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Influence of Tillage Practices and Irrigation Schedule on Yield and Yield Attributes of Rice (*Oryza sativa* L.) Varieties in Sokoto Rima Flood Plain.

Manasseh, E.A.,*[1] O.O Elijah[2], I.B Buji[3], Alasinrin, S. Y[4], J.O Avidime[5] and J.D Daniel[6].

*[1]Department of Soil Science and Agricultural Engineering, Usmanu Danfodiyo University, Sokoto/National Agricultural Seeds Council, North-West Region, Samaru, Zaria
[2] Soil Science Department, Faculty of Agriculture/IAR, P.M.B 1044, Samaru Zaria, Nigeria
[3]Department of Soil Science, University of Maiduguri, Borno State
[4]Department of Agronomy, Faculty of Agriculture, University of Ilorin, Nigeria
[5]Department of Crop Production and Protection, Federal University Wukari, Taraba State.
[6] Department of Soil Science and Agricultural Engineering, Usmanu Danfodiyo University, Sokoto
Corresponding Email: manasseh2ng@gmail.com

Abstract
Proper soil tillage practice and adequate supply of irrigation water enhances the productivity of irrigated rice. Field experiments were conducted in Sokoto Rima flood plain, close to Usmanu Danfodiyo University Teaching and Research Farm in the dry season of 2018 and 2019. The treatments consisted of factorial combination of two tillage practices; conventional tillage (CT) and reduced tillage (RT), three irrigation schedules and three rice varieties, all laid in a split plot design and replicated three times, where tillage practice and irrigation schedule were allocated to the main plots and varieties were allocated to the sub-plots. Field observations and measurements were made for two consecutive seasons using the same experimental design and field layout. Data on 1000 grain weight, percentage unfilled grain and grain yield/ha were collected from all the rice varieties and subjected to analysis of variance (ANOVA) using SAS software and significant means were compared using Duncan Multiple Range Test (DMRT) at $P<0.05$. Significant difference ($P<0.05$) was observed between CT and RT in the value of 1000 grain weight and grain yield/ha, where CT had higher value (27.85g) compared to RT (26.87g). There was an increase in 1000 grain weight and grain yield/ha with a corresponding increase in irrigation schedule, where one day irrigation schedule had significantly ($P<0.05$) higher grain yield (5470.17Kg/ha) and FARO 44 (4185.33 Kg/ha) out yielded both FARO 60 (4036.84 Kg/ha) and 60 (3903.04 Kg/ha), respectively. In conclusion, CT with alternate one day irrigation scheduling favors the yield and yield attributes of all the rice varieties, though FARO 44 is the best.
Keywords: Tillage Practices, Irrigation Schedule and Rice Varieties.

Introduction

Tillage is defined as any physical, chemical or biological soil manipulation to optimized conditions for seed germination, emergence and seedling emergence (Lal, 1979). Soil tillage is an important factor affecting soil physical properties and crop yield, and can contributes up to 20% of yield loss (Khurshid *et al.,* 2006). In any agro ecological environment, the tillage system practiced is usually determined by the soil conditions, climate and type of crop to be grown. Tillage system affects sustainable use of soil resources through its influence on soil properties (Hammel, 1989). The proper use of tillage can improve soil related constraints, while improper tillage practices can cause a range of undesirable processes, such as depletion of organic matter and fertility, destruction of soil structure, accelerated erosion, and disruption in cycles of water, organic carbon and plant nutrient (Odunze *et al*., 2017).

The need to produce more rice with less amount of water will boost existing supplies of water, encouraged more efficient use and promote natural resources protection (Hussain *et al*., 2007). Irrigation scheduling is one of the techniques which provide a means of reducing water consumption while minimizing adverse effects on yield and the environment (Zhang *et al*., 2004).

This research aimed at evaluating the performance of some commonly officially released three rice varieties from National Cereals Research Institute (NCRI), Badeggi, Niger State, as affected by two tillage practices and three different irrigation schedules in the dry season at Sokoto Rima Flood Plain.

Materials and Methods

Experimental Location

The experiment was conducted in a farmer`s field, near the Usmanu Danfodiyo University Teaching and Research Farm, Kwalkwalawa, Sokoto State in the dry season of 2018 and 2019. The coordinates (N13^{0}05.963"E005^{0}12.650" and 252m asl) of the area were taken using global positioning system (GPS) model Garmin etrex 20.0. The soils of the study area were classified as Aeric Endoaquepts at subgroup level in the USDA Soil Taxonomy System (USDA, 2014) which correlated with Gleyic Cambisols in the World Reference Base (FAO, 2015) and Rima series (Noma, 2005). The area experiences a long dry season from October to May and a short rainy season from June to September. The dry season consists of a cold dry spell (Harmattan) roughly from November to February, followed by a hot dry spell from March to May. The rainfall is erratic, small in quantity and uneven distribution with peak in August and temperature fluctuates roughly between 40^{0}C maximum and 15^{0}C minimum (Noma, 2005).

