FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 7 No. 6, December (Special Issue), 2023, pp 211 -221
DOI: https://doi.org/10.33003/fjs-2023-0706-2187

# COMPARATIVE ANALYSIS OF PRODUCTIVITY AND CONSTRAINTS OF RAIN-FED AND IRRIGATED SUGARCANE PRODUCTION FARMING SYSTEMS IN BAUCHI STATE, NIGERIA

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## ABSTRACT

The study assessed the productivity of Rain-Fed Farming System (RFFS) and Irrigated Farming System (IRFS) farming systems of sugarcane production in Bauchi State, Nigeria. Using primary data collected in a three-stage purposive sampling procedure from a total of 231 sugarcane farmers. Descriptive statistics, productivity index, farm budgetary techniques, Z-statistics, Likert scale and Kendall's coefficient of concordance were used to analyse the data. The farmers mean age was 44 years RFFS and 42 years IRFS with an average of 7years of formal education with a mean farming experience of 11 years. The average productivity index for the RFFS was 382 kg/ha, compared to 1824 kg/ha for IRFS. The costs and returns analysis revealed a gross margin of ₦430,038.82 RFFS and ₦947,697.23 IRFS, with a net farm income of ₦414,342.25 RFFS and ₦926,638.339 IRFS. The profitability ratio was 1.14 for RFFS and 1.85 IRFS. The most serious constraints associated with both systems are inadequate capital and access to credit facilities ($\bar{X}$=2.74) RFFS, ($\bar{X}$=2.41) inadequate extension services ($\bar{X}$= 2.63) RFFS, ($\bar{X}$= 2.24) IRFS, and high cost of farm inputs ($\bar{X}$= 2.44) RFFS and ( $\bar{X}$= 2.18 ) IRFS with a pooled Kendall W value of 0.201 and, 0.166 respectively. A t-test value of 9.579 at 1% level implied statistically significant productivity differential. The study concluded that sugarcane production is profitable, however, IRFS gave higher profitability ratio compare to RFFS. Access to better extension services was recommended if the sugar cane famers are to make better use of available resources in the study area.

**Keywords**: Rain fed, Irrigated, Sugarcane, Farming system, Bauchi

## INTRODUCTION

Sugarcane (*Saccharum officinarum*) is one of the most important crops in the world because of its immense usage in the daily life of man and or any nation for industrial uses aimed at nutritional and economic sustenance. Sugarcane contributes about 60% of the total world sugar requirement while the remaining 40%, is from beet (Girei and Giroh, 2012). It is a tropical crop that usually takes between 8 to 12 months to reach its maturity. Mature cane may be green, yellow, purplish or reddish and considered ripen when sugar content is at maximum. The main driver behind the expansion of land under sugarcane farming and increasing sugarcane monoculture is the rise in the world's demand for sugar but rather than explore the rising demand, among 92 countries that belong to the international sugar organization, Nigeria is the only one that belongs to the category of sugar importers and ranked fourth. Evidence showed that when compared to some selected West African Sugar producing countries, Nigeria is the least food secured in terms of sugar (National Sugar Development Council, 2012). Arising from the overdependence on sugar importation, cultivation of sugarcane for industrial purpose has suffered a serious setback due to poor performance of government established and owned sugar companies in Nigeria. The desired productivity improvements and competitiveness in Nigerian sugarcanes enterprises have been difficult to achieve over the years due to weaknesses in the commodity marketing system; the lack of attention to develop the commodity chain, producing value added products (value-chain) and enhance market access (FAOSTAT, 2015).

Sugar industries in Nigeria rely more on improved cultivars brought in from overseas rather than those developed in Nigerian Research Institutes, for reason not beyond inadequate information about the performance of these local cultivars that were bred in this country. The country's sugar industry only supplies about 3% of the nation's requirement. (NSDC, 2012). In Nigeria, according to the Food and Agriculture Organization Statistics (FAOSTAT), (2017), the trend of sugarcane production can be deduced to have being increasing. The production trend between 1992 and 2001 increased between 1% and 9.7% but decreased more for up to 30% in 1994. In the last decade, the production increased more than ever, that is between 3.4% and 52.5%, especially in 2009 where the significant expansion occurred. This was as a result of double and more increase in the area of harvest. The trend in the first half of this period is an upward one before it then fluctuated. This trend of sugarcane production in Nigeria from 1992 – 2016 is presented in Table 1.

**Table 1: Trend of Sugarcane Production in Nigeria from 1992 – 2016**

| Year | Area Harvested (Ha) | Yield (Tonnes/Ha) | Production (Tonnes) |
|---|---|---|---|
| 1992 | 22400 | 40.00 | 896000 |
| 1993 | 23800 | 38.03 | 905000 |
| 1994 | 18750 | 33.76 | 633000 |
| 1995 | 19270 | 30.57 | 589000 |
| 1996 | 21053 | 29.21 | 615000 |
| 1997 | 21900 | 30.82 | 675000 |
| 1998 | 23000 | 29.35 | 675000 |

| | | | |
|---|---|---|---|
| 1999 | 24000 | 28.42 | 682000 |
| 2000 | 24000 | 28.96 | 695000 |
| 2001 | 23000 | 30.65 | 705000 |
| 2002 | 40000 | 18.75 | 750000 |
| 2003 | 42000 | 19.00 | 798000 |
| 2004 | 43000 | 19.86 | 854000 |
| 2005 | 44000 | 20.77 | 914000 |
| 2006 | 47000 | 21.00 | 987000 |
| 2007 | 63000 | 23.90 | 1506000 |
| 2008 | 71890 | 19.64 | 1412070 |
| 2009 | 73060 | 19.19 | 1401680 |
| 2010 | 73060 | 19.16 | 1400000 |
| 2011 | 74000 | 19.59 | 1450000 |
| 2012 | 74000 | 19.59 | 1450000 |
| 2013 | 74000 | 19.59 | 1450000 |
| 2014 | 75000 | 19.73 | 1480000 |
| 2015 | 75050 | 20.12 | 1510000 |
| 2016 | 77000 | 20.06 | 1545000 |

Source: FAOSTAT, (2017).

