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Comparative Analysis Of Dry And Rainy Season Of Paddy Rice Yield Using Modified Wilcoxon Sign Rank Test In Katsina

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ABSTRACT
Rice is the second most grown cereal and staple food for half of the world's population. It remains the staple food in Nigeria and the livelihood of many local farmers. Therefore, it is becoming an important agricultural product that should attract the attention of the government and policy makers for its impact on both local and international markets for the welfare and development of the country. This paper analyzes the yield differences between the rainy and dry seasons of paddy rice yield in 2022. Data for the study were collected in bags per hectare in Dandume, Danja, Sabuwa, Kafur, Dutsinma and Jibia local governments of Katsina state. Three hundred farmers were selected using purposive sampling and questionnaires were administered by the researcher. Data was analyzed using Wilcoxon Rank Sum Test. However, Modified Wilcoxon Signed Rank test for Dandume, Danja, Sabuwa, Kafur, Dutsinma and Jibia result shows that the yield of paddy rice for the rainy and dry season are not the same. Furthermore, lack of improved seeds, fertilizers, pest attacks and unpredictable weather caused by climate change affected farming practices in some of the area in the state. Therefore, the government should provide improved seeds, timely allocation of fertilizers, agrochemicals and modern methods of rice production which can increase the yield of rice in the state and the country at large.
Keywords: Wilcoxon Sign Rank, Rainy, Dry, Paddy Rice, Analysis, fertilizer

INTRODUCTION
Rice is the second most common cereal and the staple food for more than half of the world's population. Also, it remains the diet of typical Nigerians as well as the main livelihood of many local farmers in the country. Therefore, it becomes an important agricultural commodity that should draw the attention of the government and policy makers to its impacts on both domestic and international markets for the well-being and development of the nation. People depend only on rice for food, especially in developing countries. In 2015, Nigeria was the world's second and Africa's largest importer of rice, the country has been so dependent on imports to fill the domestic supply gap that arose due to the inability of local producers to meet demand. It is also on the front line in the fight against world hunger and poverty. It was also stated that some challenges faced by rice production include reduction/stagnation of productivity, degradation of land and water resources. Moreover, rice production is affected by environmental changes; as such, climate change has emerged as a major concern for environmentally and economically vulnerable countries. For these reasons, farmers adopt different agricultural practices to cope with these changes in weather patterns, which still resulted in poor rice harvests by many farmers in the country. Thus, damaged

infrastructures affect food prices and increase dependence on imported food aid. Different studies have been conducted in different countries on rice production by different authors, such as in which canopy analysis data were used to assess the impact of fertilizer use on the technical efficiency of rice farms in Kogi State, Nigeria. Their result suggested that rice farms cultivated with fertilizer can expand production potentials by 74% compared to those farms without fertilizer application and concluded that farmers should be encouraged to adopt the optimal fertilizer rate in order to achieve an increase in rice production. The impacts of climate change, lack of fertilizers and other agricultural inputs on rice production have been the subject of study by many researchers due to its importance in human life. However, the dry season is usually a much more challenging period for farmers than the rainy season; sometimes the rain comes late and ends early and in some other cases farmers find it tiring to farm during the dry season with eight months of drought (Longtau, 2003).

According to National Cereals Research institute farmers can harvest 12 tonnes of paddy rice in one hectare if technology will get to the farmers easily for 20cm by 20cm plant spacing not one meter by 20cm, this is almost one third of the field being utilized and the remaining two thirds was not utilized, such farmers cannot obtain optimum yield. In 2009, the federal government initiated the Nigerian National Rice Development Strategy to raise rice production from 3.4 million metric tonnes to 12.8 metric tonnes by 2018 (Longtau, 2003).

Rice has become the world's second most important grain after wheat in terms of production, due to the recent decline in maize production (Jones, 1995). It is widely cultivated throughout the tropics; and where flood controls are effective as in Southeast Asia, production is high. Most of the foreign rice imported into West Africa is from Southeast Asia. In sub-Saharan Africa, West Africa is the main producer and consumer of rice (WARDA, 1996). West Africa accounts for 64.2% and 61.9% of total rice production and consumption in sub-Saharan Africa, respectively. With the exception of Burkina Faso and Niger, rice is a staple crop throughout West Africa, particularly in Côte d'Ivoire, Gambia, Guinea, Guinea-Bissau, Liberia, Senegal and Sierra Leone. The Niger River drainage system is a major rice growing environment in the region. Nigeria has a leading role in rice production in West Africa. Nigeria ranks highest as a producer and consumer of rice in the sub-region with figures of just over 50% (WARDA, 1996). Rice is known to have been grown along the Niger for more than 3000 years (Imolehin and Wada, 2000).

