.1^{c}	6.06^{b}	6.13^{de}	0.88^{d}	0.97^{c}	0.88^{bc}	0.95^{bc}
$RP_{80}PD_2$	5.7^{bc}	5.7^{ab}	7.26^{b}	6.90^{cd}	1.00^{abc}	1.02^{c}	0.90^{ab}	1.01^{abc}
$RP_{80}PD_4$	6.3^{a}	6.0^{a}	8.53^{a}	9.53^{a}	1.05^{a}	1.90^{b}	0.95^{a}	1.05^{a}
Level of	*	*	*	*	*	*	*	*
SE±	0.06	0.13	0.21	0.28	0.01	0.04	0.01	0.02

Means followed by the same letter(s) within column are not significantly different at 5% level of probability (DMRT).

Table 4: Effect of rock phosphate and poultry droppings on exchangeable bases and CEC in 2016 and 2017 growing seasons at CAPAR farm of Usmanu Danfodiyo University, Sokoto

Treatment	Ca		Mg		K		Na		CEC	
	→				cmol/kg			←		
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
RP_0PD_0	0.77^{e}	0.87^{c}	0.63^{cd}	0.62^{d}	0.21^{d}	0.22	0.36	0.11^{e}	4.99^{d}	5.66^{e}
RP_0PD_2	0.78^{e}	1.00^{ab}	0.62^{d}	0.66^{d}	0.94^{a}	0.98	0.35	0.63^{b}	6.62^{b}	8.83^{bc}
RP_0PD_4	0.80^{de}	1.25^{ab}	0.62^{d}	0.82^{b}	0.97^{a}	0.99	0.39	0.52^{c}	7.16^{b}	9.06^{bc}
$RP_{60}PD_0$	0.83^{a-}	0.99^{ab}	0.70^{bc}	0.77^{c}	0.87^{c}	0.84	0.34	0.47^{c}	5.78^{c}	8.53^{cd}
$RP_{60}PD_2$	0.90^{ab}	1.23^{ab}	0.72^{bc}	0.83^{b}	0.94^{a}	0.96	0.37	0.66^{b}	7.33^{b}	8.70^{cd}
$RP_{60}PD_4$	0.94^{a}	1.31^{a}	0.77^{a}	0.95^{a}	0.98^{a}	1.02	0.40	0.83^{a}	8.85^{a}	9.63^{a}
$RP_{80}PD_0$	0.91^{ab}	0.96^{bc}	0.68^{bc}	0.83^{b}	0.91^{b}	0.89	0.39	0.23^{d}	6.26b	8.23^{d}
$RP_{80}PD_2$	0.92^{ab}	1.05^{ab}	0.74^{a}	0.85^{b}	0.96^{a}	0.99	0.39	0.82^{a}	6.37^{b}	9.00^{bc}
$RP_{80}PD_4$	0.94^{a}	1.31^{a}	0.82^{a}	0.87^{b}	0.98^{a}	1.02	0.37	0.83^{a}	8.54^{a}	9.30^{ab}
Level of	*	*	*	*	*	NS	NS	*	*	*
SE±	0.03	0.10	0.02	0.02	0.01	0.01	0.03	0.03	0.37	0.17

Means followed by the same letter (s) within column are not significantly different at 5% level of probability (DMRT)

Effect of application of rock phosphate amended with poultry droppings on the dissolution of Sokoto Rock Phosphate (SRP)

Application of rock phosphate in combination with poultry droppings significantly ($P<0.05$) influenced rock phosphate dissolution in 2016 and 2017 cropping seasons with increase in poultry dropping levels (Table 2). Kofi *et al.* (2016) confirmed that, the dissolution of Togo rock phosphate increased with the increase in the quantity of poultry manure applied. The result further indicates that, Sokoto rock phosphate is better used in combination with poultry droppings than its sole application as shown in this study that, when applied with poultry droppings, a significant difference in available phosphorus was obtained than using sole rock phosphate. Also, the maximum value of P (1.08 mg/kg) obtained from this study was greater compared to that obtained by Audu *et al.* (2013), who reported the highest value of 0.95 mg/kg of P from rock phosphate rates of 0, 25, 50 and 75 kg/ha used in a trial conducted in a weakly acidic soil condition. This might be attributed to the strongly acid nature of the soil and difference in rock phosphate rates. The level of phosphorus in 2017 trial was higher when compared to that of 2016. This might be due to residual effect of rock phosphate applied in 2016 cropping season.

The phosphorus in the soil ranged from 0.70 - 1.08 mg kg^{-1} which was rated low based on the standard ratings of Esu (1991). The low level of phosphorus could be attributed to the low dissolution and low release of P under low rainfall in Sokoto, semi-arid zone. This agrees with the findings of Musa *et al.* (2012) who reported low dissolution of Sokoto rock phosphate under low rainfall conditions. Treatments with rock phosphate plus 4 tonnes/ha of poultry droppings produced higher value of Ca compared to the remaining treatments. This could be attributed to the higher rate (4 tonnes/ha) of poultry droppings which aided the release of more calcium from rock phosphate. Irshad *et al*. (2013) also found that organic matter solubilized phosphate in rock phosphate, resulting in the release of phosphorus and calcium into soil solution. Rock phosphate treated plots had higher value of magnesium compared to those without rock phosphate and this might be due to the release of magnesium through the dissolution of rock phosphate. Dev (1990) reported that rock phosphate is not only a source of phosphorus, but it also contains nutrients like calcium and magnesium. All the plots treated with poultry droppings gave higher value of CEC than the plots without. This could be the influence of the poultry droppings applied that improved the CEC. Mbah and Mbagu (2006) reported that, application of organic matter increased cation exchange capacity of soils, thus indicating greater nutrient retention capacity of the soil.

Effect of the treatments on growth and yield components of groundnut (*Arachis hypogaea* L.)

Effects of application of rock phosphate and poultry droppings on growth and yield parameters of groundnut at 6 WAP are shown in Table 5. The result indicates that, the treatments had significant ($P<0.05$) effects on all the growth and yield parameters considered. This might be due to the application of the treatments. Gobara *et al*. (2006) reported that increasing rate of phosphorus from 30 to 60 kgP_2O_5/ha significantly increased vegetative growth, yield and its components, as well as seed quality and protein content of groundnut. In addition, Nasir-Alla *et al*. (1998) reported that phosphorus application increased the number of branches/plant, yield of pod/plant/ha of groundnut. Similarly, Ibrahim *et al*. (2014) observed that, application of 3.0 tonnes/ha of poultry manure significantly increased the growth parameters of groundnut such as plant

height, number of leaves, number of branches and canopy spread. Furthermore, Subrahmaniyan *et al*. (1999) reported that, poultry manure improved number of pods/plant, pod yield and haulm yield in groundnut.