Sugarcane is cultivated either under irrigation farming system (IRFS) or rain-fed farming systems (RFFS) in the tropical areas with ample rainfall. Land productivity in area suitable for its rain-fed production is typically much higher than cultivated land in cooler regions or arid sub-tropical and tropical agriculture, and the crop is found throughout the tropics and sub-tropics (Forum for Agricultural Research in Africa (FARA), 2008).

However, large part of the world cannot grow it for climatic reasons and its impact in this suitable area is, therefore, more significant. Hence, climatic changes threaten the sustainability of the most rain-fed sugar farming systems (Aina *et al*., 2015). According to Oni (2016), certain climate change scenarios may harm sugarcane growth and yield without the introduction of appropriate irrigation facilities. Therefore, rain-fed sugarcane farming system is gradually being replaced by irrigated farming system whenever such transition is possible. In addition, low efficiency irrigation systems are being replaced by high efficiency systems to make sugarcane farming more economically sustainable. However, irrigation is one of the most expensive of sugarcane farming systems and can account for more than 25% of the production cost (Aina *et al*., 2015). Therefore, the dimensions of sugarcane irrigation systems need to be adjusted for water conservation while simultaneously reducing operational costs. Like most major tropical crops, sugarcane growth, yield and quality respond markedly to variation in moisture present in the soil; Therefore, availability of water is an important factor causing variation in sugarcane yield and juicy quality.

With growing population, the demand for sugar consumption is on increase in Nigeria. The trends in sugarcane industrial activities suggest that the demand for sugar will continue to rise to the point that demand for sugar in Nigeria will outstrip supply thereby causing a deficit in supply (Lyocks, 2016). Nigeria's farming practice is largely rain-fed. However, considerable investment has also been made in irrigation infrastructure which is yet to make the desired impact on food security in the country. Both irrigated and rain-fed farming systems are dominated by small scale farmers who majorly cultivate less than five hectares. It is in this light that this study, seeks to assess sugarcane production under rain-fed and irrigated farming systems in Bauchi State, Nigeria. Hence, the study provided answers to the following research questions: What are the socio-economic characteristics of sugarcane farmers under rain-fed and irrigated farming systems in the study area? What is the productivity of sugarcane production under rain-fed and farming systems in the study area? What are the constraints of sugarcane production under rain-fed and irrigated farming systems in the study area?

The main objective of this study is to assess the rain-fed and irrigated farming systems of sugarcane production in Bauchi State, Nigeria. The specific objectives are to: describe the socio-economic characteristics of sugarcane farmers under rain-fed and irrigated farming systems; determine the productivity of sugarcane production under the two systems rain; examine the constraints to sugarcane production the farming systems in the study area.

## MATERIALS AND METHODS

### The study Area

Bauchi State, Nigeria. is located in the North-East agro ecological zone of the country between Latitudes 9°30' and 12°30' North of the equator, and Longitudes 8°45' and 11°0' East of the Greenwich meridian. Situated in the North-East geopolitical zone of Nigeria, the state is bordered by Jigawa to the north, Yobe to the northeast, Gombe to the east, Taraba and Plateau to the south, Kaduna to the west and Kano to the northwest is bounded in a clockwise direction by Yobe, Gombe, Taraba, Plateau, Kaduna, Kano and Jigawa states. It comprised of 20 Local Government Areas (LGAs), namely; Alkaleri, Bauchi Bogoro, Dambam, Darazo, Dass, Gamawa, Ganjuwa, Giade, Itas Gadau, Katagum, Kirfi, Jama'are, Missau, Ningi, Shira, Tafawa-Balewa, Toro, Warji and Zaki. Bauchi State covers land area of about 49,259 $Km^2$ with a projected to be about 6,216,486 in 2018 at 2.8% growth rate per annum (National Bureau of Statistics (NBS), 2016).

Bauchi state is heterogeneous in terms of ethnicity, with predominant tribes like Hausa, Fulani, Jarawa, Tangale, Waja, Balewa, Sayawa and Tarewa. The entire western and northern parts of the state are generally mountainous and rocky. The study area falls within the Sudan Savannah vegetation zone with an average annual rainfall of 1,300 to 1,600mm per annum which commences in April and ends in October. The residents of the area are engaged in agriculture with trading activities. Common crops cultivated includes millet, sugarcane, maize, guinea corn, and groundnut and Livestock rearing. (Bauchi State Agricultural Development Project (BSADP), 2019.