Rice production in the United States and around the world has experienced many changes over the past three centuries. According to the US Rice Federation (2004), technological advances in the rice industry have allowed the United States to become one of the most innovative rice-producing countries in the world. Perhaps the most important innovation in the field of rice production is the development of high-yielding varieties and hybrid seeds. New varieties and hybrids offer the potential for many changes in the industry, including higher yields and the possibility of price impacts due to increased supply. Furthermore, improved cultivars lead to increased production on less land, which saves additional resources (eg, water, labor, chemicals, and land) needed to support the world's population (Borlaug 2003). The majority of rice farmers in Nigeria depend on traditional technologies with the use of productivity enhancing inputs resulting in a national average yield of 1 to 2.5 tonnes per hectare (Nwite et al., 2008). In light of this, smallholder profitability has important implications for any development strategy adopted in Nigeria. An improvement in the understanding of its profitability can greatly assist policy makers in formulating and improving policy, as well as in assessing the effectiveness of current and past reforms. The research found this problem which calls for a study to identify most significant difference between rainy and dry season associated to paddy rice yield in the state.

LITERATURE REVIEW

According to Manoj et al., (2013) analyses the differences of technical, allocative, cost and scale efficiencies of irrigated and rain-fed rice farmers in Sri Lanka in two different perspectives; first, relative to a common metafrontier, defined as the boundary of an unrestricted technology set and second relative to group frontiers defined to be the boundaries of restricted technology sets in each group. Data envelopment analysis (DEA) metafrontier and group frontier approaches are used for cross section survey data of 90 farms. Rain-fed farms perform comparably with the irrigated farms based on the group frontier results. Rain-fed farmers may be operating as technically efficient as they could, given the existing production technology. However, rain-fed farms move significantly towards inefficiency compared to the irrigated farms under the metafrontier technology. Results indicate that the irrigation shifts the rice sector production frontier to a higher level. In addition, a second stage bootstrapped truncated regression shows that efficiency differences between two regions are explained by the timely availability of the water to a significant extent. They suggest that future sectoral policies should be designed to address the efficiency enhancing factors such as irrigation, quality seed, land ownership and scale and female labour participation.

According to Nayak et al., (2018) stated that there has been a significant advancement in the application of statistical tools in plant pathology during the past four decades. These tools include multivariate analysis of disease dynamics involving principal component analysis, cluster analysis, factor analysis, pattern analysis, discriminant analysis, multivariate analysis of variance, correspondence analysis, canonical correlation analysis, redundancy analysis, genetic diversity analysis, and stability analysis, which involve in joint regression, additive main effects and multiplicative interactions, and genotype-by-environment interaction biplot analysis. The advanced statistical tools, such as non-parametric analysis of disease association, meta-analysis, Bayesian analysis, and decision theory, take an important place in analysis of disease dynamics. The most recent technologies such as micro-array analysis, though cost effective, provide estimates of gene expressions for thousands of genes simultaneously and need attention by the molecular biologists. Some of these advanced tools can be well applied in different branches of rice research, including crop improvement, crop production, crop protection, social sciences as well as agricultural engineering. They suggested that rice research scientists should take advantage of these new opportunities adequately in adoption of the new highly potential advanced technologies while planning experimental designs, data collection, analysis and interpretation of their research data sets.

According to Ran et al., (2018) identifies the factors affecting rice yield gap in southwest China where the data of rice yield from a total of 76 experiments were collected in 2008 and 2009 in Chongqing, southwest China. For each location, two treatments with fertilizer and without fertilizer were carried out, each treatment was performed with three replications, and yield gap was calculated using fertilized yield minus unfertilized yield. Seventeen influencing-factors including variety, fertilization, climate, terrain, and soil properties were obtained at each location. Regression tree (RT) model were employed to investigate relative important of influencing-factors to rice yield gap variability. The result of Pearson correlation analysis suggested yield gap of rice was positively correlated with sunshine hours, phosphorous and potassium fertilizers, while negatively correlated with soil available nitrogen content. The results of RT showed that the selected influencing-factors explained about 74.1% of rice yield gap variation. Meanwhile, the result also indicated variety followed by others had more influence on rice yield gap variation.

