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EFFECTS OF WATER MANAGEMENT PRACTICE ON RICE PRODUCTION USING IRRIGATION SCHEDULING AT DIFFERENT MOISTURE CONTENTS ON FOUR (4) DIFFERENT VARIETIES IN SEMI-ARID REGION OF NIGERIA

Galadima Umar Idris*[1], Kachallah Audu Sariu,[2] Sadiq Ali Abubakar[3] and Zannah Usman[4]
Department of Agricultural Engineering, Federal Polytechnic Monguno, Borno State, Nigeria

Abstract: *Water Scarcity for rice Irrigation is a challenging factor for food security in most developing countries. The increasing scarcity of freshwater due to demand by several bodies is threatening the sustainability of irrigated rice. This study is aimed to determine the growth parameters and yield components of four different varieties of rice grown under different water management practice in Borno State North Eastern part of Nigeria. Four different moisture contents were prepared at flooded water content, above 0.1 bar moisture stress, 0.60 MAD and 0.70 MAD respectively. Four (4) different rice varieties namely PPT1, Nerica3, Faro44 and 57 were randomly assigned to all moisture contents in split plot randomized complete block design. Plant height among the varieties was recorded high in all varieties at MC1 with PPT1 126 cm followed by, Faro44 and 57. Root length was recorded higher under low moisture contents with Nerica3 having the highest root length of 70 cm at MC4. The highest yield under conventional practice MC1 was recorded higher in PPT1 with 26 g/pot followed by Faro44 with 18.6 g/pot. At MC4 However, Nerica3 produces the highest yield compared to the other varieties. The study concludes that under conventional practice of flooded water content, rice varieties with high above ground tend to produce more yield compared to those with low above ground biomass. However, under moisture stress rice varieties with above ground biomass produce more yield.*

Keywords: *Rice crop Production; Drought Stress; Irrigation Scheduling; water management; Manageable allowable depletion (MAD)*

INTRODUCTION

Rice is produced in at least 95 countries across the world and it provides staple food for more than half the population of the world (Ainsworth, 2008). Rice is planted on about 154million hectares or on 11% of the world cultivated land (Khush, 2005). Rice production has kept pace over the past decades in both production and consumption across the world (Marshall and Wadsworth, 1993). Over 90 percent of the world's rice is produced and consumed in the Asia-Pacific Region (Khush, 2005). Rice is the Agricultural commodity with Third – highest production of 741.5 million tonnes in 2014 after sugar cane 1.9 billion tonnes and maize 1.0 billion tonnes (Tigga *et al*., 2017).

Water Scarcity for rice Irrigation is a challenging factor for food security in most developing countries. The increasing scarcity of freshwater due to demand by several bodies is threatening the sustainability of irrigated rice (Bouman and Tuong, 2001). As less water will be available for growing rice, increase in rice production must keep pace to meet up with the population growth which was estimated to reach 8 billion people by 2025 as projected by the United Nations (Khush, 2005). Producing more rice with less water is, therefore, a challenging task for the food, economic, social and water security of rice production regions globally (Facon, 2000). Reduction in rice yield can be termed as a threat to food security and can also affect the livelihood and economy of more than 3 billion people which rely solely on rice as their primary food source (Van Nguyen and Ferrero, 2006).

Rice may not necessarily require much flood as the existing conventional practice as most of the water applied is lost due to seepage, deep percolation and high evapotranspiration due to the high flooding level. Excessive flooding in the paddy field, increases percolation which contributes reasonably to water lost than providing the required water need by the rice plant for optimum productivity (Tuong and Bhuiyan, 1999).

This study is aimed to determine the growth parameters and yield components of four different varieties of rice grown under different water management practice in Borno State North Eastern part of Nigeria.

Effective water management practice will guarantee rice production in a water scarce environment to meet up with the production need of the growing food security challenges in the semi-arid region of Borno State Nigeria.

MATERIALS AND METHODS

Methodology

The study was conducted at teaching and research farm Ramat Polytechnic Maiduguri, Borno State. Enclosed pot with a top opening measuring 45 cm × 45 cm to prevent losses due to seepage and percolation was used with a soil volume of 81,000 cm^3 with a planting density of two plants per pot.