Table 5: Effect of rock phosphate and poultry droppings on the performance of growth and yield parameters of groundnut at 6 weeks after planting in 2016 and 2017 growing seasons at CAPAR farm of Usmanu Danfodiyo University, Sokoto.

Treatment	No. of Leaves/plant		No. of branches/plant		No. of Pods/plant		Seed yield (kg/ha)	
	2016	2017	2016	2017	2016	2017	2016	2017
RP_0PD_0	47^{e}	55^{e}	5^{d}	7^{f}	17^{c}	13^{e}	117.7^{d}	166.6^{e}
RP_0PD_2	76^{cd}	103^{cd}	7^{bcd}	8^{ef}	20^{c}	29^{cd}	244.4^{c}	308.9^{d}
RP_0PD_4	88^{bc}	104^{bcd}	7^{bc}	9^{de}	25^{b}	33^{bc}	257.7^{c}	328.9^{cd}
$RP_{60}PD_0$	70^{d}	90^{cd}	7^{bcd}	10^{de}	19^{c}	26^{cd}	200.0^{cd}	313.3^{d}
$RP_{60}PD_2$	104^{a}	111^{bc}	8^{abc}	13^{bc}	26^{b}	33^{bc}	288.9^{bc}	453.3^{b}
$RP_{60}PD_4$	108^{a}	127^{ab}	10^{a}	16^{a}	34^{a}	47^{a}	413.3^{a}	580.0^{a}
$RP_{80}PD_0$	70^{d}	87^{d}	7^{bcd}	9^{de}	19^{c}	24^{d}	242.2^{c}	306.6^{d}
$RP_{80}PD_2$	92^{ab}	112^{bc}	8^{abc}	11^{cd}	27^{b}	32^{bcd}	280.0^{bc}	404.4^{bc}
$RP_{80}PD_4$	99^{ab}	143^{a}	9^{ab}	14^{ab}	33^{a}	39^{ab}	360.0^{ab}	573.3^{a}
Level of	*	*	*	*	*	*	*	*
SE±	16.08	23.03	0.63	0.78	1.16	2.94	22.83	21.74

Means followed by the same letter(s) within column are not significantly different at 5% level of probability (DMRT)

CONCLUSION.

Application of Sokoto rock phosphate amended poultry droppings under groundnut production significantly affected the soil pH, organic carbon, total nitrogen, available phosphorus, exchangeable calcium, magnesium, potassium and CEC. Combined application of the fertilizers also improved the yield and performance of groundnut. Rock phosphate at 60 kg/ha plus poultry dropping at 4 t/ha gave the best performance of groundnut. It also gave a higher solubility of rock phosphate and therefore, recommended.

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INHERITANCE OF GRAIN YIELD AND YIELD PARAMETERS IN RICE (*Oryza sativa* L.) USING PARTIAL DIALLEL MATING DESIGN.

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ABSTRACT.

A study on the Inheritance of grain yield and yield parameters in rice using partial diallel mating analysis was carried out at the National Cereal Research Institute (NCRI), Badeggi, Bida, Niger State. The planting materials used in this experiment include a variety of new Africa Rice (NERICA 1 also known as FARO 55) and four varieties of other FARO rice (FARO 41, 47, 63 and 64). Planting materials were crossed according to a partial diallel mating analysis. Parent lines and F_1 hybrids were evaluated, individual and joint analyses of variance were performed, the result obtained from the analysis of variance for the parameters analyzed showed that there was a high significant difference at the parent line and the Specific Combining Ability (SCA) for the parameters observed at ($P<0.05$) and least significance at the General Combining Ability (GCA) and replication on the side of plant height at harvest and panicle count at replication at ($P<0.05$). However, Heritability in narrow sense was observed to be high in all studied trait from 0.82% to 0.98%. The crosses between FARO 41 x FARO 47 and FARO 47 x FARO 63 were identified as the most promising F_1 for breeding programmes for higher grain yield. Therefore can be recommended to farmers for high grain yield.

Keywords: Partial Diallel, Mating, FARO 41, FARO 47, FARO 55, FARO 63, and FARO 64.

INTRODUCTION.

New rice for Africa (*Oryza sativa* L.) varieties with early maturity and high yield potential are a very important breeding challenge. Quantitative genetic parameters like heritability and variance elements are helpful for coming up with new breeding programmes Genetic improvement of plants for quantitative traits requires reliable estimates of heritability and gene action in order to plan an efficient breeding programme Anyanwu & Obi (2014) and Tuhina *et al*., (2015). Among different methods to assess the nature of gene action in the parents, the diallel cross technique is a systematic method (Verma, 2003). Many studies show that rice yield related characters (tiller No, filled grains per panicle and grain weight) and agronomic characters (plant height and days to flowering) are inherited quantitatively, related genetically to one another and influenced if the growing environments (Kobayashi *et aI.*, 2003).

The value amount of heterosis as well as the General Combining Ability and Specific Combining Ability effects is important considerations for hybrid breeding (Herrmann, 2007).

Exploiting from diallel analysis in rice breeding has usually conducted to guage combining ability for quantitative traits and helpful results are offered. Despite the advances of molecular breeding, classical quantitative genetic analysis remains useful in rice improvement. therefore estimation of genetic parameters like heritability and mixing ability provide inferences regarding the predominant action of the genes, indicates the acceptable choice strategy to be applied within the breeding program and permits the identification of the simplest folks (Torres & Geraldi, 2007).The grain yield of rice depends on several components, including grain quality characteristics (Fan *et al.*, 2006; Gupta *et al.*, 2006). Grain quality is both objective and subjective depending on the end-use (Koutroubus *et al.*, 2004), but components of grain quality commonly agreed upon include nutritional and milling qualities, and appearance, of which grain size is one component. Grain size is an important character to study not only because of its contribution to yield. This research is therefore aimed at evaluating inheritance pattern of grain yield and yield parameters in Rice using partial diallel mating Design.

MATERIALS AND METHODS.

Description of Experimental Site and Varieties.

Experiment on the Inheritance of grain yield and yield parameters in rice using partial dialle mating analysis were carried out at the Rice Breeding Crossing Block and the Research Institute demonstrations farm, National Cereal Research Institute, (NCRI), Badeggi Bida Niger State. Bida is situated at latitude 9.08^0 North and longitude 6.02^0 East and 151 meters above sea level.

Varieties and other Material used for Emasculation and Crossing

The varieties used for this experiment include New Africa Rice (NERICA 1 also known as FARO 55) and four varieties of FARO rice (FARO 41, 47, 63 and 64) with known agronomic and yield potentials (Table 3.1) were used for this experiment.

Site Preparation, Planting and Experimental Design.

The experimental crossing block was cleared to reduce weed infestation while the five (5) parents of the rice plants were planted in 5 liters bucket filled with top loamy soil (3/4 filled with soil), arranged in a randomized complete block design with four replication each.

