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Environmental Degradation, Improved Technologies Utilization and Output among Rain-Fed and Irrigated Sugarcane Farmers in Bauchi State, Nigeria

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ABSTRACT: In the northern part of Nigeria, desertification has grossly affected water available and land carrying capacity for both pastureland and farmlands. Using primary data collected in a three-stage purposive sampling procedure from a total of 231 sugarcane farmers, we accessed technology utilization in Rain-Fed Farming System (RFFS) and Irrigated Farming System (IRFS) among sugarcane producing farmers in Bauchi State. Data were analysed using descriptive statistics, Z-statistics, and Kendall's concordance statistics. The farmers mean age was 43 years with an average of 7 years of formal education. About, 56.1% of the farmers in RFFS utilized light texture soil with good drainage, 69.9% raised sugarcane nursery during land preparation, 71.5% utilized Autumn planting while 76.4% utilized weeding by hoe; 31.7% applied NPK fertilizer at 112kg(N), 25kg(P), 48kg(K) rate/acre; and 64.2% utilized manual harvesting. Comparatively, 62.0% of farmers in IRFS utilized ploughing depth of 30cm during land preparation, 59.3% utilized combination of cultural and chemical methods of weeding, 74.8% utilized application of water once at every 7 days during growing phase of sugarcane, 31.7% applies inorganic fertilizer and 54.6% utilized early harvesting (10 – 11 months) of sugarcane plantation. The major constraint sugar cane production in the study area includes inadequate capital and access to credit facilities. The study recommends more education and sensitization for sugarcane farmers on how to appropriately employ improved technologies to optimize their production outcomes.

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Adoption and utilization of Agricultural technologies is an important aspect of modern farming practices in most developing parts of the world including Nigeria, as it helps to improve crop yields, reduce production costs, and increase the overall efficiency of the agricultural sector. Resulting from poor access of farmers to agricultural technology, there has been noticeable decline in agricultural productivity. In most developing countries of the world, agricultural technology plays important role in driving growth for smallholder farmers. An important factor in improving productivity of farmers and increasing food production is to advance, transfer, and utilize relevant agricultural technologies. (Farm Square, 2022). Small scale farmers in Nigeria operates relatively complex farming system based on differing Agro ecological zones (AEZ). Consequently, farmers in the different AEZ need access to a wide variety of both locally validated and improved technologies if they are to increase their productivity. Agricultural technology

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includes a range of materials, processes, and knowledge. To ensure a successful transfer agricultural technology to end users, different institutional arrangements are needed due to its complexity. There are now hardware and software components for improved technologies. For instance, a new crop variety, as a type of material technology cannot be fully exploited without having a complimentary set of agronomic or crop management practices, including pest management. It also needs higher levels of management, including improved nutrition, housing and preventive health services for (Obayelu, 2016).

While the government has implemented number of policies aimed at boosting agricultural productivity and food security, rural smallholder households in Nigeria continue to face supply and demand side challenges: notably poor land tenure system, very low level of irrigation development, limited research on agricultural technologies, high cost of farm inputs, poor access to markets, and high postharvest losses and waste FAO, (2022). These are further compounded by the negative impacts of changing climate in terms of high temperatures and low and unpredictable rainfall patterns, given that the agriculture sector in Nigeria, like other SSA countries, is mainly rain fed. Increasing agricultural productivity and boosting food security, therefore, requires surmounting these challenges at the plot level, including the adoption of sustainable agricultural practices (SAPs) and improved technology utilization Teklewold *et al*, (2013). There are many identified problems associated with the growing of sugarcane in Nigeria with respect to both rain-fed and irrigated farming systems, although the overall environmental impact can be said to be much larger than any other problems making it inevitable for most small-scale farmers to operate relatively complex farming systems in each agroecological zone (AEZ) in Nigeria, Obayelu, (2016) noted that solving environmental problems in agriculture requires developing and diffusing new technologies. Because utilization of improved agricultural technologies is central to transformation of sustainable farming system, and a motivating force for increasing agricultural productivity. Among the major goals of Nigerian agriculture development programs and policies is transition from low productivity subsistence agriculture to a high productivity agro industrial economy through improved technology adoption. This implies a shift from traditional methods of production to new science-based methods of which include new technological components (Hassen, 2014). Therefore, there is a need for farmers in the different AEZ to access a wide variety of validated technologies if they are to improve their productivity (Atata *et al*, 2020).