Four different moisture content was prepared based on the soil moisture tension relationship of the experimental soil similar to Idris *et al*., (2020), with little adjustment. MC 1 will be, maintained at flooded water, MC 2 was managed at a soil tension equivalent to 0.1 bar (Above field capacity) Thus, the volumetric moisture content was allowed to deplete to a corresponding moisture content of 0.1 bar before irrigation water will applied up to flooded level. MC 3 was managed at 0.60 Manageable allowable depletion (MAD) thus, the volumetric moisture content was allowed to deplete to a corresponding moisture content of 0.65 MAD, While MC4 was managed at managed at 0.75 MAD respectively

Experimental Design and layout

Table 1 below shows the experiments layout of the proposed research. Four (4) different rice varieties namely, Pathum Thani 1, Faro 68, new rice for Africa (Nerica3) and Faro44 was assigned to the treatments in split plot randomized complete block design. The treatment combination of moisture content (MC), and rice variety is 4x4x4 with total of 16 treatment replicated 4 times.

Table 1: Experimental Design and layout

Moisture contents	Varieties			
MC1 (flooded)	PPT1	NERICA3	Faro 57	Faro 44
MC2 (0.1 bar)	Faro 44	PPT1	NERICA3	Faro 57
MC (0.65 MC)	Faro 57	Faro 44	PPT1	NERICA3
MC4 0.75 MC)	NERICA3	Faro 57	Faro 44	PPT1

Irrigation application at the various soil moisture content (MC)

Irrigation water will maintained at 2.5 cm above the soil surface after planting for one (1) week at all pots. Adjustment begins after one week at all the MC's. Volumetric water content was monitored regularly at all treatments on daily basis using ProCheck 5TE (water content, EC and temperature sensor, Decagon Device). The depleted percentage of moisture content will then be calculated and recorded using (Idris *et al*., 2020).

$$PV = \frac{d}{D} \times 100 \qquad (1)$$

Where: PV is the percentage of volumetric water content d refers to depth of the total available water and D depth of soil.

Hence, the equivalent volume of water depleted was calculated and applied in volume (liters).

Using: $V = A \times d$ (2)

Where V the volume of water applied is, A refers to area irrigated and d refers to depth of total available water depleted.

Crop water use was determined by dividing the volume of irrigation water applied by the irrigated area (mm^3/mm^2). Rice growth and yield parameters data was collected in accordance with the standard evaluation system for rice provided by the International Research Institute of Rice (IRRI 2002). Rice root was removed using an electric pressure pump, then manually counted and measured. Pest was controlled chemically to prevent attack from various rice diseases and fertilizer was applied based on the soil nutrient of the experimental soil determined in the laboratory.

RESULTS AND DISCUSSION

Table 2 bellow shows a comparative results of growth parameters and yield components of four different varieties of rice under four different water management practice.

Plant Height

Plant height among the varieties was recorded high in all varieties at MC 1 with high significant different at $P<0.05$. PPT1, Faro44 and 57 has the highest value with Nerica3 having the lowest height among the varieties at all MCs. Plant height decreases with decrease in moisture content among the all the varieties The highest height was recorded in PPT1 at 126 cm at MC 1 while the lowest height was observed in Nerica3 at MC 4 with 70 cm.

Root Length.

The highest root length was recorded in MC 4 in Nerica3 with 70 cm followed by PPT1 with 57.7cm and 60 and 57 cm were recorded for Faro57 and 44 respectively. The root length increases with decrease in moisture content among all the varieties. Statistically there is high significant difference at $P<0.05$ among varieties at all moisture content.

Tiller Number

The tiller number among the varieties increased at MC 2 in all varieties with the exception of Nerica3 with maintained the same tiller number at all MC. The highest tiller number was recorded in Faro44 with about 13 tiller number followed by PPT1 and Faro57. Nerica3 maintained 3 tiller number at all MCs. Tiller number was recorded least in MC1 among all the varieties. Statistically there is high significant difference at P>0.05 among varieties under different MC. However, numerically there is no much tiller difference with the same MC for Faro 44, 57 and PPT1.

Filled Grain Percentage.

The percentage of filled grain percentage was recorded high in MC1 among all the varieties with Nerica3 having the highest percentage of 85% followed by PPT1, Faro44 and 57. Filled grain was recorded at all water contents level with Nerica3 having the highest filled grain among the varieties.

Yield

The highest yield was observed in MC1 among all the varieties with PPT1 having 26 g/pot followed by Faro44 with 18.6 g/pot. Yield among varieties decreases with decrease in water content, with Nerica3 recording high yield in MC3 and 4. While PPT1 having the highest yield in MC2.