According to Manoj et al., 2012. Studied the production efficiency of Sri Lankan rice farms using 90-farm cross-sectional survey data. They investigated technical efficiency, allocation efficiency (AE) and cost efficiency (CE) using the data envelopment analysis (DEA) method. On average, 87% of the farmers were technically proficient; irrigated farms were more efficient (88%) than rain fed farms (82%). The average cost, classification and scaling efficiencies were 73%, 84% and 87%, respectively. The adjusted bias TE estimates indicate an expected 25% output expansion with a given input combination to be fully efficient as opposed to 16% based on the original estimate. The second stage of the Tobit regression indicates that efficiency is influenced by agricultural size, water security, ownership, seed quality, family labor endowment and female labor participation.

According to Ajibefun, (2008) compare the predictive ability of parametric and non-parametric techniques for boundary models in technical efficiency analysis. The Stochastic Frontier Production Function (SFPF), a parametric technique, and Data Envelopment Analysis (DEA), a nonparametric technique, were estimated and compared. Analytical results show that the sample farmers have different levels of technical efficiency, ranging from 0.22 to 0.87 for both strategies. Also the results of both parametric and non-parametric techniques showed that the age and educational level of the sample of farmers had a significant effect on the level of technical proficiency. Estimates of mean technical

efficiency do not differ significantly by the methods used, although some differences in the magnitudes of individual technical efficiencies are observed for the two strategies.
According to Ran et al., (2018) identified the factors affecting rice yield gaps in southwest China and rice yield data from a total of 76 trials were collected in 2008 and 2009 in Chongqing, southwest China. For each site, two treatments were performed with and without fertilizer, and each treatment was performed in triplicate, yielding curves minus fertilizer yield was calculated using no fertilizer. Seventeen potential influencers were found at each site, including species, fertilizer, climate, topography, and soil properties. Regression tree (RT) models were employed to investigate the most important factors influencing the evolution of rice yield curves. Results of Pearson correlation analysis suggested that rice yield curve was positively correlated with sunlight hours, phosphorus and potassium fertilizers and negatively correlated with available soil nitrogen content. The RT results showed that the selected influential factors explained about 74.1% of the variance in rice yield curve. On the other hand, the results also showed that variety followed by others significantly influenced the variation in rice yield curve.
According to Koehuan, (2020) estimated the main food water productivity based on crop water use and then analyzed the growth of total factor productivity using non-parametric Data envelopment analysis-Malmqist index (DEA-MI) method. They applied secondary panel data for the period 2000-2015 regarding weather data, areas where staple food is harvested, and staple food production. The results showed that the productivity of rice bran water ranged from 0.290 to 0.930 m-3 kg and the productivity of maize water ranged from 0.553 to 1.590 m-3 kg. Based on single-input and single-output DEA-MI analysis, the average total paddy water productivity (PWTFP) index was 1.014, while the average magnitude of efficiency change (EFC) index was 0.992, and the technological change index (TEC) was 1.062.

Aim And Objective

The aim of this research paper was to identify the most significant in dry and rainy season which is associated to paddy rice yield in state in other to achieve the following objective.

- Find out the yield differences between the dry and rainy season for each local governments under study.

Research Hypotheses

There is no significant difference between dry and rainy season of a paddy rice yield for each local government.

MATERIALS AND METHODS

The Wilcoxon rank-sum test and Krsukal-Wallis one-way ANOVA are widely used to calculate differences in means of two or more independent (unpaired) samples. The Wilcoxon rank sum test is named after Frank Wilcoxon (1892 – 1965), who proposed, in a single paper, both the Wilcoxon signed rank test and the rank-sum test in which he discards any armed data and then calculates the signed rank. Wilcoxon`s test played an important role in the development of non-parametric methods for bivariate data. The modified Wilcoxon signed-rank (MWSR) test was developed to adopt correlated data for paired and unpaired data for an appropriate p value. The Kruskal-Wallis rank sum test is a nonparametric method for testing whether multivariate data originate from a sample of a homogeneous distribution. It is used to compare more than two independent samples with equal or different sample sizes.
The data for this study was collected in bags per hectare in Funtua and Katsina senatorial district for the year 2022/2023. A purposive sample of 300 farmers from Dandume, Sabuwa, Kafur, Danja Dutsinma and Jibia were administered using questionnaires by Age content researcher, wheat in bags (Rainy/Dry), with Education level and Main source of income and others.