Treatments and Experimental Design

The treatments consisted of factorial combination of two tillage practices (Conventional tillage (CT); which involves cutting, inverting, puddling and leveling the field plots and reduced tillage (RT)**;** which involves puddling and leveling of the plots all with local hoes, shovels and rake), three irrigation schedules (one day, two days and three days irrigation scheduling, which were carried out from one week after transplanting to hard dough stage) and three rice varieties (FARO 44, 60 and 61).

The treatments were laid in a split plot design replicated three times. Tillage system and irrigation schedule was allocated to the main plots, while varieties were allocated to the sub-plots. Field observations and measurements were made for two consecutive seasons (dry) using the same experimental design and field layout.

Experimental Materials

Foundation seeds of rice which were commercially released were obtained from National Cereals Research Institute, Badeggi, Niger State. The varieties were: FARO 44, 60 and 61.

Agronomic Practices

Nursery preparation

A nursery bed was established for the three varieties (FARO 44, 60 and 61) around the edge of the experimental field. Each seed was treated with seed dressing chemical (Apron star ® 50 DS), which contains metalaxyl-M 20% w/w, difenoconazole 2% w/w and thiamethoxam 20% w/w. It was used at the rate of 3.0 kg of seed per 10g sachet of chemical to protect the seeds from soil borne pests and diseases.

Land preparation

Before onset of the experiment, the entire field was cleared of shrubs, pre-wetted and sprayed with 3.0 litre ha^{-1} of a systemic herbicide. Both disturbed and undisturbed soil samples were collected for some selected soil physical and chemical properties determination according to standard procedures, before imposing the treatment composition. The tillage was incorporated as per the treatment, followed by the construction of basins and water channels. The main plot size for each tillage was 4m × 10.2m (40.8m^2), the sub-plot sizes within the main plots was 4m × 3m (12 m^2) and net plot was 3m × 2.5m (7.5 m^2)

Transplanting and irrigation

The entire plot was flooded with water and the rice seedlings after being wetted overnight in the nursery were transplanted after 28 days of its establishment, using transplanting rob at inter and intra row spacing of 20cm × 20cm apart, with two seedling per stand. Immediately after transplanting, the field was sprayed with pendimethalin at the rate of 1.2ai/Kg ha^{-1} and irrigation water was maintained for one week all through the field before imposing of the irrigation scheduling according to the treatment combination of alternate one day, two and three days irrigation to each of the beds to a depth of 10cm water level.

Weed control

Weeding was done at 3 and 6 WAT using local hoe followed by hand pulling of weeds in the plots as the need arises which assisted to maintain weed free plots.

Fertilizer application

Fertilizer was broadcasted at the recommended rate of 100, 40 and 40 Kg, N, P_20_5 and K_2O per ha^{-1} respectively. 40 Kg of nitrogen and full dose of phosphorous and potassium were applied at 2WAT using NPK 15:15:15: while a split dose of 30 Kg N ha^{-1} was applied at 6WAT and the balance of 30 Kg N ha^{-1} was applied during panicle initiation using Urea (46%) as a source of N.

Pests and disease control

Birds were controlled by using nets and no incidence of disease and rodents was recorded.

Harvesting, Threshing and Winnowing

The crop was harvested at physiological maturity when the entire plants had turned yellow and the grain fully filled and at hard dough stage. The plants within the net plot were cut at ground level and bundled into sheaves. Each net plot harvested was threshed by putting into polythene sack and beaten with sticks. The paddy collected for each net plot was cleaned by winnowing, sun-dried and weighed using a sensitive electronic weighing balance model BL 20001.

Determination of Crop Yield and Yield Attributes.

1000 grain weight (g)

A randomly selected 1000 seeds were counted from the harvest of each net plot and weighed using a sensitive electronic weighing balance model BL 20001.

Percentage unfilled grain

The empty spikelets were counted from 5 randomly selected panicles at harvest from each net plot. The average was taken for all panicles and the percentage of unfilled grains was calculated. The empty seeds were designated as sterile while the remaining seeds were considered as normal seeds (Nagato and Chaudhry, 1969).