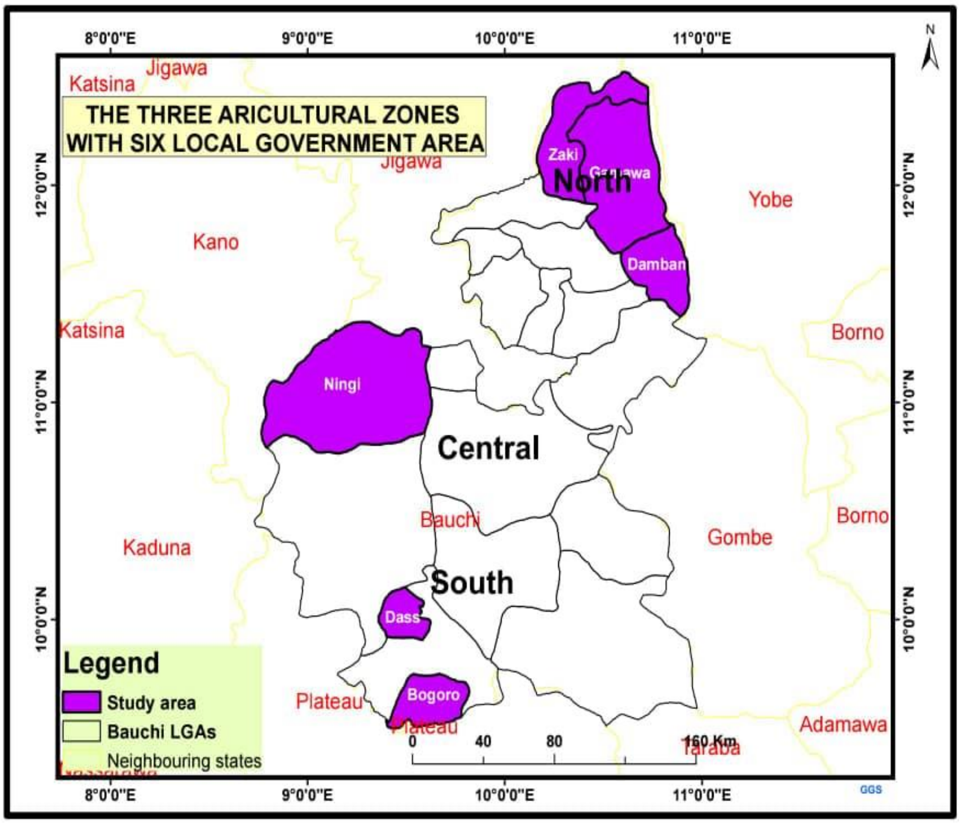


Figure 1: Showing The three Agricultural zones and six Local Government Areas of the study.

**Sampling Procedure and Sample Size**

Three-stage sampling procedure was used for this study. The first stage involved the purposive selection of two (2) LGAs each from the three (3) agricultural Zones in the state to make a total of six (6) LGAs selected. The second stage involved purposive selection of two (2) villages from each of the selected LGAs to make up a total of twelve (12) villages considered for this study. In the final stage, Taro Yamane's formula at 5% precision level was used to select a sample size of farmers resulting to a total of 231 farmers. The sample outlay of the respondents is presented in Table 2. Taro Yamane's formula is given as:

$$n = \frac{N}{1+N(e)^2} \qquad (1)$$

Where n = Sample size, N = Finite population, and e = limit of tolerable error (5% precision level).

**Table 2: Sample outlay of the respondents in the study area**

| Agricultural zones | LGA's | Villages | Sample frame | Sample size |
|---|---|---|---|---|
| **Farmers under rain-fed farming system** | | | | |
| **Bauchi South** | Bogoro | Badagari | 21 | 14 |
| | | Bungu | 11 | 8 |
| | Dass | Wandi | 12 | 8 |
| | | Baraza | 13 | 10 |
| **Bauchi Central** | Ningi | Kudu | 16 | 11 |
| | | Yamma | 14 | 10 |
| | Dambam | Zaura | 12 | 8 |
| | | Danbam | 15 | 10 |
| **Bauchi North** | Zaki | Maiwa | 13 | 10 |
| | | Makawa | 14 | 10 |
| | Gamawa | Gadiya | 19 | 12 |
| | | Tumbi | 18 | 12 |
| **Sub-total** | **6** | **12** | **178** | **123** |
| **Farmers under irrigated farming system** | | | | |
| **Bauchi South** | Bogoro | Badagari | 11 | 8 |
| | | Bungu | 14 | 10 |
| | Dass | Wandi | 12 | 9 |
| | | Baraza | 10 | 7 |
| **Bauchi Central** | Ningi | Kudu | 14 | 10 |

| | | | | |
|---|---|---|---|---|
| | | Yamma | 12 | 9 |
| | Dambam | Zaura | 11 | 8 |
| | | Danbam | 13 | 10 |
| **Bauchi North** | Zaki | Maiwa | 14 | 10 |
| | | Makawa | 12 | 9 |
| | Gamawa | Gadiya | 10 | 7 |
| | | Tumbi | 15 | 11 |
| **Sub-total** | **6** | **12** | **148** | **108** |
| **Total** | **12** | **24** | **326** | **231** |

Source: Bauchi State Agricultural Development Project (BSADP), 2019

**Method of Data Analysis**
Both descriptive and inferential statistics were used to analyse the data in line with the stated objectives of the study. The descriptive statistics includes mean, frequency distribution, percentages and the Likert type scale rating, while the inferential statistics were productivity index, and Kendall's coefficient of concordance. Thus, objectives i was achieved using descriptive statistics (mean, frequency distribution and percentages), objective ii was achieved using productivity index, objective iii was achieved using while objective iii was achieved using descriptive statistics (mean, frequency distribution and percentages) as well as 3-point Likert type scale rating and Kendall's coefficient of concordance respectively. The hypotheses was achieved by using z-test.

**Model Specification**
***Productivity index*:** The productivity index model is specified as:

Productivity Index = $\frac{P_i}{A_i}$ *in* Kilogramme per Hectare (2)

Where
Pi = Output of the Farmer in Kilogramme, Ai = Area of Farm-land Cultivated in Hectares

**Likert type rating scale**
The 3-point Likert type rating was used to examine the constraints associated with sugarcane production under two farming systems. The model entails defining a scale of statement that mirrors the respondent's perception towards an underlying variable and establishing a score reflecting a quantitative measurement of the perception of each farmer. Their responses were very Severe (VS), Severe (S) and Not Severe (NS) with the corresponding values of 3, 2 and 1, respectively. The mean score value of less than 2.0 was taken as not severe constraint, while mean score value equal to 2.0 and or greater than 2.0 was taken as severe constraint to sugarcane production in the study area. Therefore, mean score for 3-point Likert scale is computed thus:

Mean score = $\frac{\Sigma fx}{n}$ (3)

**Kendall's coefficient of concordance**
The Kendall's coefficient was also used to examine the constraints to sugarcane production under irrigated and rain-fed farming system in the study area as stated in objective five (v). Kendall's coefficient (W) measures the extent of the agreement levels among several respondents who have common characteristics of suffering in a given set of challenges (Legendre, 2005). It is an index ratio of observed variance of the sum of ranks to the maximum possible variance of the ranks. The reason for the computation of the index is to find the ranks sum for each challenge being ranked. If there is a maximum agreement among the respondents` ranking, then the ranking is said to be perfect, otherwise, there is variability within or among the ranks sum (imperfect).