Most rural poor are engaged in smallholder agriculture, attempt to address these are often geared toward improving agricultural practices as a means of increasing productivity, efficiency there by improving their welfare. Agricultural technologies are targeted at increasing agricultural productivity by replacing the old methods with modern and more efficient methods (Barla, 2013). As a way of reconciling the necessity for sustainable and profitable food production, improve productivity and food security, adoption of improved agricultural technology is a tool that cannot be compromised. Low performance of the agriculture sector does not only threaten the livelihood, but it also affects the production capacity of the natural resources base, accelerates environmental degradation and fails to address poverty and malnutrition. There necessitated, a rising momentum in policies that are geared at improving the rate of agricultural technology adoption and utilization by farmers in the country. Many west African countries including Nigeria have structures set up to improve agricultural technology adoption such as the West Africa Fertilizer Program (WAFP) that is focused on improving agricultural productivity through the distribution of high quality and affordable fertilizers to most constrained farmers. In recent years, Nigeria has implemented an agricultural promotion policy that targets agricultural sector sustainability and rural development. Efforts are also taken to develop input market which is an important component for the structural progress of the agricultural sector (Druilhe and Barreiro-Hurle, 2012). Though the outcome of interest from the adoption of agricultural technology is not exhaustive, we find that focusing on smallholders' productivity and food consumption in Nigeria is yet to receive enough attention, for instance, the application of appropriate fertilizers remains low with an average annual application rate of 12 kilograms per hectare (kg/ha). This falls short of the expected 50 kilograms per hectare by African governments by 2015 (Falaju, 2016; IFDC, 2016 Atata *et al*, 2020). Such low rate of adoption and utilization of agricultural technology, among farmers, can be potentially traced to poor finance, lack of access, and lack of knowledge of farmers regarding these technologies (Ellis *et al*, 2007) therefore, the need for addressing these situations.

To create more sustainability and meet up with the growing demand of sugarcane products, farming practices requires not just adopting a new technology for crop management, pest control, quality control and integrated diseases management but also ensuring the full utilization of such innovations. 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). It is in this light that this study, seeks to assess sugarcane production under rain-fed and irrigated farming systems in Bauchi State, Nigeria. This paper is investigated environmental degradation, improved technologies utilization and output among rain-fed and irrigated sugarcane farmers in Bauchi State, Nigeria.

Statement of Hypothesis: H_0: There is significant difference in the mean output of IRFS and RFFS sugarcane producing farmers in Bauchi State.

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. 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 a land area of about 49,259 Km^2 with a projected population of about 7,336,748 in 2024 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.

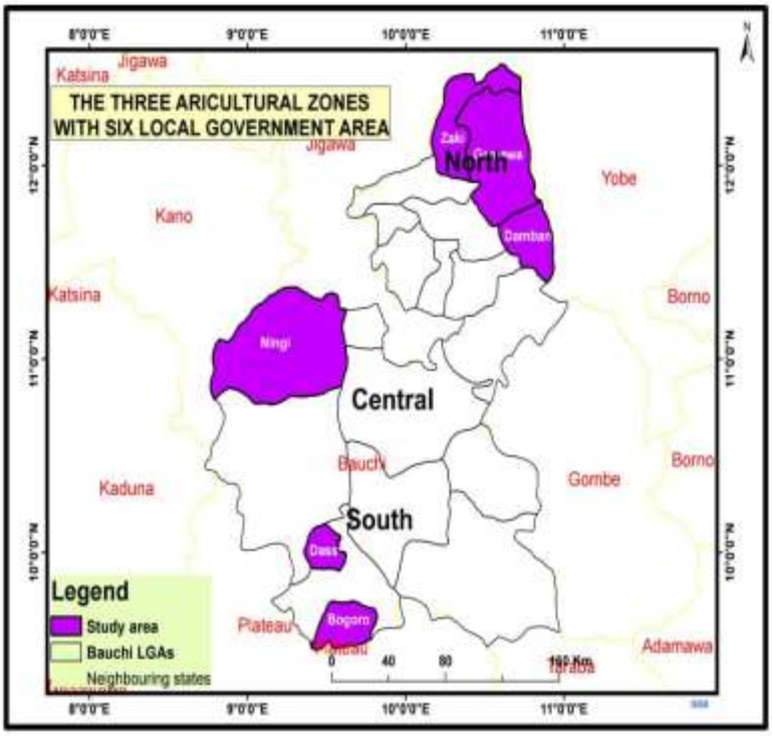

Fig 1 Showing the three Agricultural zones and six Local Government Areas of the study. Source: Ciphers graphics.