Grain yield (kgha^{-1})

The harvested panicles from each net plot were threshed and the paddy winnowed and weighed using a sensitive electronic weighing balance and the yield expressed in Kg per hectare.

Data Analysis

Data generated were subjected to analysis of variance (ANOVA) using SAS 9.3 software, (SAS, 2011). Significant means were compared using Duncan multiple range test (DMRT) at P<0.05 (Gomez and Gomez, 1984).

Results and Discussion

Selected Physical and Chemical Properties of the Soils of the Study Area before onset of the Experiment.

Some physical and chemical properties of the soils of the study area are shown on Table 1. The results obtained shows that sand content decreased with increase in depth within the range of 0-20 cm depth, silt content increased with depth while there was no change in clay contents across the two depths. This shows that there was no clay illuviation across the two depths and the textural class of the soils is mainly clay loam across the two depths.

The bulk density of the soils increased with increasing depth from 1.39 gcm^{-3} in 0-10 cm to 1.42 gcm^{-3} in 10- 20 cm, respectively. These values were within the range for clay loam soils which will not restrict root growth (Arshad *et al*., 1996).

Soil pH measured in both water and $CaCl_2$ slightly increased with depth, but with neural acidity at both depths. These values agree with the claim of Reich *et al.* (2001) and Mohammed (2012) that most of the sub-Saharan West African soils are having a pH range of slightly acidic to moderately alkaline. The range is within the favorable limit for which plants` nutrients are available (Weil and Brady, 2016).

value of organic carbon, total nitrogen and available phosphorus were all very low across the two depths, according to the ratings of Lombin (197) and Esu (1991). All the above values confirm that the soils are inherently low in fertility status (Lombin, 1987; Odunze, 2003). This may be attributed to cultivation intensity that persisted in the area for a long time, which resulted in the continuous mining of soil nutrients. Low to medium organic matter content in tropical soils (including fadama) is common as observed by the work of Awode *et al.* (2008).

The Ca and Mg values were considered low while Na was high based on the rating of Esu (1991). The results were in disagreement with the findings of Mohammed (2012). This values obtained may be as a result of continuous irrigation of the soil with irrigation water that may have relatively higher value of Na, which may precipitate both Ca and Mg in the exchange sites over time (FAO, 1985). Based on the ratings of Esu (1991), the K values were high at the surface 0-10 cm and low in 10-20 cm depths. The variation in these values may be attributed to the slow immobilization of K ions within the soil depths from top to button and it could have been adsorbed at the exchange site. The neutral acidic nature of soils at both depths, enhanced its availability Mohammed (2012).

The CEC is low using the rating of Esu (1991). The results were also in agreement with the findings of Mohammed (2012). Tropical soils are characterized by low to medium CEC values because of the abundance of kaolinite clay; which contributes barely little to the exchange capacity of such soils. Weil and Brady (2016) are of the opinion that the contribution of organic matter to the total CEC of the soil is much higher than that of clay.

Table 1: Physical and Chemical Properties of the Soils of the Study Area before onset of the Experiment.

Parameters	0-10 cm value	10-20cm value
Sand (gkg^{-1})	290	270
Silt (gkg^{-1})	370	390
Clay (gkg^{-1})	340	340
USDA Textural Class	**Clay loam**	**Clay loam**
Bulk Density (g/cm^{-3})	1.39	1.42
pH (H20)	7.00	7.20
pH (0.01M $CaCl_2$)	6.70	6.80
Organic Carbon (gkg^{-1})	9.80	5.50
Total Nitrogen (gkg^{-1})	1.40	0.80
Available Phosphurus (mg/kg)	4.42	4.28
Exchangeable Bases (Cmol/kg)		
Calcium (Ca^{2+})	1.32	1.04
Magnessium (Mg^{2+})	3.56	2.81
Sodium (Na^{+})	0.32	0.84
Potassium (K^{+})	0.40	0.20
CEC	5.08	6.88

Influence of Tillage Practices, Irrigation Schedule and Variety on One Thousand Grain Weight, Percentage Unfilled Grain and Grain Yield/ha in 2018 Dry Season at Kwalkalawa.

Table 2 presents results on the influence of tillage practice, irrigation schedule and variety on one thousand grain weight, percentage (%) unfilled grain and the grain yield/ha of rice in 2018 dry season at Kwalkwalawa. Significant difference was observed between CT and RT in the values of 1000 grain weight, where CT had higher value compared to RT. The one day irrigation schedule was significantly higher than the two days irrigation schedule in the value of 1000 grain weight, while three days irrigation schedule was the least. A significant difference was also noticed among the rice varieties with respect to 1000 grain weight, where FARO 44 had significantly higher value of 1000 grain weight, followed by FARO 60 while FARO 61 had the least.