Kendall's coefficient of concordance (W) is given by the relation:

$$W = \frac{12S}{P^2\,(n^3 - n)} - P^T \quad (4)$$

Where
W = Kendall's coefficient of concordance; P = number of respondents ranking the constraints, n = number of quality perceptions' = correction factor for tied ranks,
S = sum of squares statistics over the row sum of ranks (Ri),
The sum of square statistics (S) is given as:

$$S = \sum_{i-1}^{n}(Ri - R)^2 \quad (5)$$

Where
Ri = row sums of rank; R = mean of Ri, the correction factor for tied ranks (T) is given as:

$$T = \sum_{k-1}^{m}(t_k^3 - t_k) \quad (6)$$

The test of significance of Kendall's coefficient of concordance was done using the chi-square statistic which is computed using the formula:

$$X^2 = P\,(n - 1)\,W \quad (7)$$

Where
n = number of constraints, P = number of respondents, and W = Kendall's coefficient of concordance.
The null hypothesis for Kendall's coefficient (W) is that, there is no agreement among respondents on the constraint hindering sugarcane production under irrigated and rain-fed farming system in the study area. If the computed or calculated chi-square is greater than the tabulated chi-square, then the null hypothesis will be rejected, otherwise it will be accepted.

**Hypothesis Testing:** Hypothesis was tested using the Z-test statistics.
The Z-test statistics or model is

$$Z = \frac{X_1 - X_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}} \quad (8)$$

Where
For hypothesis
Z = Calculated Z value
$\bar{X}_1$= Mean productivity of farmers under irrigation farming system, $\bar{X}_2$ = Mean productivity of farmers under rain fed farming system, $S_1^2$ = Standard deviation of farmers under irrigation farming system, $S_2^2$ = Standard deviation of farmers under rain fed farming system, $n_1$ = Sample size of farmers under irrigation farming system
$n_2$ = Sample size of farmers under rain fed farming system.

## RESULTS AND DISCUSSION
### Socio-Economic Characteristics of the Respondents
The following socio-economic variables were examined; age, sex, marital status, educational status, household size, farming experience, farm size, farmland acquisition, access to credit, extension visits, membership of cooperatives and secondary occupation.

***Age of the respondents***

Table 3 revealed that majority (78.9%) of the respondents under rain-fed and irrigated (88.0%) farmers were aged between 26 – 55 years with a mean age of 44 and 42 years respectively. The pooled results revealed that (83.1%) of the respondents were within the age range of 26 – 55 years with a mean age of 43 years. This implies that most of respondents were in their mid-age and most productive stage in life. Farmers age is important determinant of the quality and quantity of work done on the farm, because at this age bracket they have ability and energy and are capable of performing most farm operations, thus, produce optimum or expected productivity within the limit of available technology. This finding agreed with the study of Tashikalma *et al*. (2014) who reported in their study the socio-economic characteristics of farmers under irrigation and rain-fed farming system in Adamawa State, Nigeria. They found that most of the farmers in their study area under rain-fed and irrigation were in their productive years between 31 – 50 years.

***Sex of the respondents***

As revealed in Table 3, the pooled result showed that majority (98.7%) of the respondents were males, under the rain fed, about (97.6%) of the farmers and all (100.0%) farmers under irrigated system were males. This implies that gender wise, males dominate sugarcane production enterprise in the study area, which could be due to its tedious nature of sugarcane cultivation. In most rural settings, especially in the northern area, roles are ascribed based on gender differences, as males are known to be engaged in strenuous agricultural production. This finding is in agreement with Girei and Giroh (2012) on analysis of factors affecting sugarcane production under the out-growers scheme in Adamawa State reported that majority of their respondents were males in sugarcane production.

***Marital status of the respondents***

Marital status is the act of being married or unmarried (such as single, divorced or widowed). As shown in Table 3, the pooled results revealed that majority (97.0%) of the respondents were married, this also is reflected in the two systems under consideration. For instance, under the rain fed, about (96.7%) of the farmers were married while the result under irrigated system revealed a slightly higher (97.2%) number of farmers were married. This show that married individuals are more into sugarcane production in the study area. This attribute has implication on how responsible the farmers are, furthermore, sugar cane is a cash crop, its production could possibly mean providing financial succour for the families. This finding is in agreement with the work of Anaryu (2017) who reported that majority of the farmers in his study area were married and responsible.

***Educational status of the respondents***

Findings from the study as presented in table 3 revealed that more than half (56.7%) of the respondents acquired formal education with a mean of 7 years. Also, 51.2% of the respondents under rain-fed farming system acquired formal education, while 62.1% of the respondents under irrigated farming system had formal education. The mean years spent in formal education by respondents under rain-fed and irrigated farming system was 6 and 8 years, respectively. This implies that most of the respondents had one form of formal education or the other with at least primary education been attained by most farmers in the study area. Education is an important variable in agricultural development as it enhances farmers' decision-making process for adoption of new innovation in sugarcane production. This is in line with the findings of Abdul *et al*. (2016) who reported that most of their respondents acquired one form of formal education or the other with at least up to primary school level.

**Farming experience of the respondents**

The result from the farmers on their farming experience is as shown in Table 3 The pooled result revealed that more than half (57. %) of the respondents had farming experience ranging between 6 and 20 years with a mean of 10 years. Slightly more than half of the farmers under rain-fed (51.2%) and about (63.9%) of those under the irrigated farming system had farming experience within the range of 6 – 20 years with a mean farming experience of about 10 and 12 years, respectively. This implies that some of the respondents have been into sugarcane production over a relatively long period of time. Farming experience have implication for decision-making process. Farmers gain experiences when carrying out the same farming operations day in day out repeatedly, this often lead to farming expertise. This finding is also substantiate finding of Tashikalma *et al*. (2014) who posited that most of the farmers in their study area had more than 10 years of farming experience and their experiences catalysed or enhanced their farm operations or practices,

***Household size of the respondents***

Household size refers to the total number of people living together under the same roof and eating from the same pot. As revealed in Table 3, the result on household size revealed that most (65.0%) of the respondents had 6 – 20 people per household with mean of 11 people per household, while most of the respondents under rain-fed (65.8%) and irrigated (63.9%) farming system had household size within the range of 6 – 20 people with an average of 10 and 12 people, respectively. This implies that the respondents in the study area had large household size. Large household size is a good source of family labour that could enhance the capacity of the farmers to engage in sugarcane production. This also agrees with the findings of Abdul *et al*. (2016) who stated that large household size is an important factor in agricultural production because they are all involve in the farm operations which can improve timely operation, reduce cost and crop failure thereby leading to higher output.