Data Processing

Data analysis method involves analyzing variables using data R package. The data failed the assumption of normality and equal variance, so non-parametric methods will be considered. Therefore, the modified Wilcoxon signed rank will be considered.

Wilcoxon Rank Sum Test: Wilcoxon rank sum test is described as the non-parametric version of the two- sample t – test. After recalling the assumption of the two- sample t- test for comparing two population means which are normally distributed, equal variance, independence are not satisfied. Therefore Wilcoxon signed rank test comes in. If $m_1 and\ m_2$ are the sample size $R_1 and\ R_2$ is simply sum of the first $m_1 + m_2$ positive integer which is known to be $\frac{(m_1+m_2)(m_1+m_2+1)}{2}$.The formula enable the research to find R_2 if he know R_1 and vice versa. When the use of the rank sums was first proposed as a nonparametric alternative to the two-sample t-test, the decision was based on $R_1\ or\ R_2$.

$$U_1 = m_1 m_2 + \frac{m_1(m_1+1)}{2} - R_1 \ldots\ldots\ldots\ldots 2$$

$$U_2 = m_1 m_2 + \frac{m_2(m_2+1)}{2} - R_2 \ldots\ldots\ldots\ldots 3$$

$$U = min(U_1, U_2) \ldots\ldots\ldots\ldots 4$$

Where $m_1 and\ m_2$sample size of are $R_1 and\ R_2$ are the rank sum of corresponding samples. As of the Wilcoxon version of the test, when p < α, then the test statistics is rejected at α level of significance.

RESULTS

Table 1: Summary Statistics Of Rice Production During The Rainy And Dry Seasons In Katsina, Nigeria.

		Dry Season	Rainy Season	Difference
	Min			
	1st Quarter	36.5	28.5	8
Dandume Local Govt(Bags/ha)	Median	41	34	7
	3rd Quarter	39.76	32.48	7.28
	Mean	43.75	37	6.75
	Max	50	46	4
		Dry Season	Rainy Season	Difference
	Min	20	20	0
	1st Quarter	35	24	11
Danja Local Govt(Bags/ha)	Median	40	28.5	11.5
	3rd Quarter	38.56	29.28	9.28
	Mean	42	33.75	8.25
	Max	50	45	5
		Dry Season	Rainy Season	Difference
	Min	20	20	0
	1st Quarter	34	26	8
Sabuwa Local Govt(Bags/ha)	Median	41	30	11
	3rd Quarter	38.48	30.8	7.68
	Mean	45	34.75	10.25
	Max	50	45	5
		Dry Season	Rainy Season	Difference
	Min	20	20	0
	1st Quarter	34	26	8
Kafur Local Govt(Bags/ha)	Median	40.5	31	9.5
	3rd Quarter	38.4	30.86	7.54
	Mean	43	34.75	8.25
	Max	50	45	5
		Dry Season	Rainy Season	Difference
	Min	20	20	0
	1st Quarter	38.25	24	14.25
Dutsinma Local Govt(Bags/ha)	Median	41	32	9
	3rd Quarter	39.44	31.42	8.02
	Mean	43	36.75	6.25
	Max	50	46	4
		Dry Season	Rainy Season	Difference
	Min	20	20	0
	1st Quarter	40	26.25	13.75
Jibia Local Govt(Bags/ha)	Median	41.5	31.5	10
	3rd Quarter	41.66	31.82	9.84
	Mean	45	35.75	9.25
	Max	52	50	2