Generation of F_1 (Hybridization)

The experimental materials were crossed according to a partial diallel mating analysis (Miranda and Geraldi, 1984) and a modified method of rice crossing (Sarkarung, 1999 ;). The F_1 were generated through emasculation and hand pollination of the parents. Reciprocal crosses were not carried out as such ten F_1 were generated from the five parents as per the table below.

Generation of F_1 (Hybridization)

	A	B	C	D	E
A	-------	AB	AC	AD	AE
B	AB	------	BC	BD	BE
C	AC	BC	------	CD	CE
D	AD	BD	CD	------	DE
E	AE	BE	CE	DE	-------

Emasculation.

It was done in the afternoon on previous day or early morning on the day of pollination. The ear just emerged is selected and all spiklets already opened are clipped, the spiklets which are likely to be opened are selected and six anthers from each spiklet is removed with needle and fine

pointed forceps. The emasculated ears after examination with lens were covered with perforated envelops (USDA, 2014).

Pollination.

Pollination is done between 9am and 10am in the morning, matured anthers are collected from protected male parent in petri dish and dusted on the stigma of emasculated flower with brush and forceps the pollinated plants are covered with envelop to protect natural cross pollination (USDA, 2014).

Evaluation of the F_1 and the Parent.

The first filial generation (F_1) and the two parents were evaluated in the NCRI research demonstration field during the 2018 farming season, and the data collected include:

Days to 50% flowering, Plant height at harvest, Tiller count (number of tiller per plant), Panicle count (number of panicle per plant), Harvest count (yield per plant) and hundred grain weight.

Data/Statistical Analysis.

Individual and joint analyses of variance were performed by the GLM procedure of the SAS program (SAS Institute, 1999) according to the complete randomized block design, considering experiments and genotypes as fixed effects. Genetic analysis to estimate general combining ability (GCA), specific combining ability (SCA) and their interaction effect with location, was performed using the Griffing (1956) method 4, model I, adapted for a partial diallel by the methods of Geraldi and Miranda (1988) and Oliveira *et al.* (1987) while significant means were separated using least significant difference (LSD) at 5% level of probability. The statistical tools used are: Analysis of variance (ANOVA).

RESULTS.

Inheritance of grain yield and yield parameters in rice using a partial diallel mating analysis was carried out at the National Cereal Research Institute (NCRI) Badeggi Bida Niger State during 2017-2018 cropping season. Four varieties of rice (FARO 41, FARO 47, FARO 63 and FARO 64) and a variety of NERICA 1 rice also known as FARO 55 were obtained from the research institute for the studies. The five parents were crossed in a partial diallel mating design to give a total of 10 treatments without reciprocal crosses. The rice plants were planted in 5 liters bucket filled with top loamy soil (3/4 filled with soil), arranged in a randomized complete block design with four replications. Parent lines and F_1 hybrids were evaluated, individual and joint analyses of variance were performed, Genetic analysis to estimate general combining ability (GCA), specific combining ability (SCA) and their interaction effect with location, was estimated Analysis of variance revealed high significant difference for all the parameters studied. This indicate a heritable portion of the phenotypic variance and it is a good index of transmission of a character from parents to their off springs.

Results showed that there were appreciable variability in all the parameters studied with the cross between FARO 47 x FARO 64 showing the highest mean value of 96.00 for days to 50% flowering and FARO 47 has the least mean value of 65.67. Plant height at harvest had a mean of 78.59 ranging from 52.33 (FARO 63 x FARO 64) to 119.33 (FARO 41 x FARO 55) though, on tiller count, a mean of 11.73 was recorded ranging from 7.33 (FARO 41 x FARO 63) to 21.33 (FARO 41 x FARO 47). On panicle count, a mean of 5.06 was recorded ranging from 2.44 (FARO 63) to 9.33 (FARO 47 x FARO 55). Harvest count had a mean of 3.73 ranging from 1.67 (FARO 41 x FARO 47) to 5.67 (FARO 63 x FARO 64) and on hundred grain weight, mean of 25.17 was recorded ranging from 20.13 (FARO 41 x FARO 64) to 30.73 (FARO 41 x FARO 47). Heritability in narrow sense was observed to be high in all studied trait from 0.82% to 0.98%.

Table 1: Mean squares of Diallel Crosses from the analysis of variance of the diallel crosses in Rice *Oryza sativa*

Sources	Df	50%F	PH	Tcount	Pcount	Hcount	HGW
Replication	2	12.87	69.32	6.43	2.87*	0.20	2.60
P1 X p2	9	240.77**	918.41**	38.55**	10.39**	6.11**	60.19**
GCA	4	120.40	617.05	4.83	3.64	2.64	2.03
SCA	5	57.96**	133.41**	17.30**	3.37**	2.03**	17.54**
Error	19	4.64	7.69	1.36	0.27	0.37	2.76

Mean squares from the analysis of variance of the diallel for days to 50% flowering, PH, Tcount, Pcount, Hcount and HGW
KEY: 50%f=50% flowering, PH= Plat Height, Tcount= Tiller counting, Pcount= Panicle counting, Hcount=Harvest counting, and HGW= Hundred Grain Weight.

Table 2: Mean values from the analysis of variance of the diallel crosses in Rice *Oryza sativa*

Crosses	50%f	Ph	Tcount	Pcount	Hcount	Hgw
A (FARO 41)	76.33	75.44	11.56	5.89	4.33	20.17
B (FARO 47)	65.67	62.56	7.56	3.78	2.00	23.70
C (FARO 55)	75.67	77.67	12.44	5.00	4.67	30.17
D (FARO 63)	69.67	53.78	15.44	2.44	3.33	30.13
E (FARO 64)	77.00	85.22	8.56	4.33	3.00	26.93
A x B	70.67	72.33	21.33	6.00	1.67	30.13
A x C	74.67	119.33	11.67	4.56	3.33	27.00
A x D	87.33	80.78	7.33	3.44	4.00	26.83
A x E	89.67	106.00	11.67	6.11	2.00	20.13
B x C	82.33	78.44	14.67	9.33	4.33	20.27
B x D	76.00	68.33	8.67	4.78	5.33	30.27
B x E	96.00	80.44	12.11	7.44	5.33	20.30
C x D	71.33	52.33	11.11	3.89	5.67	30.20
C x E	74.33	88.78	9.11	3.44	1.67	20.43
D x E	92.33	77.44	12.73	7.56	5.33	20.33
Mean (ixj)	78.60	78.59	11.73	5.06	3.73	25.17
LSD(0.05)	3.12	4.02	1.69	0.75	0.88	2.41

Mean value for days to 50% flowering, PH, Tcount, Pcount, Hcount and HGW
KEY: 50%f=50% flowering, PH= Plat Height, Tcount= Tiller counting, Pcount= Panicle counting, Hcount=Harvest counting, and HGW= Hundred Grain Weight.

