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Original Article

Effect of Irrigation Frequency and Tillage Practices on Rice Growth and Yield Parameters in Adamawa State Nigeria

Freedom Timon [1] and Ibraheem Alhassan [2*]

[1] Adamawa State University, Mubi, Nigeria

[2] Federal College of Horticulture, DadinKowa, Gombe State, Nigeria

ABSTRACT

Sustainable and economically affordable irrigation and tillage practices are needed to increase rice production in Nigeria for the growing population. Experiments were conducted in a split plot design with three replications at Lake Geriyo Irrigation scheme farms in Yola, Nigeria. Three irrigation intervals (3, 6 and 9 days) and three tillage practices (zero, minimum and deep) were imposed on rice during the dry seasons of 2012 and 2013. Results indicated that both irrigation intervals and tillage practices had significant influence on growth parameters while; irrigation has the most influenced on yield attributes. Higher paddy yields (3834.57 and 3753.52 kg ha^{-1}) and harvest index (45.10 and 44.89%) were recorded with 3 days irrigation interval closely followed by 6 days irrigation interval in both years respectively. Significant interactive effect was observed to be higher with 3 days irrigation interval and deep tillage on number of tillers and plant height, while straw weight and harvest index were higher with 3 days irrigation interval and zero tillage. Irrigation intervals of between 3 to 6 days with zero tillage for rice can conveniently reduce irrigation water and labour requirement with sustainable yields in the study area.

Keywords: Irrigation interval, Tillage, Paddy yield and Rice

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crops and provides food security and livelihood for millions of people across the globe. In Nigeria the demand for rice has risen tremendously over the years estimated to increase at the rate of10% per annum (Akande, 2002). To meet this demand, world rice production must increase by more than 60 per cent in the next 30 years (IRRI, 1989), which is possible only if soil, water resources and inputs are used more efficiently (Singh *et al*., 2014). The reliance majorly on rainfall

Corresponding Author: Ibraheem Alhassan < ialhassand@gmail.com >

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agriculture does not speak well for the rising demand and the cost of imports in Nigeria. Irrigation agriculture should be embrace holistically in order to come out of deficit in production. Because of the imminent danger posed by water shortage, various strategies to improve water usage of irrigated crops have been put in place; they include among others deficit irrigation, precision irrigation technology such as drip irrigation and soil and water conservation practice. Reducing water input in rice production can bring about conserving water, save energy and reduce the cost of burning in pumping water for irrigation. Reducing water input in rice production can have a high societal and environmental impact if the said can be diverted to areas were competition is high.

Farmers usually adopt intensive tillage operations for rice with the main intention of controlling weeds, minimizing percolation rate of water and preparing a soft bed for crop establishment. This system results in high energy consumption, drudgery of labour and high cost of cultivation. Recently, there is a growing concern to reduce the cost of cultivation by minimizing the cost on land preparation (Mathew and Johnkutty, 2003). Therefore with increasing cost, the most efficient and economical practice must be determine since both tillage and irrigation require high energy inputs. Tillage practices like conservation tillage or reduced tillage in addition to their primary advantage of reducing soil loss, offers economically sound tillage methods, improves water infiltration and soil profile recharge during the growing season, reduces evaporation, and improves water use efficiency of stored water during short drought periods (Hobbs, 2007). It's therefore essential to know the irrigation frequency and tillage practice that sustains physical and chemical propertiesof the soil, enhances water use efficiency and save cost. The study was carried out to determine the effect of regulated irrigation and different tillage practices on the growth and yield of rice in Adamawa State Nigeria.

Materials and Methods

The experiment was conducted at the Lake Geriyo Irrigation site in Yola North local government area of Adamawa State, Nigeria. The Irrigation Project Site is situated at the North Western part of Jimeta-Yola, North Eastern Nigeria. It lies between longitude 12^0 and 12^0 28^1east of Greenwich and latitude 9^0 16^1 and 9^0 19^1 North of the equator. The area is between 150 and 180 meters above sea level. It is bounded in North East by River Benue, Jimeta in the South West and Namtari Forest Reserve on the West. It covers an area of 850 hectares. The annual rainfall Yola ranges from 700-1,000mm, and the temperature ranges between 15.2^0 – 39^0C (Adebayo, 1999). Relative humidity follows the simple relationship with change of the season while, geological formations of the area include alluvium, basement complex, sedimentary and volcanic rocks (Usman, 2005). The soils of the area is clay loam in texture, moderate bulk density, slightly acidic, very low in organic carbon, total nitrogen, ECEC and available P. The water retention properties of the soils are moderate (Table 1).