Figure 1: Dry season Data visualization of Paddy yield

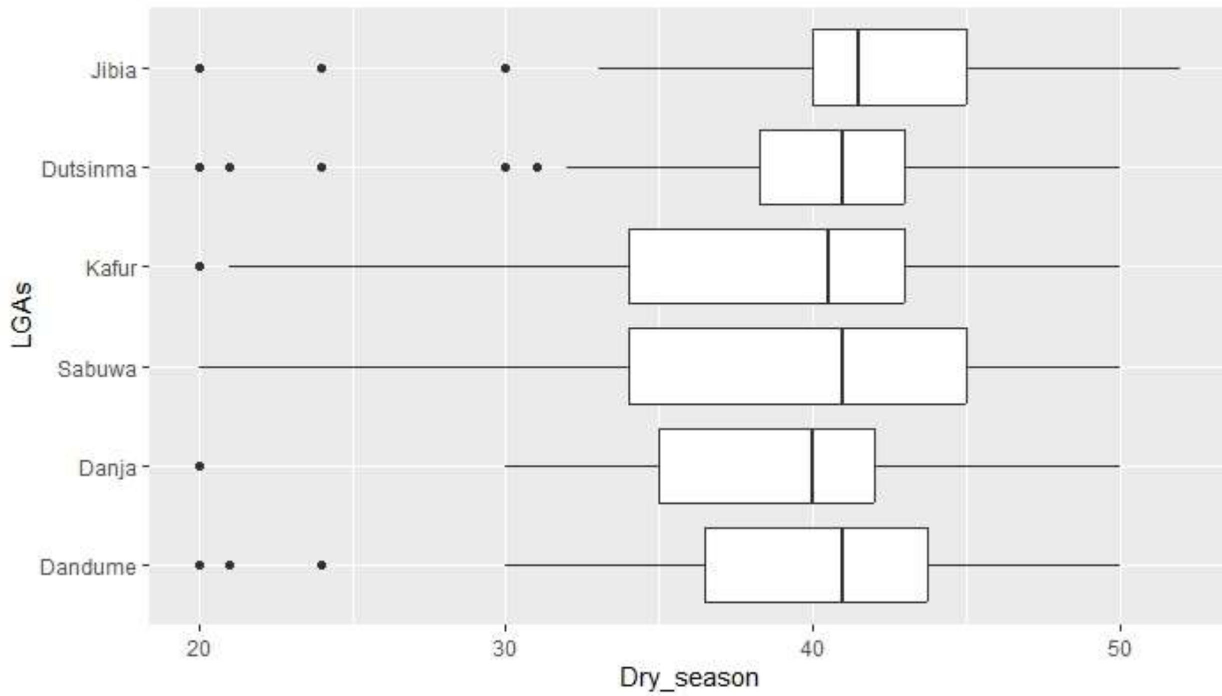

Figure 2: Rainy season Data visualization of Paddy yield

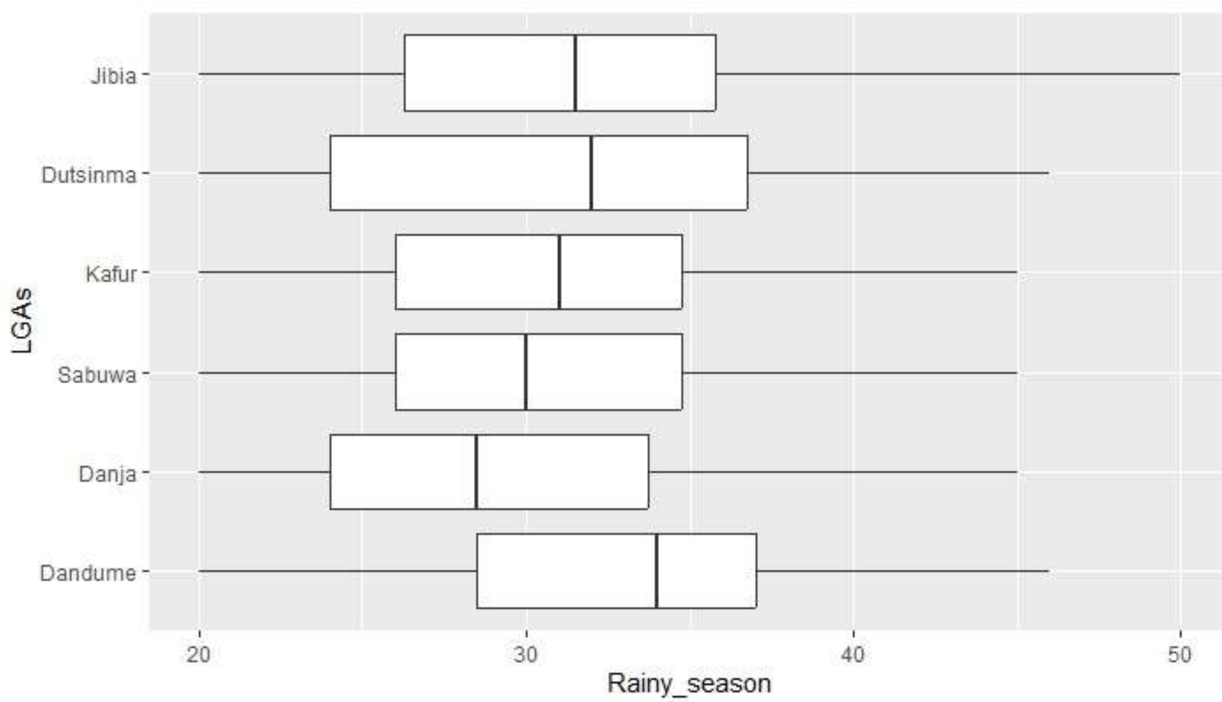

Table 2: Summary Statistics Of Rice Production During The Rainy And Dry Seasons In Katsina, Nigeria.

Dry Season		***Dandume***	***Danja***	***Sabuwa***	***Kafur***	***Dutsinma***	***Jibia***
	1st	36.5	35	34	34	38.25	40
	3rd	39.76	38.56	38.48	38.4	39.44	41.60
Rainy Season	1st	28.5	24	26	26	24	26.25
	3rd	32.48	29.28	30.8	30.86	31.42	31.82

Table 3. Modified Wilcoxon Signed Rank test for Dandume Local Government Area:

H_0: The Median difference for the paddy rice yield in the rainy season equals that of dry season in Dandume LGA.

Wilcoxon Rank Sum Test with Continuity Correction
Data: Dandume Dry vs Dandume Rainy W= 1928.5, p-value = 0.0002

Since the p-value (0.0002) is less than the alpha (0.0025), the null hypothesis is rejected and concludes that the yield of paddy rice for the rainy and dry season in Dandume Local Government Area is not the same.

Table 4. Modified Wilcoxon Signed Rank test for Danja Local Government Area:

H_0: The Median difference for the paddy rice yield in the rainy season equals that of dry season in Danja LGA.

Wilcoxon Rank Sum Test with Continuity Correction
Data: Danja Dry vs Danja Rainy W= 2107, p-value = 0.00003

Since the p-value (0.00003) is less than the alpha (0.0025), the null hypothesis is rejected and concludes that the yield of paddy rice for the rainy and dry season in Danja Local Government Area is not the same.