***Farm size of the farmers***

Farm size is the total area of land that is put into agricultural production and an important fixed factor of production. As shown in Table 3, the pooled result of the respondents revealed that most (68. %) of the respondents had farm size of less than 3.1 hectares with a mean farm size of 3.1 hectares. Also, more than half (56.9%) of the respondents under rain-fed farming system had farm size of less than 3.1 hectares with a mean farm size of 3.9 hectares of farmland, while majority (80.5%) of the respondents under irrigated farming system had farm size of less than 3.1 hectares with mean farm size of 2.3 hectares. This revealed that most of the farmers in the study area were small to medium scale sugarcane farmers. The respondents under rain-fed sugarcane farming system had more farmland compare with those under irrigated sugarcane farming system. This finding corroborates the work of Anaryu *et al.* (2017) who found some of the rain-fed farmers and most of the irrigated farmers in his study cultivated less than 3 hectares of sugarcane farmland.

***Method of farmland acquisition by the respondents***

The pooled result of the respondents with respect to farmland acquisition revealed that majority (75.8%) of the respondents acquired their farmland through inheritance, followed by purchase (19.0%) and gift (11.7%). Also, majority of the respondents under rain-fed (78.9%) and irrigated (73.1%) farming system acquired their farmland through inheritance, followed by 21.1% and 16.7% who acquired their farmland through purchase respectively.

**Table 3: Distribution of the Respondents based on Socio-Economic Characteristics**

| Variables | Rain-fed (n = 123) | | Irrigated (n = 108) | | Pooled (n = 231) | |
|---|---|---|---|---|---|---|
| | **Freq** | **%** | **Freq** | **%** | **Freq** | **%** |
| Age (years) | | | | | | |
| **< 26** | 8 | 6.5 | 5 | 4.6 | 13 | 5.6 |
| **26 – 35** | 19 | 15.5 | 25 | 23.2 | 44 | 19.0 |
| **36 – 45** | 38 | 30.9 | 38 | 35.2 | 76 | 32.9 |
| **46 – 55** | 40 | 32.5 | 32 | 29.6 | 72 | 31.2 |
| **> 55** | 18 | 14.6 | 8 | 7.4 | 26 | 11.3 |
| Mean | **44** | | **42** | | **43** | |
| Sex | | | | | | |
| **Male** | 120 | 97.6 | 108 | 100.0 | 228 | 98.7 |
| **Female** | 3 | 2.4 | 0 | 0.0 | 3 | 1.3 |
| Marital status | | | | | | |
| **Single** | 4 | 3.3 | 3 | 2.8 | 7 | 3.0 |
| **Married** | 119 | 96.7 | 105 | 97.2 | 224 | 97.0 |
| Education (years) | | | | | | |
| **Non-formal** | 60 | 48.8 | 41 | 37.9 | 100 | 43.3 |
| **Primary** | 31 | 25.2 | 22 | 20.4 | 54 | 23.4 |
| **Secondary** | 25 | 20.3 | 30 | 27.8 | 55 | 23.8 |
| **Tertiary** | 7 | 5.7 | 15 | 13.9 | 22 | 9.5 |
| Mean | **6** | | **8** | | **7** | |
| Experience (years) | | | | | | |
| **< 6** | 48 | 39.0 | 27 | 25.0 | 75 | 32.5 |
| **6 – 10** | 45 | 36.6 | 34 | 31.5 | 79 | 34.2 |
| **11 – 15** | 10 | 8.1 | 21 | 19.4 | 31 | 13.4 |
| **16 – 20** | 8 | 6.5 | 14 | 13.0 | 22 | 9.5 |
| **> 20** | 12 | 9.8 | 12 | 11.1 | 24 | 10.4 |
| Mean | **9.8** | | **11.6** | | **10** | |
| Household size (number) | | | | | | |
| **< 6** | 33 | 26.8 | 21 | 19.4 | 54 | 23.4 |
| **6 – 10** | 39 | 31.7 | 36 | 33.3 | 75 | 32.5 |
| **11 – 15** | 32 | 26.0 | 20 | 18.5 | 52 | 22.5 |
| **16 – 20** | 10 | 8.1 | 13 | 12.1 | 23 | 10.0 |
| **> 20** | 9 | 7.3 | 18 | 16.7 | 27 | 11.7 |
| Mean | **10** | | **12** | | **11** | |
| Farm size (hectares) | | | | | | |
| **< 3.1** | 70 | 56.9 | 87 | 80.5 | 157 | 68.0 |
| **3.1 – 5.0** | 33 | 26.8 | 11 | 10.2 | 44 | 19.0 |
| **> 5.0** | 20 | 16.3 | 10 | 9.3 | 30 | 13.0 |
| Mean | **3.9** | | **2.3** | | **3.1** | |
| Farmland acquisition | | | | | | |
| **Inheritance** | 96 | 78.9 | 79 | 73.1 | 175 | 75.8 |
| **Purchase** | 26 | 21.1 | 18 | 16.7 | 44 | 19.0 |
| **Rent** | 6 | 4.9 | 13 | 12.1 | 19 | 8.2 |
| **Gift** | 14 | 11.4 | 13 | 12.1 | 27 | 11.7 |

Source: Field Survey, 2019

**Mean sugarcane output of the respondents**

Table 4 revealed the mean output of the respondents from sugarcane production. The pooled result from the farmers revealed minimum output of 100 kg, maximum output of 10000 kg and mean output of 1408.80 kg. For the rain fed system, the minimum output was 100 kg, maximum 1100 kg and a mean output of 519.67 kg, under the irrigated farming system the farmers had 160 kg Minimum, a maximum of 10,000 kg and mean output of 2,421.5 kg implying that irrigated farming system produced higher output compared to the rain-fed. The fact that irrigation allows farmers to undergo two production cycle per season may be responsible for the better outcome.