The rice variety used for this experiment was Faro-44. The experiment was laid out in a Split Plot Design and replicated three times. Each replication contains 9 plots giving a total of 27plots with each plot measuring 3 x 3m. The Main plot factor is Irrigation (I) which has three different levels of irrigation, viz; I_0= 3 days irrigation interval, I_1= 6days irrigation interval and I_2= 9days irrigation interval. The Sub plot factor is Tillage practice (T), which has three different tillage depths, T_0 =zero tillage, T_1 = shallow tillage (10cm) and T_2 = Deep tillage (20cm). The experimental site was cleared of shrubs and stubbles and prepared manually into check basin measuring 3m x 3m with the use of hoe. In reduce tillage plots, seeds were sown without tilling the soil except for making bunds around the basins, and holes for sowing seeds, while shallow and deep tillage plots, were prepared to the required depth using hoe. The seeds were sown by direct seeding using hoe at a spacing of 20cm between rows and 20cm within rows.

Table 1: Soil physico-chemical properties of the experimental site

Soil properties	Value
Physical properties	
Sand (%)	39.37
Silt (%)	24.13
Clay (%)	36.50
Textural class	Clay-loam
Bulk density (g cm^3)	1.53
Field capacity (%)	27.63
Permanent wilting point (%)	13.20
Available water capacity (%)	14.43
Chemical properties	
pH (water)	5.63
pH (0.01M $CaCl_2$)	6.10
EC (dsm^{-1})	7.32
OC (g kg^{-1})	0.64
Total N ((g kg^{-1})	0.08
Available P (g kg^{-1})	2.04
Exchangeable bases ($cmolkg^{-1}$)	
Ca^{2+}	2.25
Mg^{2+}	0.35
Na^{+}	0.30
K^{+}	0.44
ECEC	3.81

Source: Timon (2014)

Irrigation

Water was pumped from wells using water pump that supply water to the check basin. The flow or discharge rate was measured using velocity volume method. Each basin was ponded with equal volume of water at each irrigation period. $Q=V/T$

Where: Q = discharge rate, V = Volume and T= time taken to fill known volume (Trimmer, 1994).

Fertilizer was applied as NPK at the rate of 80 Kg N, 30 Kg P_2O and 30 Kg K_2O per hectare. First application was carried out at sowing, another at three weeks after sowing (WAS), and the last application was done at six weeks (WAS).

Weeds were controlled using paraquat at 25Kg per ha as a pre-emergence herbicide. Later 2-4D was use as selective herbicide to control weeds at the rate of 250ml in 20litres of water per ha (WARDA, 2008). Where obnoxious weeds exist, they were weeded by hoe and for reduce tillage plots weeds were uprooted using hands.

Laboratory Analysis

Soil physical and chemical properties were determined using the methods suggested by Ryan *et al.* (2001). Bulk Density was determined using a short cylinder core of about 5cm long and 5cm diameter and calculated using the expression by Cassel (1982):Total Porosity was calculated by assuming a particle density of $2.65Mgm^{-3}$ and then using the expression as given by Childs and Bybord (1969).Available Phosphorus was determined by Bray-I procedure, described by Page *et al.* (1986).

Field Study

Plant height per plant was measured from the ground level to the apex using meter rule, five plants were sampled and average value computed.
Number of tillers per hill was collected by counting tillers fromfive hills sampled from each plot and the average was computed. Numbers of spikelet per hill werecounted and the average taken was recorded from the five hills sampled from the middle of the plot. 1000 grain were counted from each plot and weighed after harvest and expressed in kilogram.
Straw of the sampled one meter square was left to dry on the field for about ten (10) days weighed and expressed in kilogram per hectare. The middle one square meter was sampled from each plot and harvested using cutting sickle for grain yield analysis. The harvested portion was threshed, weighed and represented as paddy yield in kilogram per hectare.
Harvest Index was computed as the percentage of the ratio of the economic yield to that of the biological yield.