Table 3: Estimate of Genetic variance from the analysis of variance of the diallel crosses in Rice *Oryza sativa.*

Traits	σ_e^2	σ_{GCA}^2	σ_{SCA}^2	H^2
50%F	4.64	15.61	53.31	0.94
PH	7.69	120.91	125.72	0.98
Tcount	1.36	0.00	15.95	0.92
Pcount	0.27	0.07	3.10	0.92
Hcount	0.37	0.00	1.67	0.82
HGW	2.76	1.77	14.78	0.87

Estimate of Genetic variance components and heritability for days to 50% flowering, PH, Tcount, Pcount, Hcount and HGW
KEY: 50%f=50% flowering, PH= Plat Height, Tcount= Tiller counting, Pcount= Panicle counting, Hcount=Harvest counting, and HGW= Hundred Grain Weight.

Table 4: Estimate of GCA effects from the analysis of variance of the diallel crosses in Rice *Oryza sativa*

	50%F	PH	Tcount	Pcount	Hcount	HGW
A	1.42**	15.23**	1.22	0.00	-0.83	-0.35
B	-0.58	-7.71**	1.42	1.33	0.00	-0.25
C	-3.67**	5.90**	0.08	0.06**	0.25	0.60
D	0.92*	-15.07**	-0.83	-0.97**	1.25	3.03**
E	9.08**	11.23**	-1.11	0.72**	-0.33	-4.38**
SE	0.77	1.23	0.00	0.10	0.00	0.40

Estimate of GCA effects for days to 50% flowering, PH, Tcount, Pcount, Hcount and HGW.
KEY: 50%f=50% flowering, PH= Plat Height, Tcount= Tiller counting, Pcount= Panicle counting, Hcount=Harvest counting, and HGW= Hundred Grain Weight.

Table 5: Estimate of SCA effects from the analysis of variance of the diallel crosses in Rice *Oryza sativa*

Crosses	50%F	PH	Tcount	Pcount	Hcount	HGW
A x B	-8.77**	-13.78**	6.96**	-0.53	-1.23	5.60
A x C	-1.68	19.61**	-1.37	-0.70	0.18	1.62
A x D	6.40**	2.03	-4.79**	-0.78	-0.15	-0.98
A x E	0.57	0.94	-0.18	0.19	-0.57	-0.27
B x C	7.98	1.67	1.43	2.74**	0.35	-5.23**
B x D	-2.93**	12.53**	-3.65**	-0.78	0.35	2.36**
B x E	8.90**	-1.67	0.07	0.19	1.93*	-0.20
C x D	-4.52**	-17.08**	0.13	-0.39	0.43	1.44
C x E	-9.68**	-6.94**	-1.59	-2.53**	-1.98*	-0.92
D x E	3.73**	2.69*	3.00**	2.61**	0.68	-3.44**
SE	1.95	2.00	1.95	1.95	1.72	1.78

Estimate of SCA effects for days to 50% flowering, PH, Tcount, Pcount, Hcount and HGW
KEY: 50%f=50% flowering, PH= Plat Height, Tcount= Tiller counting, Pcount= Panicle counting, Hcount=Harvest counting, and HGW= Hundred Grain Weight.

DISCUSSION.

Mean squares from the analysis of variance of the diallel for days to 50% flowering, plant height at harvest, tiller count, panicle count, harvest count and hundred grain weight is presented in Table 1. The result obtained from the analysis of variance for the parameters analyzed showed that there was a high significant difference at the parent line and the SCA for the parameters observed at ($P<0.05$). Least significance was recorded for GCA and replication on the side of plant height at harvest and panicle count at replication at ($P<0.05$). Knowledge of components of genetic variation helps in formulating the most efficient breeding methods (Tiwari & Sirohi, 2016). The result of this research agrees with the report of Akram *et al*., (2007) were he reported genetic components analysis revealed that plant height at maturity, number of tillers and grain yield per plant were all influenced by both additive and non-additive genetic components. The mean performance of the plant at 50% flower (Table 2) showed that there was no significant difference at ($P<0.05$) among the crosses except cross between FARO47 x FARO 64 with highest mean value of 96.00 this is significant when compare to other crosses with a high mean value of the cross between FARO 63x FARO 64 with a mean value of 92.32 followed by the cross between FARO 41 x FARO 64 with a mean value of 89.69 followed by cross between FARO 41 x FARO 63 with a mean value of 87.33 and cross between FARO 41 x FARO 47 had the least mean value of 70.67.

The mean performance of the plant height at harvest shows that the cross between FARO 41 X FARO 55 has the highest mean value of 119.33 (cm) followed by the cross between FARO 41 x FARO 64 with a mean value of 106.00 (cm) and the cross between FARO 55 x FARO 63 had the least mean value of 52.33

The mean performance for tiller count shows that the cross between FARO 41 x FARO 47 has the highest mean value of 21.33 followed by the cross between FARO 47 x FARO 55 with a mean value of 14.67 while the cross between FARO 41 x FARO 63 has the least mean value of 7.33. This mean performance showed that there was a significant between the crosses of FARO 41 x FARO 55 (11.67) and FARO 55 x FARO 63 (11.11) but there was no significant between crosses of FARO 41 x FARO 47 with mean value of 21.33

The mean performance of panicle count shows significant difference for the cross between FARO 41 x FARO 47 with the mean value of 6.00 and FARO 41 x FARO 64 with a mean value of 6.11 though, the cross between FARO 47 X FARO 55 had the highest mean value of 9.33 and the cross between FARO 41 x FARO 63 and FARO 55 x FARO 64 had the least mean values of 3.44 each.

The mean value for harvest count shows significant difference with the cross between FARO 55 x FARO 63 having highest mean value of 5.67 followed by the cross between FARO 47 x FARO 63, FARO 47 x FARO 64 and FARO 63 x FARO 64 with the mean values of 5.33 respectively while the cross between FARO 41 x FARO 47 and FARO 55 x FARO 64 had least mean values of 1.67 each.

The mean value for hundred grain weight shows a significant difference with cross between FARO 41 x FARO 47 having highest 30.73 mean value followed by cross between FARO 47 x FARO 63 (30.27), FARO 55 x FARO 63 (30.20), FARO 47 x FARO 64 (20.30), FARO 47 x FARO 55 (20.27) and FARO 41 x FARO 64 with the least mean value of 20.13. Among the five parents studied, the Parents *viz.*, FARO 41, 47, 55, 63 and 64 were found as general combiners for the breeding programs for improving yield and yield contributing traits. Similar results were reported earlier by Salgotra *et al.*, (2009). FARO 41 and 55 followed were found as good general combiners for plant height, followed by FARO 41 and 64. FARO 41 and 47 were effective combiner for tillers plant

per plant, followed by FARO 47 and 55. For panicle counting, FARO 41 and 47 were better combiner than other varieties of FARO. For 100-grain weight, and grain yield per plant FARO and FARO 47 were the best combiners followed by FARO 47 FARO 63 in Partial Diallel Mating analysis. Thus, selection based on phenotypic value of this character would be reliable and effective. Other authors (Rita *et al*., 2009 and Tuhina *et al*., 2015) reported similar results for 100-grain weight in rice.