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, Kothari and Garg (2014), at 5% precision level was used to select a sample size of farmers resulting to a total of 231 farmers. Kothari and Garg (2014), and specified as in equation 1:

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

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

Method of Data Analysis and Model Specification: Descriptive statistics, Likert type scale rating, and Kendall's coefficient of concordance were used to analyse the data. The Kendall's coefficient was also used to examine the constraints hindering sugarcane production under irrigated farming system. Kendall's coefficient of concordance (W) is given by the relation:

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

Where W = Kendall's coefficient of concordance; P = number of respondents ranking the constraints, n = number of quality perceptions; T = 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:

$$S = \sum_{i-1}^{n} (Ri - R)^2 \quad (3)$$

Where: R_i = row sums of rank; R = mean of R_i

The correction factor for tied ranks (T) is given as:

$$T = \sum_{k-1}^{m} (\,t_k^3 - t_k) \quad (4)$$

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

$$X^2 = P\,(n - 1)W \quad (5)$$

Where: n = number of constraints, P = number of respondents, and W = Kendall's coefficient of concordance.

Hypothesis Testing: Hypothesis was tested using the t-test statistics.

RESULTS AND DISCUSSION

Mean Output from sugarcane by the respondents: Table 2 shows that the mean output of farmers under the rainfed system was 519.67 kg with minimum and maximum of 100 kg and 1100 kg respectively while the IRFS mean output was 2421.53kg. Output has direct impact on the accruable income or benefit from any enterprise. In this case, higher income is desirable for sustainable livelihood and wellbeing of the farmers. Ajayi *et al.* (2016) who noted that the ability of smallholder farmers to meet up households' needs can only possible from higher income generated from their farm produce.

Table 1: Mean respondents' output from sugarcane production in Kilograme

Output	Minimum (Kg)	Maximum (Kg)	Mean (Kg)
Rain-fed	100	1100	519.67
Irrigated	160	10000	2421.53
Pooled	100	10000	1408.85

Source: Field Survey, 2019

Utilization of Recommended Technologies under Rain-fed and Irrigated: Table 3 shows the level of recommended technologies utilized by the farmers under RFFS. In terms of soil requirement for sugarcane production, more than half (56.1%) of the respondents utilized light texture soil with good drainage, while 54.5% utilized heavy soil with good drainage and 44.7% utilized optimal soil pH level (6.0 to 6.5). about (69.9%) of the farmers adopted raising sugarcane nursery site during land preparation before sugarcane planting, while 63.4% employed ploughing depth of 30cm, 42.3% of the utilized pre-manuring of farmland before planting as a means of land preparation. In some cases, deep-ploughing with tractors using mould-board plough are carried out to prepare the sugarcane field, this facilitate good growth and sugarcane development. With regards to planting, majority (71.5%) of the farmers utilized Autum planting (September to October), and 48.8% employed spring planting (February to March). Fifty-six (56.1%) of the respondents planted sett horizontally in the furrow, 53.7% used long and thick stem of about 40cm. Sugarcane is mostly planted either stem planting or setting with the roots and shoots into a furrow. Availability of good quality cane materials are essential for better germination, good growth and development. During weeding operation majority (76.4%) of the farmers' applied hand weeding by hoe, while 68.3% utilized de-trashing as weed control measure while 39.8% employed weed free environment and 28.5% utilized mulching as a means of weed prevention. As noted by Dayo *et al.* (2009) that low yield could result from low or inadequate use of agricultural inputs and this eventually translate to low or small earning and poverty of farmers. With respect to application of fertilizers, some of the RFFS farmers applied NPK (31.7%) NPK at 112kg, 25kg and 48kg rate/ha. According to Singh *et al.* (2018) that fertilizer recommendation is based on targeted yield which need to be developed for sugarcane production in different climatic zones.