Data Analysis

The data obtained was subjected to analysis of variance (ANOVA). The means of treatment found to be significantly different at $p = \leq 0.5$ were separated using the least significant difference method (LSD) (CropStat, 2007),

Results and Discussion

The means of treatment for rice plant growth parameters in 2012 and 2013 cropping seasons are presented in Table 2. The irrigation treatments results revealed highly significant differences ($P \leq 0.01$) on plant height and number of tillers per hill. The three days irrigation had the highest plant height of 84.80 and 83.25cm, while the least plant height was observed at nine days irrigation with 74.70 and 75.61cm respectively for both seasons. The number of tillers per hill was higher with three days irrigation (13.19 and 13.04). The results of the main effect of tillage showed significant differences ($P \leq 0.05$) on plant height, while no significant difference was observed on the number of tillers per hill 2012. The deep tillage practice had the highest plant height of 80.18 cm, while the least plant height was observed at shallow tillage practice with 75.17 cm. In 2012 and 2013 cropping seasons the results of the main effect of irrigation intervals revealed highly significant difference on number of spikelets, 1000 grain weight, paddy yield, straw weight and harvest index, with three days irrigation schedule recording highest values. This may be attributed to the constant availability of water (moisture), while the least values were with the 9 days irrigation. This was in agreement with the findings of Tuong *et al*. (2005) and Belder *et al*. (2004) who reported that water stress reduces rice growth and yield parameters. The differences recorded among the tillage practices was supported by the report of Alam *et al*. (2013) that tillage makes soil surface loose and porous, thus enhanced the capacity of soil to store and retain moisture, which becomes readily available for plant physiological development.
The results in 2013 season showed highly significant difference ($P \leq 0.01$) on the number of tillers per hill which was maximum with deep tillage practice (12.74 tillers per hill), while the least was recorded in the zero tillage practice (12.44). The highest values of the growth, yield attributes and yield were observed with three days irrigation intervals and decreased with increased in the intervals. This could be due to moisture stress and less frequent irrigation. This conforms to the findings of Amiri *et al.* (2009) and Ali Abu Khalifa (2010) who reported that water stress reduced number of tillage and plant height and that higher values of yield component were recorded with frequently irrigated treatment (three days irrigation intervals). This may be attributed to the loose and finer nature of the soils that allows for effective plant rooting and facilitate good water and nutrient uptake (Veenstra *et al*., 2006).
The means of the main effect of the irrigation treatments on number of spikelets, 1000 grain weight, paddy yield, straw weight and harvest index are presented in Table 3. The results

revealed highly significant difference ($P \leq 0.01$) in all these parameters. Number of spikelets was highest (85.69) with 3 days irrigation schedule, while the least (74.45) was recorded with 9 days irrigation schedule. 1000 grain weight (g), paddy yield (kgha^{-1}), straw weight and harvest index, all indicated highly significant differences with the 3 days irrigation schedule having the highest values of 21.59g, 3753.52 kgha^{-1}, 4608.21 kgha^{-1}, 44.89%, respectively, while the lowest values were observed in the 9 days irrigation schedule with 20.32g, 3265.30 kgha^{-1}, 4368.80 kgha^{-1}, 42.77%, respectively. The higher paddy and straw yield recorded with 3 days irrigation interval could be attributed to the higher numbers of effective tillers and spikelets in 3 days interval compared to other irrigation schedules. The finding was similarly observed by Islam and Kalita (2014).The means of the main effect of the tillage treatments for rice plant yield parameters revealed no significant difference on number of spikelets per plant, 1000grain weight, paddy yield, straw weight and harvest index in both cropping seasons.

Table 2: Effects of different irrigation frequencies and tillage practices on rice plant growth parameters in 2012 and 2013 dry seasons

	2012		2013	
Treatments	Number of tillers	Plant height (cm)	Number of tillers	Plant height (cm)
Irrigation (I)				
I_0	13.19	84.80	13.04	83.25
I_1	12.73	74.70	12.45	75.67
I_2	12.18	74.39	12.17	75.61
P of F	0.000	0.000	0.000	0.000
LSD (5 %)	0.36	3.46	0.26	2.18
SE	0.1194	1.16339	0.8827	0.7354
Tillage (T)				
T_0	12.74	75.17	12.44	76.17
T_1	12.49	78.53	12.48	78.81
T_2	12.51	80.18	12.74	80.54
P of F	0.305	0.021	0.05	0.002
LSD (5 %)	0.35	3.46	0.26	2.18
SE	0.1194	1.1634	0.8827	0.7354