There was no significant difference in percentage unfilled grain between the two tillage systems, but significant difference in percentage unfilled grain was observed with the irrigation schedule, where three days irrigation schedule had significantly higher values of percentage unfilled grain, followed by two days irrigation schedule and one day irrigation schedule had the least value. The varieties also exhibited significant differences in the percentage unfilled grain, where FARO 60 had a significantly higher value, followed by FARO 44 while FARO 61 was the least.

The result of grain yield/ha shows that significant difference was observed between tillage, irrigation schedule and variety, where conventional tillage had significantly higher grain yield/ha compared to RT. There was an increase in grain yield with corresponding increase in water application, where one day irrigation schedule had significantly higher grain yield compared to the other two irrigations. The varieties also showed significant variation in grain yield/ha, with FARO 44 having a significantly higher grain yield/ha, followed by FARO 60 and then FARO 61. These observed differences in yield and yield attributes between tillage, irrigation schedule and variety may be as a result of good soil preparation, less weed competition and available water for the production of assimilates. The yield and yield parameters were favored in CT and one day irrigation schedule than other treatment combinations due to the fact that CT may have less weed competition than RT and one day irrigation schedule does not sufficiently allowed the growth of weed to compete for nutrients, water, light and space with rice, this enables rice to efficiently utilized the available nutrients and water.

Abu and Malgwi (2012) reported higher values of 1000 grain weight, blank grain percentage and grain yield/ha in an experiment conducted at Talata Mafara, and observed that higher water application and shortened irrigation frequencies favors these yield attributes and assisted in higher paddy yields. These also agreed with the findings of Manasseh *et al.* (2018) and Ojo *et al.* (2018) in a yield evaluation trial of rice at Jega, Kebbi state.

There was also a highly significant interaction effect between irrigation schedule and variety on grain yield/ha in 2018 (Table 3). FARO 44 and one day irrigation schedule had the highest grain yield/ha while FAROs 44, 60 and 61 with three days irrigation schedule gave the least and statistically at par.

Table 2: Influence of Tillage Practices, Irrigation Schedule and Variety on One Thousand Grain Weight (g), Percentage Unfilled Grain (%) and Grain Yield/ha (kg/ha) of Rice during 2018 Dry Season..

Treatment	**1000-Grain wt (g)**	**% Unfilled grain**	**Grain yield (kg/ha)**
Tillage (T)			
CT	27.06a	8.76	3843.92a
RT	26.00b	9.07	3663.71b
SE±	0.074	0.111	26.284
Irrigation schedule (W)			
One day schedule (W1)	30.16a	5.42c	5021.36a
Two days schedule (W2)	27.08b	8.25b	4092.18b
Three days schedule (W3)	22.33c	13.08a	2147.91c
SE±	0.091	0.135	32.191
Varieties (V)			
FARO 44	28.18a	9.16b	3905.12a
FARO 60	26.67b	9.69a	3756.76b
FARO 61	24.72c	7.90c	3599.57c
SE±	0.091	0.135	32.191
Interaction			
T × W	NS	NS	NS
T × V	NS	NS	NS
W × V	NS	NS	**
T × W × V	NS	NS	NS

Means followed by the same letter(s) within the same column are not significant at 0.05 level of probability, RT=Reduced tillage, CT= Conventional tillage, SE±=Standard Error, NS= Not significant and **= Highly significant.

Table 3: Interaction between Irrigation Schedule and Variety on Grain Yield/ha (kgha^{-1}) During 2018 Dry Season.

	Variety		
Irrigation schedule (W)	FARO 44	FARO 60	FARO 61
W1	5410.05a	4942.35b	4711.67c
W2	4055.20d	4148.63d	4072.72d
W3	2250.10e	21.79.30e	2014.33e
SE±		55.756	

Means followed by the same letter(s) are not significantly difference at 5% level of probability using DMRT, W1= One day irrigation schedule, W2= Two days irrigation schedule and W3= Three days irrigation schedule.

Influence of Tillage Practices, Irrigation Schedule and Variety on One Thousand Grain Weight, Percentage Unfilled Grain and Grain Yield/ha in 2019 Dry Season at Kwalkalawa.