**Table 4: Mean sugarcane output of the respondents in kilogram**

| Output | Minimum (Kg) | Maximum (Kg) | Mean (Kg) |
|---|---|---|---|
| **Rain-fed** | 100 | 1100 | 519.67 |
| **Irrigated** | 160 | 10000 | 2,421.5 |
| **Pooled** | 100 | 10000 | 1,408.8 |

Source: Field Survey, 2019

**Productivity of Sugarcane under Rain-fed and Irrigated Farming System**

The results of the farmers under the two systems are presented in Table 5. The pooled result in terms of sugarcane productivity revealed that a little above half of the respondents (51.0%) recorded a productivity ranging between 261 – 1000 kg/ha with an average productivity of 1056 kg/ha. Under rain-fed farming system, more than half (60.2%) of the farmers recorded a productivity ranging between 261 – 1000 kg/ha with a minimum of 55 kg/ha, maximum of 928kg/ha and an average productivity (mean) of 382 kg/ha.

Similarly, more than half (58.3%) of the respondents under irrigated farming system realised sugarcane more than 1000 kg/ha with minimum of 160 kg/ha, maximum of 8000 Kg/ha and an a mean of 1824 Kg/ha. productivity alludes to the ability of a production system to produce economically and efficiently. However, in 2021, sugar cane yield for Nigeria was 175,796 Kg/ha. Though Nigeria sugar cane yield fluctuated substantially in recent years, it tended to decrease through 1972 - 2021 period ending at 175,796 hg per ha in 2021( Knoema,2022). This implies that both farmers under rain-fed and irrigated farming systems are producing below the optimum productivity going by their mean productivity. It expected that given a better employment of available resources, there is room for improvement under the two system. Onogwu *et al.* (2017) noted that improvement in agricultural productivity is generally considered to be as a result of a more efficient use of the factors of production, the good combination of land, labour, capital and entrepreneurship.

**Table 5: Distribution of the Respondents based on Sugarcane Productivity(kg/ha)**

| | Rain-fed | | Irrigated | | Pooled | |
|---|---|---|---|---|---|---|
| Productivity class (kg/ha) | **Freq** | **Percentage** | **Freq** | **Percentage** | **Freq** | **Percentage** |
| **< 261** | 49 | 39.8 | 1 | 0.9 | 50 | 21.7 |
| **261 – 500** | 49 | 39.8 | 11 | 10.3 | 60 | 25.9 |
| **501 – 750** | 15 | 12.3 | 9 | 8.3 | 24 | 10.4 |
| **751 – 1000** | 10 | 8.1 | 24 | 22.2 | 34 | 14.7 |
| **> 1000** | 0 | 0.0 | 63 | 58.3 | 63 | 27.3 |
| **Total** | 123 | 100.0 | 108 | 100.0 | 231 | 100.0 |
| Mean | **382** | | **1824** | | | **1056** |
| Minimum value | **55** | | **160** | | | **55** |
| Maximum value | **928** | | **8000** | | | **8000** |

Source: Field Survey, 2019

**Test of hypotheses**

The null hypothesis which states that there is no significant difference between the productivity of sugarcane farmers under irrigated and rain-fed farming system in the study area was tested using t – test statistics. The result of the pair- t – test as presented in Table 7 revealed t – statistic value of 9.579 at 1% level of probability. This implies that there was a significant difference in the mean output level of the sugarcane farmers under IRFS and rain-fed farming system in the study area. The null hypothesis was, therefore, rejected.

**Table 6: T-test estimate for null hypothesis**

| | Mean (kg) | Standard dev. | t – value | Decision |
|---|---|---|---|---|
| Irrigated sugarcane productivity index | 1824 | 147.39 | 9.579*** | Reject |
| Rain-fed sugarcane productivity index | 382 | 21.74 | | |
| Mean difference | 1442 | | | |

Source: Field survey, 2019 *** = significant at 1% probability level

**Constraints associated with Sugarcane Production Systems**

As presented in Table 4, the pooled result of perceived constraints associated with sugarcane production in the study area, revealed inadequate capital and access to credit facilities ($\bar{X}$= 2.58), inadequate extension services ($\bar{X}$= 2.45), high cost of farm inputs ($\bar{X}$= 2.32) and poor access to training on sugarcane production ($\bar{X}$= 2.32) ranked 1st, 2nd and 3rd, 4threspectively, among the severe constraints perceived by the respondents in the study area.

The study revealed that the major perceived severe constraints associated with sugarcane production under rain-fed farming system RFFS in the study area includes inadequate capital and access to credit facilities ($\bar{X}$= 2.74), inadequate extension services ($\bar{X}$= 2.63) and high cost of farm inputs ($\bar{X}$= 2.44) ranked 1st, 2nd and 3rd, respectively. Similarly, for IRFS the major constraints perceived to be severe by the farmers under IRFS includes inadequate capital and access to credit facilities ($\bar{X}$= 2.41), poor access to training on sugarcane production ($\bar{X}$= 2.31) and inadequate extension services ($\bar{X}$= 2.24) ranked 1st, 2nd and 3rd, respectively. This implies are the major constraints associated with sugarcane production under both rain-fed and irrigated farming system in the study area. These findings agreed with that of Sulaiman *et al.* (2015) that identified inadequate funding or credit facilities in sugarcane farmers' perception, challenges and response to climate change in Kaduna State, Nigeria as major constraints.