I_0 = 3 Days irrigation I_1= 6 Days irrigation I_2 = 9 Days irrigation T_0= Zero tillage T_1= Shallow tillage T_2 = Deep tillage

Interaction effects between irrigation interval and tillage practices on rice in 2013 season

The interaction effect between irrigation intervals and tillage practices was only significant in 2013 cropping season on number of tillers per hill, plant height, straw weight and harvest index (Tables 4). The result indicated that three days irrigation interval with deep tillage (I_0T_2) significantly gave higher number of tillers per hill and plant height but, statistically at par with 3 days irrigation interval and zero tillage treatment (I_0T_0). Straw weight and harvest index were significantly higher with 3 days irrigation interval and zero tillage treatment (I_0T_0). This shows that three days irrigation interval was more dominant in the interaction.

Table 3: Effects of different irrigation levels and tillage practices on rice plant yield parameters in 2012 and 2013 dry season.

	2012					2013				
Treatment	No. of spikelet per plant	1000 grain weight (g)	Paddy yield (Kg/Ha)	Straw weight (Kg/Ha)	Harvest Index (%)	No. of spikelet per plant	1000 grain weight (g)	Paddy yield (Kg/Ha)	Straw weight (Kg/Ha)	Harvest Index (%)
					Irrigation					
I_0	88.58	21.68	3834.57	4668.09	45.10	85.69	21.59	3753.52	4608.21	44.89
I_1	76.73	21.13	3627.92	4482.58	44.72	75.53	21.16	3524.93	4481.15	44.03
I_2	73.98	20.35	3339.24	4368.98	43.32	74.45	20.32	3265.30	4368.80	42.77
P of F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LSD (5%)	3.02	0.21	95.38	61.87	0.62	2.54	0.15	29.28	57.38	0.26
SE	1.017	0.7192	32.1012	20.8234	0.2085	0.8558	0.5051	9.856	19.3132	0.8627
					Tillage					
T_0	78.35	21.03	3611.16	4517.97	45.39	76.13	20.91	3484.54	4473.98	43.75
T_1	80.40	20.95	3604.98	4516.52	44.36	78.00	20.96	3505.36	4476.73	43.87
T_2	80.55	21.18	3585.58	4485.15	44.39	80.04	21.20	3555.65	4507.44	44.08
P of F	0.259	0.102	0.844	0.471	0.994	0.101	0.261	0.632	0.417	0.083
LSD (5%)	3.02	0.21	95.38	61.87	0.62	2.54	0.15	29.28	57.38	0.26
SE	1.0179	0.7192	32.1012	20.8234	0.2085	0.8558	0.5051	9.856	19.3132	0.8627

I_0 = 3 Days irrigation I_1= 6 Days irrigation I_2 = 9 Days irrigation T_0= Zero tillage T_1= Shallow tillage T_2 = Deep tillage.

Table 4: Interaction effects of irrigation frequencies and tillage practices on plant growth and yield parameters of rice in 2013 dry seasons

Parameter	No. of Tillers	Plant Height (cm)	Straw weight (kg/ha)	Harvest Index (%)
Treatment				
I_0T_0	13.22	79.97	5440.79	45.11
I_0T_1	12.64	82.79	4589.56	44.89
I_0T_2	13.25	86.98	4694.28	44.68
I_1T_0	12.32	71.64	4485.47	43.87
I_1T_1	12.61	75.95	4461.29	43.96
I_1T_2	12.43	79.24	4496.68	44.26
I_2T_0	11.78	76.91	4395.69	42.26
I_2T_1	12.19	77.68	4379.34	40.77
I_2T_2	12.55	75.41	4331.36	43.29
P of F	0.012	0.014	0.050	0.003
LSD	0.4542	3.7845	99.3893	0.444
SE	0.1529	1.2737	33.4515	0.1494

I_0 = 3 Days irrigation I_1= 6 Days irrigation I_2 = 9 Days irrigation
T_0= Zero tillage T_1= Shallow tillage T_2 = Deep tillage.

CONCLUSION

From the result obtained in this study, it can be concluded that three days irrigation and zero tillage produced the highest yield while other growth parameters were better under three days irrigation and deep tillage.

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