Table 2. RFFS' Utilization of Recommended Technologies (n=123)

Variables	Utilized		Not Utilized	
	Frequency	**Percent (%)**	**Frequency**	**Percent (%)**
Soil requirement				
Heavy soil with good drainage	67	54.5	56	45.5
Light texture soil with assured irrigation	69	56.1	54	43.9
Soil with good Ph	55	44.7	68	55.3
Land preparation				
Ploughing depth of 30 cm	78	63.4	45	36.6
Pre-manuring of farmland before planting	52	42.3	71	57.7
Raising nursery	86	69.9	37	30.1
Planting				
Long and thick stem of about 40 cm	66	53.7	57	46.3
Sett planted horizontally in the furrow	69	56.1	54	43.9
Autum planting (September to October)	88	71.5	35	28.5
Spring planting (February to March)	60	48.8	63	51.2
Weeding				
A weed free environment	49	39.8	74	60.2
Hand weeding by hoe	94	76.4	29	23.6
De-trashing	84	68.3	39	31.7
Mulching	35	28.5	88	71.5
Application of atrazine	32	26.0	91	74.0
Fertilizer application				
Soil fallow	30	24.4	93	75.6
Application of NPK	39	31.7	84	68.3
Types of Harvesting				
Row thinning	68	55.3	55	44.7
Earthing up	37	30.1	86	69.9
Propping	33	26.8	90	73.2
Manual	79	64.2	44	35.8
Mechanical (Harvester)	9	7.3	114	92.7
Ratooning	53	43.1	70	56.9
Stumble shaving	34	27.6	89	72.4

Under IRFS, (62.0%) utilized ploughing depth of 30cm during land preparation, while 57.4% utilized spacing of more than 45cm in land preparation. About 55.6% applied pre-germinated nursery setts as a means of land preparation. With regards to planting, estimated (65.7%) sowed at a depth of 30cm, 59.3% utilized modified planting method, and 47.2% utilized pit diameters of 75cm and 42.5% inter-row spacing.
Other improved technologies utilized by the farmers includes inter-cropping with tomatoes (39.2%), centre to centre by 105cm (38.0%), space transplanting (38.0%), ring pit (35.2%), intra-row spacing (32.4%) and seed rate technology (25.0%). Sugarcane is mostly planted by either stem planting or sett with the roots and shoots into a furrow.

Over a half (59.3%) combination of cultural and chemical methods for weeds prevention and control, 39.8% utilized weed sensor technology and 28.7% weed seeker technology for managing weed infestation in their plantation. Other improved recommended technologies utilized includes variable rate technology (44.4%), skip furrow technology (42.6%) and application of water in furrow (40.7%).
Regarding the application of fertilizer, (31.7%) applied inorganic fertilizer while (24.4%) utilized suitable organic fertilizer.

Thus, fertilizer application in sugarcane production is recommended at two-third of nitrogen, while the remaining one-third being phosphorus and potash.

Hypothesis testing. The null hypothesis stated that there is no significant difference between the output of sugarcane farmers under irrigated and rain-fed farming system in the study area was tested using t – test statistics. The result of the t – test as presented in Table 6. The t – statistic value of 9.31 at 1% level of probability implies there was significant difference in the mean output of the farmers under the two farming systems in the study area.

The null hypothesis was, therefore, rejected in favour of the alternative hypothesis.

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.

Table 3: Respondents' Utilization of Improved Technologies under Irrigated (n = 108)