Table 5. Modified Wilcoxon Signed Rank test for Sabuwa Local Government Area:

H_0: The Median difference for the paddy rice yield in the rainy season equals that of dry season in Sabuwa LGA.

Wilcoxon Rank Sum Test with Continuity Correction
Data: Sabuwa Dry vs Sabuwa Rainy W= 2107, p-value = 0.00041

Since the p-value (0.00041) is less than the alpha (0.0025), the null hypothesis is rejected and concludes that the yield of paddy rice for the rainy and dry season in Sabuwa Local Government Area is not the same.

Table 6. Modified Wilcoxon Signed Rank test for Kafur Local Government Area:

H_0: The Median difference for the paddy rice yield in the rainy season equals that of dry season in Kafur LGA.

Wilcoxon Rank Sum Test with Continuity Correction
Data: Kafur Dry vs Kafur Rainy W= 1954, p-value = 0.00018

Since the (p-value=0.00018) is less than the alpha (0.0025), the null hypothesis is rejected and concludes that the yield of paddy rice for the rainy and dry season in Kafur Local Government Area is not the same.

Table 7. Modified Wilcoxon Signed Rank test for Dutsinma Local Government Area:

H_0: The Median difference for the paddy rice yield in the rainy season equals that of dry season in Dutsinma LGA.

Wilcoxon Rank Sum Test with Continuity Correction
Data: Dutsinma Dry vs Dutsinma Rainy W= 1954, p-value = 0.00036

Since the (p-value=0.00036) is less than the alpha (0.0025), the null hypothesis is rejected and concludes that the yield of paddy rice for the rainy and dry season in Dutsinma Local Government Area is not the same.