Estimated narrow sense heritability ranged from 0.82% to 0.98% (Table 3). These findings agree with the works of Kuriata *et al*. (2003), Mendes *et al*. (2006). Kumar & Gupta (2004), Muraya *et al*. (2006), Tabassum *et al*. (2007) and Hussaini *et al*. (2009) who reported additive gene action in rice. Heritability is the heritable portion of the phenotypic variance and it is a good index of transmission of a character from parents to their off springs. Its estimate is important because; it determines the expressivity of a gene carried by a genotype. If heritability of a character is high as in this case, the phenotypic value provides a fairly close measure of the genotypic value and thus, breeder can base his selection on the phenotypic performance, thereby the knowledge of heritability helps the plant breeder in pre selecting the result for a particular character (Johnson *et al.,* (1955) Tuhina-Khatun *et al*., (2007).

For hundred grain weight, a significant and positive GCA effect was observed in FARO 63. This result confirm with the earlier findings of (Najeeb *et al*., 2011 and Sajad *et al*., 2014) who recognized the existence of some dominance effects while concluding that the major component of genotypic variance in rice is additive High estimates of heritability (narrow sense) were also reported for plant height and moderate heritability for a number of branches per plant (Mahmood *et al.,* 2004). High heritability for plant height and harvest index (Verma & Srivastava, 2004) whereas high heritability for grain length (Sajad *et al.* 2014) also reported in rice crop. High heritability for days to 50% flowering, plant height, panicle length, grains per panicle, harvest index, 1000-grain weight and grain yield in rice also reported (Kumar *et al*., 2016) whereas high heritability for kernel length, kernel breath, L/B ratio, kernel length after cooking and amylose content was reported (Savitha and Kumari,2016).

The GCA is the average performance of a parent in crosses which is an estimate of its breeding value for each parent (Table 4) was determine for day to 50% flowering parents adapted to a sub-tropical conditions had a negative significant effects (Reduces days to 50% flowering in their hybrid) such as FARO 55 and FARO 47 this parents could be a useful donor for an early flowering trait. For plant height at harvest, a significant and negative GCA effect was recorded for FARO 47 and FARO 63. This findings agrees with that of (Verma & Srivastava 2004; Sajad *et al*., 2014), Bui & Tuan, (1991) indicating the relevance of additive and non additive effect in the inheritance of the traits. For panicle counting, a significant and positive GCA effect was recorded for FARO 47, FARO 55 and FARO 64 respectively. These findings contradict the work reported by Verma & Srivastava (2004) who reported the relevance of both additive and non additive effect in the inheritance of this trait. Non-additive genetic effects result from allelic interactions, being the intralocus interaction known as dominance, and interlocus interactions known as epistasis (Lync & Walsh 1998). Therefore, when non additive genetic effects are an important source of variation in trait expression, genotypic selection may induce to recombine progenies that do not have the highest breeding values (Hallauer *et al*., 2010).

The cross between FARO 41 x FARO 47 had negative and significant SCA effect for day to 50% flowering and plant height at harvest and positive and significant SCA effect for tiller count and hundred grain weight. The cross

between FARO 47 x FARO 55 had a positive and significant SCA effect for panicle count. The cross between FARO 47 x FARO 63 had a negative and significant SCA effect for days to 50% flowering and exhibited a positive and significant SCA effect for hundred grain weight. The cross between FARO 63 x FARO 64 had a positive and significant SCA effect for tiller count and panicle count. (Table 5).The implication of positive significance of SCA on this tiller count is that it increases the number of tillers while the negative significance reduces the numbers of tillers.

The crosses between FARO 41 x FARO 47 and FARO 47 x FARO 63 were identified as the most promising genotypes for breeding programmes for higher grain yield. All the crosses with high SCA effect for grain yield involve one of the parents with good GCA and other with poor GCA.

Similar observation of high SCA obtained from crosses involving high and low GCA was also made by Reddy (2002). Additive and non additive type of interaction might have been responsible for high SCA effect for grain yield in this cross. (Mahmood *et al*., 2004 & Sajad 2014). Reported about the possibility of interaction between positive alleles from good combiner and negative alleles from poor combiner in high x low combiner crosses and suggested for the exploitation of heterosis in F_1 generation as their high yield potential will be unfixable in succeeding generations if no repulsion face of linkage is involved. Individual crosses may be exploited in heterosis breeding programme to improve the trait of interest in rice crop. The earlier findings in support of present results for SCA/GCA effects were also reported (Roy & Senapati, 2012; Singh *et al.,* 2013; Kumari *et al.,* 2014; Menaka & Ibrahim, 2016; Aditya & Bhartiya, 2017) in rice. The traits which showed dominance or non-additive type of gene effects might be improved by inter-mating the most desirable segregates followed by selection. Whereas, traits that exhibited a predominance of non-additive gene effects would require maintaining considerable heterozygosity through mating of the selected plant in early segregating generations to attain maximum genetic gain. Therefore, few cycles of recurrent selection followed by pedigree breeding would be effective for the improvement of grain yield.

SUMMARY.

Inheritance of grain yield and yield parameters in rice using a partial diallel mating analysis was carried out at the National Cereal Research Institute (NCRI) Badeggi Bida Niger State during 2017-2018 cropping season. Four varieties of rice (FARO 41, FARO 47, FARO 63 and FARO 64) and a variety of NERICA 1 rice also known as FARO 55 were obtained from the research institute for the studies. The five parents were crossed in a partial diallel mating design to give a total of 10 treatments without reciprocal crosses. The rice plants were planted in 5 liters bucket filled with top loamy soil (3/4 filled with soil), arranged in a randomized complete block design with four replications. Parent lines and F_1 hybrids were evaluated, individual and joint analyses of variance were performed, Genetic analysis to estimate general combining ability (GCA), specific combining ability (SCA) and their interaction effect with location, was estimated Analysis of variance revealed high significant difference for all the parameters studied. This indicate a heritable portion of the phenotypic variance and it is a good index of transmission of a character from parents to their off springs

Results showed that there were appreciable variability in all the parameters studied with the cross between FARO 47 x FARO 64 showing the highest mean value of 96.00 for days to 50% flowering and FARO 47 has the least mean value of 65.67. Plant height at harvest had a mean of 78.59 ranging from 52.33 (FARO 63 x FARO 64) to 119.33 (FARO 41 x FARO 55) though, on

tiller count, a mean of 11.73 was recorded ranging from 7.33 (FARO 41 x FARO 63) to 21.33 (FARO 41 x FARO 47). On panicle count, a mean of 5.06 was recorded ranging from 2.44 (FARO 63) to 9.33 (FARO 47 x FARO 55). Harvest count had a mean of 3.73 ranging from 1.67 (FARO 41 x FARO 47) to 5.67 (FARO 63 x FARO 64) and on hundred grain weight, mean of 25.17 was recorded ranging from 20.13 (FARO 41 x FARO 64) to 30.73 (FARO 41 x FARO 47). Heritability in narrow sense was observed to be high in all studied trait from 0.82% to 0.98%.