Variables	Utilized		Not Utilized	
	Frequency	**Percent (%)**	**Frequency**	**Percent (%)**
Land preparation				
Ploughing depth of 30 cm	67	62.0	41	38.0
Use of pre-germinated nursery setts	60	55.6	48	44.4
Spacing of > 45 cm apart	62	57.4	46	42.6
Planting				
Modified planting method	64	59.3	44	40.7
Sowing depth of 30 cm	71	65.7	37	34.3
Pit diameters of 75 cm	51	47.2	57	52.8
Center to center by 105 cm	41	38.0	67	62.0
Space transplanting	41	38.0	67	62.0
Seed rate technology	27	25.0	81	75.0
Inter-row spacing	46	42.6	62	57.4
Intra-row spacing	35	32.4	73	67.6
Ring pit	38	35.2	70	64.8
Inter-cropping with tomatoes	43	39.2	65	60.2
Weeding				
Combination of cultural and chemical	64	59.3	44	40.7
Weed sensor technology	43	39.8	65	60.2
Weed seeker technology	31	28.7	77	71.3
Water application				
Water application once 10 days at tillering	70	56.9	53	43.1
Water application once 7 days at growing	92	74.8	31	25.2
Water application once 15 days at maturity	70	56.9	53	43.1
Water application at the furrow	50	40.7	73	59.3
Variable-rate technology(VRT)	48	44.4	60	55.6
Skip furrow technology	46	42.6	62	57.4
Fertilizer application				
Suitable organic manure	50	46.3	58	53.7
Inorganic fertilizer	59	54.6	49	45.4
Harvesting				
Early harvesting (10 – 11 months)	59	54.6	49	45.4
Mid-season harvesting (11 – 12 months)	55	50.9	53	49.1

Major perceived severe constraints associated with sugarcane production under rain-fed farming system RFFS 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 includes inadequate capital and access to credit facilities ($\bar{X}$= 2.41), poor access to training on sugarcane production ($\bar{X}$= 2.31) and poor extension services ($\bar{X}$= 2.24) ranked 1st, 2nd and 3rd, respectively. Earlier, Sulaiman *et al.* (2015) had identified inadequate funding and poor access to credit facilities as major challenges to sugarcane farmers in Kaduna state. Furthermore, Oravee (2015) noted that lack of funding in the river basin and rural development lead to ineffectiveness of the scheme. 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) and lack of standardized means of measurement ($\bar{X}$= 2.17). 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 10th, 11th, 12th, 13th, 14th, 15th, 16th and 17th, respectively, were the constraints perceived not to be severe by the respondents under irrigated farming system in the study area.

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

Constraints	Rain-fed System (n = 123)				Irrigated System (n = 108)			
	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
Inadequate extension services	324	2.63	2nd	Severe	242	2.24	3rd	Severe
High cost of farm inputs	300	2.44	3rd	Severe	235	2.18	5th	Severe
Unavailability of improved sugarcane seedlings	296	2.41	4th	Severe	219	2.03	7th	Severe
Poor market policies and linkages	290	2.36	5th	Severe	216	2.00	8th	Severe
Inadequate and high prizes of labour	289	2.35	6th	Severe	206	1.91	11th	Not Severe
Poor access to training on sugarcane production	287	2.33	7th	Severe	250	2.31	2nd	Severe
Poor road networks from farms to market	283	2.30	8th	Severe	211	1.95	10th	Not Severe
Inadequate storage facilities for sugarcane	281	2.28	9th	Severe	186	1.72	14th	Not Severe
Inadequate or poor access to farm inputs	280	2.28	9th	Severe	237	2.19	4th	Severe
Lack of standardized means of measurement	267	2.17	11th	Severe	178	1.65	16th	Not Severe
Poor value addition for sugarcane production	256	2.08	12th	Severe	196	1.81	12th	Not Severe
Problems of pests and diseases infestation	247	2.01	13th	Severe	228	2.11	6th	Severe
Shortage of land for sugarcane farming	206	1.67	14th	Not Severe	170	1.57	17th	Not Severe
Low demand for sugarcane by consumers	206	1.67	14th	Not Severe	216	2.00	8th	Severe
Problem of drought	200	1.63	16th	Not Severe	194	1.80	13th	Not Severe
Insufficiency of irrigation water	186	1.51	17th	Not Severe	185	1.71	15th	Not Severe

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

The result of the Kendall coefficient of concordance is as presented in Table 5. 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. similarly, 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 implies that there were general agreement among the respondents with respect perceived constraints associated with sugarcane production in the study area.

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

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

Conclusion: There was high significant difference in recorded output. Improved cultural practices were well utilized by greater than half of the farmers in most cases for both rain-fed and irrigation system. The major limitations include inadequate capital and poor access to credit facilities. The study recommends better education and improved access to extension services. Opportunities for better access to inputs and credit facilities will further boost the level of technology utilization in the study area.

Declaration of Conflict of Interest: The authors declare no conflict of interest (if none).

Data Availability Statement: Data are available upon request from the first or corresponding author.

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