In the same vein, Oravee (2015) noted that lack of funding in the river basin and rural development lead to ineffectiveness of the scheme. In extension services, Mgbenka *et al.* (2015) identified access to credit and extension contact to be paramount among other factors in maximizing productivity. So also, Giroh (2012) in his study on efficiency of latex production and labour productivity in rubber plantation in Edo and Delta States, Nigeria; revealed that extension services among other factors enhances the allocation efficiency of rubber production in the study area.

Other constraints perceived by the respondents under rain-fed farming system to be severe in the study area, were unavailability of improved sugarcane seedlings ($\bar{X}$= 2.41), poor market policies and linkages ($\bar{X}$= 2.36), inadequate and high prizes of labour ($\bar{X}$= 2.35), poor access to training on sugarcane production ($\bar{X}$= 2.33), poor rural road networks from farm to market ($\bar{X}$= 2.30), inadequate storage facilities for sugarcane ($\bar{X}$= 2.28), poor access to farm inputs ($\bar{X}$= 2.28), lack of standardized means of measurement ($\bar{X}$= 2.17), poor value addition for sugarcane production ($\bar{X}$ = 2.08) and problem of pests and diseases infestation ($\bar{X}$= 2.01) ranked 4$^{th}$, 5$^{th}$, 6$^{th}$, 7$^{th}$, 8$^{th}$, 9$^{th}$, 11$^{th}$, 12$^{th}$ and 13$^{th}$, respectively. Meanwhile, constraints such as shortage of land for sugarcane farming ($\bar{X}$= 1.67), low demand for sugarcane by consumers ($\bar{X}$= 1.67), problem of drought ($\bar{X}$= 1.63) and insufficiency of irrigation water ($\bar{X}$ = 1.72) ranked 14$^{th}$, 16$^{th}$ and 17$^{th}$, respectively, were perceived not to be severe by the respondents under rain-fed farming system.

Meanwhile, other constraints perceived by the respondents under irrigated farming system to be severe were inadequate or access to farm inputs ($\bar{X}$= 2.19), high cost of farm inputs ($\bar{X}$= 2.18), this is identified by Dayo *et al.,* (2009) who found that low yield or output can be as a result inadequate use of farming inputs such as fertilizer, herbicide and other agro-chemical in any farming system and this translate to small earning to the farmers and hence, high poverty level. Problem of pests and diseases infestation ($\bar{X}$= 2.11).

In case of problem of pests and diseases was reported by Ikeme (2009) that Nigeria is currently experiencing increasing incidence of diseases and witness declining in agricultural production. This is in line with finding of Viswanathan and Rao (2011) who found 30-40% yield loss were due to severe disease associated with sugarcane crop in sub-tropic zone. However, early detection of incipient pathogen through serological and molecular techniques could help to check the spread of the disease at early stage of infection, also selection of healthy improved planting seed material or varieties and seed treatment using fungicide before planting could also be helpful in the control of fungal diseases. Moreover, use of disease resistant varieties along with good seed nursery management can form a basis to prevent/control diseases in sugarcane production and this eventually help to check the yield loss caused by disease infestation; unavailability of improved sugarcane seedlings ($\bar{X}$= 2.03), low demand for sugarcane by consumers ($\bar{X}$= 2.00) and poor market policies and linkages ($\bar{X}$= 2.00) ranked 4$^{th}$, 5$^{th}$, 6$^{th}$, 7$^{th}$ and 8$^{th}$, respectively.

Furthermore, poor rural road networks from farm to market ($\bar{X}$= 1.95),inadequate and high prizes of labour ($\bar{X}$= 1.91), poor value addition along sugarcane value chain( $\bar{X}$ = 1.81).The problem of drought ($\bar{X}$= 1.80), insufficiency of irrigation water ($\bar{X}$= 1.71).this is in line with finding posited by Cosmas *et al*. (2010) and Olayide *et al*. (2016) that insufficiency of supply water for sugarcane production during rainfall or and for irrigation cannot sustain the production of growing food demand, therefore, water resources for irrigation should be developed, because it plays a key role in agricultural and economic growth in the country (Mugagga and Nabaasa, 2016). This is also in coroboration with Akande *et al.* (2017) that posited agriculture and irrigation are intertwined especially in Nigeria where there is spatial-temporal variation of rain fall across the country, therefore every plans toward agricultural development must also extend to irrigation development system in Nigeria. Inadequate storage facilities for sugarcane ($\bar{X}$= 1.72), lack of standardized means of measurement ($\bar{X}$= 1.65) and shortage of land for sugarcane farming ($\bar{X}$= 1.67) ranked 10$^{th}$, 11$^{th}$, 12$^{th}$, 13$^{th}$, 14$^{th}$, 15$^{th}$, 16$^{th}$ and 17$^{th}$, respectively, were the constraints perceived not to be severe by the respondents under irrigated farming system in the study area.

The result of the Kendall coefficient of concordance as presented in Table 5. It revealed that the sum of mean rank of the constraints under rain-fed was 153.00 which is lower than chi-square value of 395.67 at 1% level of probability with Kendall *W* value of 0.201. More so, sum of mean rank of the constraints under irrigated was 150.01 which is lower that the chi-square value of 286.52 at 1% level of probability with Kendall *W* value of 0.166. The result on constraint pooled revealed sum of mean rank of 143.32 which is lower than the chi-square value of 574.08 at 1% level of probability with Kendall *W* value of 0.155. This implies that there was a general agreement among the respondents with respect to constraints associated with sugarcane production in the study area.