Table 8. Modified Wilcoxon Signed Rank test for Jibia Local Government Area:

H_0: The Median difference for the paddy rice yield in the rainy season equals that of dry season in Jibia LGA.

Wilcoxon Rank Sum Test with Continuity Correction
Data: Jibia Dry vs Jibia Rainy W= 2098, p-value = 0.00048

Since the (p-value=0.00048) is less than the alpha (0.0025), the null hypothesis is rejected and concludes that the yield of paddy rice for the rainy and dry season in Jibia Local Government Area is not the same.

DISCUSSION

The analysis of the data for modified Wilcoxon signed rank test as shown in Table 3 to 8 that the season with rain produces more yields for all Local Government compared to dry as p values 0.0002, 0.00003, 0.00041, 0.00018, 0.00036, 0.003752 and 0.00048 are less than significance value$\propto$ (0.05).

CONCLUSSIONS

In general, from the inspection in table 2 it was observed that the yield of paddy rice in some areas under study is low, where in some areas it is high, and the production of paddy rice during the dry season of the first quarter of the year shows that Jibia has the highest level of paddy rice yield production followed by Dutsinma. Secondly, in the third quarter Jibia also has the highest yield production followed by Dandume.

The rainy season results show that Dandume is the highest in terms of productivity followed by Jibia. In the third quarter, Dandume topped the list, followed by Jibia. Comparing the results for the dry and rainy seasons in the first and third quarters showed that Jibia had the highest yield in the dry season for the first and third quarters, while Kafur and Sabuwa had the least productive yields in the first and third quarters. However, during the rainy season, Dandume has the highest productivity in the first and third quarters, while Danja has the lowest productivity in the first and third quarters of the year.

RECOMMENDATIONS

The researcher found that Jibia local government should adopt paddy rice cultivation during dry season while Kafur and Sabuwa should adopt paddy rice cultivation during rainy season in others to get more yield. Secondly Dandume should adopt paddy rice cultivation during rainy season both in the first and third quarter of the year while Danja should adopt dry season cultivation for both quarters.

REFERENCES

Borlaug, N. "A Look at Food Production for the Next Three Decades." Texas A&M University Soil and Crop Sciences Departmental Seminar, College Station TX, 29 October 2003.

Imolehin, E.D. and A.C. Wada 2000. Meeting the rice production and consumption demands of Nigeria

Jones, M.J., 1974. Changes in soil properties resulting from fertiliser use and their effect on crop yields.

Jones, Monty P., 1995. *The rice plant and its environment*. WARDA Training Guide 2. WARDA, Bouaké,

K. Abdulkarim, and Jibril Y. Kajuru (2017): "Application of Non-parametric Methods to the Local Paddy rice yield in Funtua senatorial District of Katsina state, Nigeria". 1st International Conference of Professional Statistician Society of Nigeria". Conference paper (April, 2017). Pp 199-123

Longtau, R. 2003. *A REVIEW AND DESCRIPTION OF RICE: "PRODUCTION SYSTEMS IN NIGERIA*" Eco-systems Development Organisation WIS Partners Building,

Manoj, T., Amin, M. &, Ben, W., (2013). "Production Efficiency and Technology Gap in Irrigated and Rain-fed Rice Farming Systems in Sri Lanka: Non Parametric Approach," 2013 Conference (57th), February 5-8, 2013, Sydney, Australia 152181, Australian Agricultural and Resource Economics Society. DOI: 10.22004/ag.econ.152181

Michelle. G, 2004. "*Predicting the life cycle of rice varieties in texas"* Graduate Studies of Texas A&M University

Nayak, O.P. Mukherjee, A. K., Pandit, E., Pradhan, S.K. (2018). Application of Statistical Tools for Data Analysis and Interpretation in Rice Plant Pathology. Volume 25, Issue 1, January 2018, Pages 1-18https://doi.org/10.1016/j.rsci.2017.07.001

Ran, Y., Chen, H., Ruan D, Liu H, Wang S, Tang X, et al. (2018.) Identification of factors affecting rice yield gap in southwest China: An experimental study. PLoS ONE 13(11): e0206479. doi:10.1371/journal.pone.0206479