Table 4 shows similar trend in the result of tillage, irrigation schedule and variety on one thousand grain weight, percentage (%) unfilled grain and the grain yield/ha with the values obtained in 2018 of the same parameters (Table 2). Significant difference was observed between CT and RT in the values of 1000 grain weight, where CT had higher value (27.85g) compared to RT (26.87g). The one day irrigation schedule was significantly higher (31.39g) than the two days irrigation schedule (27.96g) in the value of 1000 grain weight, while three days irrigation schedule was least (22.73g). A significant difference was also observed with variation in the rice varieties, where FARO 44 had significantly higher value (4185.33Kg/ha) of 1000 grain weight, followed by FARO 60 (4036.84Kg/ha) while FARO 61 was the least (3903.04Kg/ha).

There was no significant difference (P>0.05) in percentage unfilled grain between the two tillage systems, while significant difference in percentage unfilled grain was observed with a decrease in irrigation as in 2018, where three days irrigation schedule had significantly higher values of percentage unfilled grain, followed by two days irrigation schedule and one day irrigation schedule was the least. The varieties also exhibited significant differences in the percentage unfilled grain, where FARO 60 had a significantly higher value (6.85%), followed by FARO 44 (6.34%) while FARO 61 was the least (5.35).

However, significant difference was observed between tillage, irrigation schedule and varieties with respect to grain yield/ha. Conventional tillage had significantly higher grain yield/ha compare to RT, there was an increase in grain yield with corresponding increase in water application, where one day irrigation schedule had significantly higher grain yield compared to the other two irrigation schedules. Varieties also show significant variation in grain yield/ha, with FARO 44 having a significantly higher grain yield/ha, followed by FARO 60 and then FARO 61. These observed differences in yield and yield attributes between tillage, irrigation schedule and variety may be as a result of good soil preparation, less weed competition, available water for the production of assimilates as well as the variation in the genetic make-up of each variety.

This consistent increase in trend for 2018 and 2019 dry season for the values of one thousand grain weight, percentage (%) unfilled grain and the grain yield/ha also agrees with the results obtained by Manasseh *et al.* (2018) and Ojo *et al.* (2018) in a yield evaluation trial of some rice varieties in Jega, Kebbi State. Alhassan (2015) also reported a significant increase in yield of FARO 44 in a multi-location trial conducted at Talata Mafara and Kadawa in Kano State on the effect of weed management practices, seeding method and seed rate.

Highly significant interaction effect also existed between irrigation schedule and variety on grain yield/ha in 2019 (Table 5). FARO 44 and one day irrigation schedule had the highest yield/Ha (5835.85 Kg/ha) while FARO 61 with three days irrigation schedule was the least (2163.60 kg/ha).

Table 4: Influence of Tillage Practices, Irrigation Schedule and Variety on One Thousand Grain Weight (g), Percentage Unfilled Grain (%) and Grain Yield (kgha^{-1}) of Rice during 2019 Dry Season.

Treatment	1000-Grain wt (g)	% Unfilled grain	Grain yield (kg/ha)
Tillage (T)			
CT	27.85a	5.96	4139.50a
RT	26.87b	6.09	3943.99b
SE±	0.082	0.129	29.331
Irrigation schedule (W)			
One day schedule (W1)	31.39a	3.94c	5470.17a
Two days schedule (W2)	27.96b	5.91b	4358.12b
Three days schedule (W3)	22.73c	8.63a	2296.93c
SE±	0.100	0.158	35.924
Varieties (V)			
FARO 44	29.05a	6.34b	4185.33a
FARO 60	27.54b	6.85a	4036.84b
FARO 61	25.49c	5.35c	3903.04c
SE±	0.100	0.158	35.924
Interaction			
T × W	NS	NS	NS
T × V	NS	NS	NS
W × V	NS	NS	**
T × W × V	NS	NS	NS

Means followed by the same letter(s) within the same column are not significant at 0.05 level of probability, RT=Reduced tillage, CT= Conventional tillage, SE±=Standard Error, NS= Not significant and **= Highly significant.

Table 1: Interaction between Irrigation Schedule and Variety on Grain Yield/ha (Kgha^{-1}) During 2019 Dry Season.

	Varieties		
Irrigation schedule	FARO 44	FARO 60	FARO 61
W1	5835.85a	5367.83b	5206.83c
W2	4321.12de	4414.55d	4338.70d
W3	2399.03f	2328.15f	2163.60g
SE±	62.221		

Means followed by the same letter(s) are not significantly difference at 5% level of probability using DMRT, W1= One day irrigation schedule, W2= Two days irrigation schedule and W3= Three days irrigation schedule.

Conclusion and Recommendation

It can be concluded from this findings that conventional tillage practices with one day irrigation scheduling favors the yield and yield attributes of all the three varieties of rice, although FARO 44 consistently out yielded the two other varieties.

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