**Table 4: Respondents' Constraints to Sugarcane Production under different Production Systems**

| | Rain-fed System (n = 123) | | | | Irrigated System (n = 108) | | | | Pooled (n = 231) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Constraints** | **WS** | **WM** | **Rank** | **Remark** | **WS** | **WM** | **Rank** | **Remark** | **WS** | **WM** | **Rank** | **Remark** |
| **Inadequate capital and access to credit facilities** | 337 | 2.74 | 1st | Severe | 260 | 2.41 | 1st | Severe | 597 | 2.58 | 1st | Severe |
| **Inadequate extension services** | 324 | 2.63 | 2nd | Severe | 242 | 2.24 | 3rd | Severe | 566 | 2.45 | 2nd | Severe |
| **High cost of farm inputs** | 300 | 2.44 | 3rd | Severe | 235 | 2.18 | 5th | Severe | 535 | 2.32 | 3rd | Severe |
| **Unavailability of improved sugarcane seedlings** | 296 | 2.41 | 4th | Severe | 219 | 2.03 | 7th | Severe | 515 | 2.23 | 6th | Severe |
| **Poor market policies and linkages** | 290 | 2.36 | 5th | Severe | 216 | 2.00 | 8th | Severe | 505 | 2.19 | 7th | Severe |
| **Inadequate and high prizes of labour** | 289 | 2.35 | 6th | Severe | 206 | 1.91 | 11th | Not Severe | 495 | 2.14 | 8th | Severe |
| **Poor access to training on sugarcane production** | 287 | 2.33 | 7th | Severe | 250 | 2.31 | 2nd | Severe | 537 | 2.32 | 3rd | Severe |
| **Poor road networks from farms to market** | 283 | 2.30 | 8th | Severe | 211 | 1.95 | 10th | Not Severe | 494 | 2.14 | 8th | Severe |
| **Inadequate storage facilities for sugarcane** | 281 | 2.28 | 9th | Severe | 186 | 1.72 | 14th | Not Severe | 467 | 2.02 | 11th | Severe |
| **Inadequate or poor access to farm inputs** | 280 | 2.28 | 9th | Severe | 237 | 2.19 | 4th | Severe | 517 | 2.24 | 5th | Severe |
| **Lack of standardized means of measurement** | 267 | 2.17 | 11th | Severe | 178 | 1.65 | 16th | Not Severe | 445 | 1.93 | 13th | Not Severe |
| **Poor value addition for sugarcane production** | 256 | 2.08 | 12th | Severe | 196 | 1.81 | 12th | Not Severe | 452 | 1.96 | 12th | Not Severe |
| **Problems of pests and diseases infestation** | 247 | 2.01 | 13th | Severe | 228 | 2.11 | 6th | Severe | 475 | 2.06 | 10th | Not Severe |
| **Shortage of land for sugarcane farming** | 206 | 1.67 | 14th | Not Severe | 170 | 1.57 | 17th | Not Severe | 376 | 1.63 | 16th | Not Severe |
| **Low demand for sugarcane by consumers** | 206 | 1.67 | 14th | Not Severe | 216 | 2.00 | 8th | Severe | 422 | 1.83 | 14th | Not Severe |
| **Problem of drought** | 200 | 1.63 | 16th | Not Severe | 194 | 1.80 | 13th | Not Severe | 394 | 1.71 | 15th | Not Severe |
| **Insufficiency of irrigation water** | 186 | 1.51 | 17th | Not Severe | 185 | 1.71 | 15th | Not Severe | 371 | 1.61 | 17th | Not Severe |

Source: Field Survey, 2019

Note: VS= VerySevere (3), S= Severe (2), NS = Not Severe (1), WM = Weighted Mean and WS = Weighted Sum. The bench means score Value is 2.0.

**Table 5: Kendal Coefficient estimates of the constraints to Sugarcane Production**

| Constraints | Rain-fed Mean Rank (n=123) | Irrigation Mean Rank (n=108) | Pooled Mean Rank (n=231) |
|---|---|---|---|
| Inadequate capital and access to credit facilities | 12.33 | 11.70 | 12.04 |
| Inadequate extension services | 11.55 | 10.65 | 11.13 |
| High cost of farm inputs | 10.53 | 10.32 | 10.44 |
| Unavailability of improved sugarcane seedlings | 10.43 | 9.43 | 9.96 |
| Poor market policies and linkages | 10.20 | 9.11 | 9.69 |
| Inadequate and high prizes of labour | 9.95 | 8.57 | 9.31 |
| Poor access to training on sugarcane production | 9.84 | 11.09 | 10.42 |
| Poor road networks from farms to market | 9.72 | 8.88 | 9.33 |
| Inadequate storage facilities for sugarcane | 9.65 | 7.52 | 8.66 |
| Inadequate or poor access to farm inputs | 9.61 | 10.42 | 9.99 |
| Lack of standardized means of measurement | 9.00 | 6.92 | 8.02 |
| Poor value addition for sugarcane production | 8.32 | 8.13 | 8.23 |
| Problems of pests and diseases infestation | 8.08 | 9.86 | 8.91 |
| Low demand for sugarcane by consumers | 6.37 | 9.15 | 7.67 |
| Shortage of land for sugarcane farming | 6.17 | 5.89 | 6.04 |
| Problem of drought | 5.92 | 7.99 | 6.89 |
| Insufficiency of irrigation water | 5.33 | 7.38 | 6.28 |
| Sum of mean rank | 153.00 | 150.01 | 143.32 |
| Kendall *W* | 0.201 | 0.166 | 0.155 |
| Chi-square | 395.67*** | 286.52*** | 574.08*** |

Source: Field Survey, 2019

## CONCLUSION

Based on the findings emanating from this study, it was concluded that the farmers under IRFS and RFFS farming systems were still productively active. Males dominated sugarcane production in the study area. Productivity was higher under IRFS compared with those under RFFS. The major constraints associated with sugarcane production under RFFS were inadequate capital and access to credit facilities, inadequate extension services and high cost of farm inputs, while constraints perceived by the respondent under irrigated farming system includes inadequate capital and access to credit facilities, poor access to training on sugarcane production and inadequate extension services. Based on the hypotheses tested, there was a significant difference in the mean productivity level and mean income of the sugarcane farmers under the two systems. it was recommended that relevant stakeholders should ensure implementation of extension programmes through capacity building; workshop and field trials the farmers can assimilate easily**.** Furthermore, formal financial institutions especially Bank of Agriculture (BOA) and Microfinance Banks come up with flexible policy on credit with single digit interest rate that will enhance access to credit by resource poor farmers while the Government both at Federal and State level should create enabling environment for sugarcane farmers and attract foreign investments and industrialization in the study area.

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