CONCLUSION.

Appreciable variation in all the parameters has been established in this study and Heritability in narrow sense was observed to be high in all studied trait with ranged values from 0.82% to 0.98% If heritability of a character is high, the phenotypic value provides a fairly close measure of the genotypic value and thus, breeder can base his selection on the phenotypic performance. Based on these results, the crosses between FARO 41 x FARO 47 and FARO 47 x FARO 63 have been identified as the most promising inbred pairs for breeding programmes for higher grain yield therefore recommended to farmer for higher grain yield.

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YIELD OPTIMIZATION IN SESAME (*Sesamum indicum* L.) USING HYDROGEN PEROXIDE AND BENZENE TREATMENTS.

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ABSTRACT.

Sesame is one of the most ancient oilseeds crop known to humanity. It plays an important role in human nutrition. Nevertheless, narrow gene pool in the available germplasms demands the need of crop reform for higher yield. An investigation was carried out on the effects of hydrogen peroxide and benzene treatments (chemical mutagens) on the yield optimization of sesame (*Sesamum indicum* L.) in Keffi, Nasarawa State. NCRIBEN-02M variety of sesame was exposed to benzene, hydrogen peroxide and the mixture of the two chemical mutagens at varying concentration (100, 75, 50, 25 and 0%). The M2 generation of the genotypes were assessed for pod length, number of seeds per pod and weight of 100 seeds. Benzene treatments, at all levels, have the highest number of pods. In M2 generation, benzene treatments produced triple pods per stalk. The increase in number of pods, seeds per pod and pod length were significant at $p \leq 0.05$. The optimum concentrations of the mutagens used for mutation in sesame, were effective at 100 and 75% of all the treatments. The most effective mutagen for inducing mutation in sesame under Keffi environment was benzene, followed by hydrogen peroxide. Benzene and hydrogen peroxide have proven themselves as chemical mutagens, in mutation breeding. They have unlocked several agronomic traits in sesame. Further, study on these mutagens will enhance the genetic variability in the growing of sesame for higher performance.

Key words: Benzene, chemical mutagens, hydrogen peroxide, mutation breeding, sesame, yield

INTRODUCTION.

Sesame (*Sesamum indicum* L.), otherwise known as sesame or benniseed is a member of the family Pedaliaceae. *Sesame indicum*, the cultivated type, (Doll & Peto, 1981; Dunkel *et al*., 1985), originated in India (Dunkel *et al*., 1985; Kirk *et al*., 1991). Sesame cultivated primarily for its oil-rich seeds (Hodgson, 2004). In Nigeria, the crop (often referred to as beniseed) is widely used and very popular in parts of the North Central, North Western and

North Eastern zones where it is usually grown. The local names are 'Ridi' Hausa, 'Ishwa': Tiv, 'Yamati'or 'Eeku': Yoruba, 'Igorigo' Ebira and 'Doo': Jukun (Willett, 1995). The seeds, which yield half of their weight in oil, are most commonly used in soups while the young leaves are used as a soup vegetable. Various parts of the plants are also used in native medicines (Williams *et al*., 2000). The stems are usually burned as fuel where firewood is scarce and the ash is commonly used for local soap production. The pressed cake remaining after the oil is removed is a rich source of protein for farm animals (Valko *et al.*, 2005).

Mutation is the sudden change in heritable genetic material at the gene or chromosome level (Hockberger, 2002). They may be caused by error during cell division or by exposure to the DNA-damaging agents or mutagens in the environment (Chatterjee and Walker, 2017). Such mutagens may include Reactive Oxygen Species (ROS) – These may be superoxide, hydroxyl radicals and hydrogen peroxide (Lee et al., 2005; Ablaku *et al.,* 2021), alkaloid from plants, such as those from Vinca species (Lipp et al., 2005), sodium azide, an azide salt, bromine and benzene (Henderson et al., 2001; Ablaku *et al.,* 2021). A wide range of characters which have been improved through induced mutation breeding, include plant architecture, yield, flowering and maturity duration, quality and tolerance to biotic and abiotic stresses. About 89% of mutant varieties have been developed using physical mutagens such as X-rays, gamma rays, thermal and fast moving neutrons (Gibbs *et al*., 2009). The use of mutation techniques has proved very successful in inducing desirable mutations such as increased seed yield, earliness, modified plant architecture, disease resistance, seed retention and high oil content in sesame (Mangi *et al*., 2016). It is recommended that while for qualitative characters selection could start with single plants in the F2, for quantitative characters it should be initiated in the F3 generation (Dolara *et al*., 2012).

Chemical mutagens have been used in recent times to unlock different genetic variability in plants. Gamma rays alone accounting for the development of 60% of the mutant varieties (Kumar *et al*., 2016). Gamma radiation has been widely applied in medicine and biology in terms of biological effects induced by a counter intuitive switchover from low doses stimulation to high-doses inhibition (Kamala & Sasikala, 1985). Gamma radiation has provided a number of useful mutants and still shows an elevated potential for improving vegetative plants (Hockberger, 2002; Cheng *et al*., 2015). The mutagenic effects of sodium azide (NaN_3) have been documented in previous reports. Kleinhofs *et al*. (1978) reported that sodium azide is a very potent mutagen in barley and induced chlorophyll deficiency as well as a wide range of morphological and physiological mutants. The chemical induces genetic sterility in rice without changes in vigour (Mensah *et al*., 2005; Henry *et al*., 2014). On the other hand, colchicine is both a polyploidising and mutagenic agent (Bragal, 1955). This chemical has been used for a long time to produce polyploidy plants. The mutagenic effects on plant morphology, chlorophyll, sterility and yield have earlier been confirmed by Ahoowalia (1967) and Mensah (1977). Balkanjieva (1980) reported the influence of genotype on mutagenic variability in barley following colchicine treatment. *Sesame indicum* L. produces seeds, which are rich in both protein and oil.