The plant height among the varieties decreases with decrease in water content among all the varieties , this could be due to stress adjustment from osmotic pressure experience by rice plant (Farooq et al., 2009). However tiller number increased among the varieties in MC2 with the exception of Nerica3 which maintain the same tiller number at all MCs this could be due it drought tolerance among the varieties (Corwin and Lesch, 2005). Root length among all the varieties increases with decrease in water content with Nerica3 having the highest root length. This could be due to its low above ground biomass (De Bauw et al., 2018). Filled grain percentage among the varieties was higher in Nerica3 at all level this could be due it breeding capacity to produce yield under drought condition. However, yield among the varieties was higher in PPT1 at MC1 and 2 this could be due it higher above ground biomass that produces high tiller number than the remaining varieties.

This study is in accordance with (Mazza et al., 2023) which state that decrease in moisture content in rice has reduce some physical properties of the rice plant. However, the findings are contrary to that of (Idris et al., 2020) which states that varieties with high above ground biomass has not produced filled grain and yield at low moisture content**.**

Table 2: Results for interactions between four (4) difference varieties at different moisture content on growth and yield of rice

MCs	Varieties	Plant Height (cm)	Root Length (cm)	Tiller Number (no)	Filled grain (%)	Yield (g/pot)
MC1	Nerica3	95.67^{c-e}	42.333^{ef}	3.333 ^{f}	85.967 ^{a}	16.367 ^{b}
	PPT1	126.33^{a}	41.333^{e-g}	13.000 ^{ab}	75.433 ^{b}	26.133 ^{a}
	Faro44	125.00^{a}	35.000^{g}	8.000 ^{e}	64.733 ^{cd}	18.600 ^{b}
	faro57	123.33^{a}	37.667^{fg}	9.000 ^{de}	57.000 ^{e}	13.800 ^{c}
MC2	Nerica3	88.67^{de}	55.000^{c}	3.333 ^{f}	82.667 ^{a}	12.333 ^{c}
	PPT1	109.6 $^{a-c}$	46.66 ^{de}	12.000 $^{a-c}$	57.267 ^{e}	17.800 ^{b}
	Faro44	113.33^{ab}	42.000 ^{ef}	13.667 ^{a}	58.000 ^{de}	8.833 ^{d}
	faro57	126.00 ^{a}	42.333 ^{ef}	12.333 $^{a-c}$	53.667 ^{e}	5.333 $^{e-g}$
MC3	Nerica3	80.67^{ef}	59.000 ^{bc}	3.333 ^{f}	67.467 ^{c}	7.600 ^{de}
	PPT1	120.67^{a}	54.667 ^{c}	11.667 $^{a-c}$	37.300 ^{f}	9.367 ^{d}
	Faro44	93.33^{c-e}	53.333 ^{cd}	10.667 $^{c-d}$	29.800 ^{g}	3.200 ^{gh}
	faro57	97.00^{b-e}	58.667 ^{bc}	12.667 $^{a-c}$	32.100 ^{fg}	3.533 ^{gh}
MC4	Nerica3	70.67^{f}	70.333 ^{a}	3.000 ^{f}	52.200 ^{e}	3.500 ^{gh}
	PPT1	110.33 $^{a-c}$	63.333 ^{b}	12.000 $^{a-c}$	27.200 ^{g}	6.000 ^{ef}
	Faro44	85.67^{d-f}	57.667 ^{bc}	11.000 $^{b-d}$	31.467 ^{fg}	4.533 $^{f-h}$
	faro57	85.67^{d-f}	60.000 ^{bc}	9.000 ^{de}	17.367 ^{h}	2.867 ^{h}
CV		9.88	7.93	13.96	8.24	14.55
LSD		**	**	**	**	**

** **Represent highly significant at P<0.05, CV represent coefficient of variance, LSD represent least significant difference.**

CONCLUSION

Based on the findings of this study, the following conclusions were made:
Rice growth is affected by decrease in moisture content among all varieties.
Tiller number increases to some extent when moisture content decreases. However, under severe moisture stress all above ground biomass tend to decrease.
Filled grain percentage is higher in varieties with low above ground biomass compared to varieties with higher above ground biomass. However, yield higher in varieties with high above ground biomass under conventional practice but low under moisture stress. Consequently, varieties with low above ground biomass tend to produce more yield compared to varieties with higher above ground biomass under moisture stress.

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