Nigerian farmers are putting more focused on sesame because of its potential as an export commodity for its seeds. Sesame oil is in high demand because of its importance in the confectionary industry worldwide (Fatima, 2021). The seed is used for the production of high quality odourless oil. To increase production of the crop there is need to have a better understanding of its genetic background. However, there is paucity of information on the locally cultivated varieties, which lack variability because of their self-pollination

status (Castro *et al.*, 2003). The present study is designed to fill the gap in knowledge of the genetic background by creating variation using mutagenic treatment of hydrogen peroxide (H_2O_2) and benzene (C_6H_6). Other mutagens like colchicine ($C_{22}H_{25}NO_6$), sodium azide (NaN_3), ethidium bromide ($C_{21}H_{20}BrN_3$) have been used to improve agronomic traits of sesame in the past years, but they are very expensive. However, mutagens like benzene and hydrogen peroxide are less expensive. They could replace the expensive mutagens if found to unlock the same variability.

Objectives of the Study.

The objectives study was to evaluate effects of hydrogen peroxide and benzene treatments on the yield of sesame in Keffi, Nasarawa State. By comparing the effects of hydrogen peroxide, benzene and combination of the two mutagens on sesame to determine the yield of M2 plant at all treatment and level.

MATERIALS AND METHODS.

Study Area.

The study hydrogen peroxide was carried out in the Department Plant Science and Biotechnology Research Garden, Nasarawa State University, Keffi. Keffi Local Government Area is located 8°50'22.8"N 7°54'16.9"E about 68 kilometre from Abuja the Federal capital and 128 kilometre from Lafia the State capital (Binbol & Marcus, 2010). Variation in temperature is generally high during the day, particularly between the months of March and April, the temperature variation continues in the cessation periods by October ending when further decline is made possible (Bartley *et al*., 1994). The average annual rainfall reaches peak (328 mm) around August dropping to 68 mm in October. About 95% of rainfall is between May and September the wettest months begin in July and August. This rain comes with thunderstorms of high intensity particularly at the beginning and towards the end of the raining season (Binbol & Marcus, 2010). The soil type in the study area is loamy (Binbol & Marcus, 2010).

Sample Collection.

The material, a variety of sesame (*Sesamum indicum* L.), NCRIBEN 002, was collected from National Cereal Research Institute (NCRI), Badeggi, Niger State.

Sample Preparation.

Seed viability test was carried out using the floating method. Genetically pure and uniform dry seeds (10 - 12% moisture content) were soaked in 100, 75, 50, and 25% concentrations of hydrogen peroxide in water for 12 hrs, and thus referred to as A. Another set of seeds were soaked in 100, 75, 50, and 25% concentration of benzene in hexane. After 12 hrs, distilled water was used to rinse the seeds. The seeds, after rinsing, were referred to as B. Another set of seeds were soaked in mixture of hydrogen peroxide in water and benzene in hexane in the ratio of 50:50, 37.5: 37.5, 25:25, and 12.5:12.5% for 12 hr. The seeds were rinsed with distilled water and thus referred to as C (AOAC, 1990). The final set of seeds was soaked in water for 12 hr. The seeds were thus referred to as D.

Experimental Design.

The treated seeds were washed in running water to remove excess chemicals and exudates from the seeds and sown directly in a spilt plot design ((Ablaku *et al.*, 2021), as shown in Appendix A. Germination was observed daily until maximum germination was attained on the 7th day after sowing (DAS) (AOAC, 1990).

Data Collection.

The treated seeds were grown from September to December 2015 at Department of Plant Science and Biotechnology Research Garden of Nasarawa State University Keffi, Nasarawa State, to rise M1 generation. The M1 generation was harvested and M2 generation was grown

from February to May 2016. In M2, data was recorded for number of capsules per plant, capsule length (cm) per plant, internode length (cm) per plant, leaf area (cm^2) per plant, number of seeds per capsule, 100 seed weight (g) per plant, days to maturity and seed yield per plant (g) (AOAC, 1990). A tape, micrometre screw gauge and meter rule were used to measure the agronomic traits. Weight of seeds were determined using an analytical weighing balance.

RESULTS AND DISCUSSION.

Yield of sesame per treatment dose of mutagen.
The yield after treatment with Benzene, Hydrogen Peroxide and the mixture of the two chemical mutagens (benzene and hydrogen peroxide) at all levels is presented in Table 1. The yield is observed using number of pods per stem, pod length, seeds per pod and weight of 100 seeds. Number of pod in the Benzene treatment was observed to be the highest in all the treatments, with a mean value of 137.02±6.73 as against the control, which was 23.33±1.01.

The mixture of benzene and hydrogen peroxide followed with number of pod per stem as 83.52±3.34 all at 100% level. The number of pods per stem decrease as the levels of chemical mutagen used in this study decrease from 100% to 25% and subsequently the control, as shown in Table 1.

The pod, length after the M2 generation is observed to be higher when compared to the control at all treatment levels. The longer the pod the more the number of seeds it is likely to contain. In this study, the number of seeds were found to be more in the Benzene treatment than all the other two treatments at their respective levels.

The overall best yield, after the M2 generation of NCRIBEN 02, stood at an average of 72.87±2.53 for Benzene treatment at level 100% followed by the same Benzene treatment at level 75% and 50% respectively.

Measurement of plant yield can be achieved through different ways and techniques. It gives a clearer direction and judgment as to which of the treatment, at what level, will give the best result needed. Number of pods per plant, pods length, seeds per pod, and weight of 100 seeds, were used to analyse the yield of the different treatment and their respective levels.

Table 4.8 show a summary of the mean difference, standard error and significance at 95% confidence and $p \leq 0.05$. There is increase in number of pods in benzene treatment and the mixture of benzene and hydrogen peroxide. The increase in number of pod in hydrogen peroxide treatment at all level is not high when compared to benzene treatment at all levels.

The pod length in benzene treatment appears to be longer in length when compared to the other treatments. The mixture of benzene and hydrogen peroxide have pod length estimated to be close to benzene treatment. Hydrogen peroxide, at level one, two and three show an increase in pod length, which is significant at 95% confidence and $p \leq 0.05$ when compared to the control.

The plot of estimated marginal means against treatment show that benzene treatment at level two, three and four, have high number of seed per pod. The number of seed per pod in level one of the benzene treatment is the least in benzene treatment. The mixture of benzene and hydrogen peroxide at level three show a significantly at 95% confidence and $p \leq 0.05$ high mean of about 84 seeds per pod. Hydrogen peroxide treatment shows an estimated mean of about 74-76 seeds per pod in all levels. The control have between 58-60 numbers of seeds per pod.

Table 1: Plant Yield at M2 between Two Weeks After Planting and Eight Weeks after Planting.

Level	Pod and Seed Yield of M2	Benzene		Hydrogen peroxide		Benzene & Hydrogen peroxide		Water/Control	
		Mean	**Std. D**	**Mean**	**Std. D**	**Mean**	**Std. D**	**Mean**	**Std. D**
100%	Number of Pods	137.02	6.73	45.52	3.09	83.52	3.34	23.33	1.01
	Pod Length **(cm)**	31.70	1.15	35.16	0.28	30.96	0.15	26.60	1.53
	Seed Per Pod	81.38	2.26	74.81	2.28	70.36	5.75	56.84	3.64
	Weight of 100 Seeds (g)	0.23	0.01	0.25	0.01	0.24	0.01	0.22	0.00
	Total	**72.87**	**2.53**	**38.93**	**1.41**	**46.27**	**2.31**	**26.74**	**1.545**
75%	Number of Pods	119.90	4.46	36.65	3.45	70.48	4.80	22.85	3.94
	Pod Length **(cm)**	34.66	0.15	34.00	0.00	32.46	0.05	26.34	1.98
	Seed Per Pod	82.64	3.73	75.35	1.98	72.31	2.07	56.68	7.36
	Weight of 100 Seeds (g)	0.25	0.00	0.27	0.02	0.27	0.04	0.24	0.03
	Total	**59.36**	**2.08**	**36.56**	**1.36**	**43.88**	**1.74**	**26.52**	**3.32**
50%	Number of Pods	96.69	11.64	30.25	1.35	48.83	2.77	21.74	9.13
	Pod Length **(cm)**	34.70	0.10	33.77	0.12	33.76	0.23	26.38	1.09
	Seed Per Pod	85.17	4.01	70.36	2.32	84.00	0.00	56.73	2.17
	Weight of 100 Seeds (g)	0.27	0.08	0.25	0.03	0.23	0.01	0.22	0.00
	Total	**54.20**	**3.95**	**33.65**	**0.955**	**41.70**	**0.75**	**26.26**	**3.09**
25%	Number of Pods	67.24	13.94	20.88	5.25	34.75	0.00	21.91	1.52
	Pod Length **(cm)**	29.21	0.34	27.49	0.09	29.50	0.10	27.40	0.26
	Seed Per Pod	72.28	7.35	73.83	2.06	72.00	0.00	56.28	5.55
	Weight of 100 Seeds (g)	0.28	0.00	0.28	0.00	0.26	0.01	0.26	0.03
	Total	**42.25**	**5.40**	**30.62**	**1.85**	**34.12**	**0.02**	**26.46**	**1.84**

Table 2: Differences Between mean value of Pods and Seeds Yield after 2 weeks to 8 Weeks of planting.

Pod and Seed Yield of M2 (I)	Pod and Seed Yield of M2 (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
56.03	30.88	25.15*	0.85	0.00	23.17	27.13
	71.50	-15.42*	0.85	0.00	-17.44	-13.48
	0.25	55.74*	0.85	0.00	53.80	57.76
30.88	56.03	-25.15*	0.85	0.00	-27.13	-23.17
	71.50	-40.62*	0.85	0.00	-42.60	-38.63
	0.25	30.63*	0.85	0.00	28.64	32.61
71.50	56.03	15.46*	0.85	0.00	13.48	17.44
	30.88	40.62*	0.85	0.00	38.63	42.60
	0.25	71.25*	0.85	0.00	69.26	73.23
0.25	56.03	-55.78*	0.85	0.00	-57.76	-53.80
	30.88	-30.63*	0.85	0.00	-32.61	-28.64
	71.50	-71.25*	0.85	0.00	-73.23	-69.26

Number of Pods = 56.0376, Pod Length = 30.8837, Seed Per Pod = 71.5047, Weight of 100 Seeds = 0.2536,

*Based on observed means.

The error term is Mean Square (Error) = 1.109

The mean difference is significant at the 0.05 level.

The increase in number of the capsules permit a substantial increase in the number of seeds produced; thereby facilitating the production of mutants producing large number of seeds. Moreover, the increase in 100 seeds weight of sesame mutants due to colchicine treatment was in line with the work of Anbarasan et al., (2012) who reported increase in grain weight of rice due to doses of Ethyl Methane Sulphonate (EMS). This was also in conformity with the work of Ashri A. (1982) who reported increase in seed yield of sesame due to EMS and sodium azide on sesame, casto bean and peanut. The results obtained in this study are in agreement with those of Antoun (1980), Gautam *et al*. (1998); Asmahan (2000), Rascio *et al*. (2001) and Osama (2002). Brooks et al., (2014) reported that the improvement of yield components in various crop plants (tomato, maize, rice and wheat), were induced after various mutagenic treatments with EMS, sodium azide and gamma rays. Moreover, the correlation between the yield and yield components of the mutants is in conformity with the findings of Akram *et al*. (1982) and Brar & Saini (1976) among the irradiated mutants of rice.

Furthermore, the increase in the number of capsules among sesame mutants, in M2 generation was in agreement with the work of Hoballah (1999) who reported increase in the number of capsules per plant among sesame mutants due to chemical and gamma irradiation; which considerably facilitate improvement in the sesame seeds yield (Mensah *et al*., 2007).

This study was carried out to evaluate the effects of hydrogen peroxide and benzene treatments on yield of sesame in Keffi. NCRIBEN 02 Variety of sesame was exposed to varying concentration of benzene, hydrogen peroxide, and the mixture of the two chemical mutagens. The M2 generation of the genotypes were assessed for agronomic traits, yield and nutritional value. Benzene treatment, at all levels, have the highest number of pods. In M2 generation, benzene treatments produce triple pods per stalk. The increase in number of pods, seeds per pod and pod length are significant at $p \leq 0.05$. The most effective mutagen for inducing mutation in sesame under Keffi environment is benzene, followed by hydrogen peroxide. Benzene and hydrogen peroxide have proven themselves as chemical mutagens, in mutation breeding. They have unlocked several agronomic traits in sesame. Further, study on these mutagens will enhance the genetic variability in the growing of sesame for higher performance.

CONCLUSION.

Benzene and hydrogen peroxide have proven themselves as chemical mutagens, in mutation breeding. They have unlocked several agronomic traits in sesame. Benzene treatments at all levels, show increase in pod length, number of seeds per pod and weight of 100 seeds as against the control. Benzene treatment also show agronomic traits improvement at all levels.

RECOMMENDATIONS.

The investigation designed in this study; induce variability through mutagenic treatments of existing genotype of sesame, for boosting seed yield. The mutagenic effects of hydrogen peroxide, benzene and combination of the two mutagens (hydrogen peroxide and benzene) on sesame should be investigated further using other phenotypes. They may likely replace other chemical mutagens that are expensive, if further investigations confirm these findings. The levels of Benzene and hydrogen peroxide used to induce mutation in sesame are effective at 100% and 75% of all the treatments and may be considered as optimum.

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