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Effects of Water Management on Rice Production at Different Manageable Allowable Depletion on Three (3) Different Varieties in Semi-Arid Region of Nigeria

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Abstract: *Rice is becoming staple food in most part of Nigeria, but the production quantity is still very far for the need of over 200,000,000 million population. The increasing scarcity of freshwater is threatening the sustainability of irrigated rice. Irrigation scheduling when water is inadequate within the paddy soil, can be an alternative means to sustain rice crop production. The study was conducted at teaching and research farm Ramat Polytechnic Maiduguri, Borno State Nigeria. This study focus on rice crop water use, growth and yield at different irrigation schemes. Three (3) moisture contents were set up to flooded water content, 0.1 bar, and 0.50 MAD respectively. Three (3) rice varieties, namely: PPT1, Nerica3 and Faro44 were assigned to the treatments in Split plot randomized complete block design (RCBD). The crop water use was recorded higher in PPT1 at all water content level with 5.11 mm/day at flooded water content. Filled grain percentage was recorded higher in MC1 among all varieties with PPT1 having 86%, followed by Nerica3 with 82.8% and faro44 with 75.4%. Grain yield was recorded higher in MC 1 for all varieties with PPT1 having highest yield of 22.98 g pot $^{-1}$ followed by faro44 with 22.78 g pot $^{-1}$ and the least yield was recorded in Nerica3 with 9.28 g pot $^{-1}$. However, at MC3 both PPT1 and Faro44 did not produced yield except Nerica3. The study concludes that PPT1 has higher crop water use and higher above ground biomass and produced the highest yield at MC1 and 2. Faro44 has shown drought tolerant features by reduction of above ground biomass with decrease in moisture content and produces under moisture content tension. While Nerica3 is more tolerant to drought and has low above ground biomass and the only variety that produced yield in MC3.*

Key words: *Rice; drought; water management*

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 154 million 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

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 & Tuong, 2001). As less water was 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 & Ferrero, 2006). The study is intended to guide farmers, extension personnel, student of Agriculture and researchers in Nigeria to use improved varieties and complementary production practice to increase productivity, as part of my contribution to the economic recovery process in the North East part of Nigeria which has been ravaged by the insurgent activities of the armed group. This research will support vulnerable population to engage in basic farming activities that will improve food security, increase in Agricultural income and improve resilience among small holder farmers and their families

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. (Tuong & Bhuiyan, 1999).Water management practice for sustainable rice production in the North East Nigeria will improve growing demand, self-sufficiency and reduce input. The study is focuses investigate soil moisture effects, crop water use and performance of different rice varieties at different water content.

MATERIALS AND METHODS

The study was conducted at teaching and research farm Ramat Polytechnic Maiduguri Borno State. Enclosed pot with a top opening measuring 40 cm × 40 cm to prevent losses due to seepage and percolation were used with a soil volume of 48,000 cm^3 with a planting density of two plants per pot.

Three (3) different moisture content was prepared based on the soil moisture tension relationship of the experimental soil. MC 1 was, maintained at flooded water, MC 2 was managed at a soil tension equivalent to 0.1 bar 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. (Above field capacity) MC 3 was managed at 0.50 Manageable allowable depletion (MAD) thus, the volumetric moisture content was allowed to deplete to a corresponding moisture content of 0.50 MAD, (Figure 1).

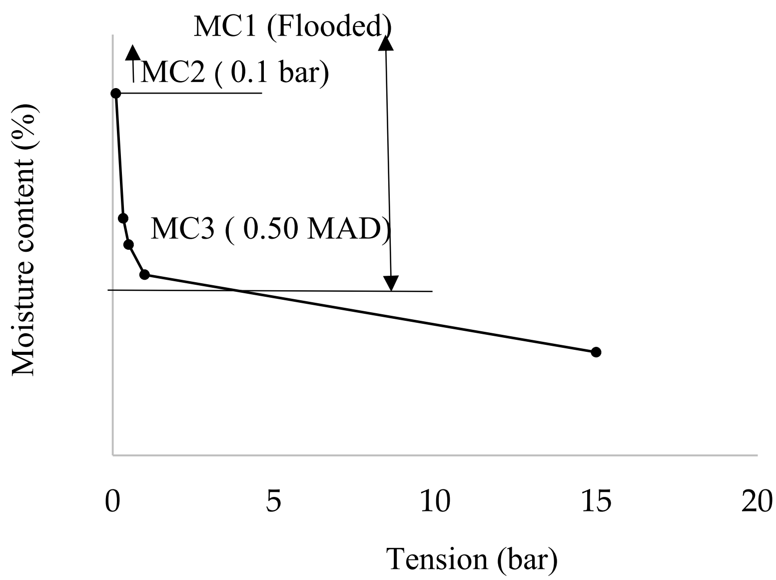

Figure1: Moisture content adjustment at different Manageable allowable depletion Three (3) different rice varieties namely, Pathum Thani 1, new rice for Africa (Nerica3) and Faro44 were assigned to the treatments in split plot randomized complete block design. The treatment combination of moisture content (MC), and rice is 3x3x4 with total of 9 treatments replicated 4 times. Table 1.

Table 1: Experimental layout in split plot complete randomized complete block design

Moisture contents	Varieties		
MC1 (flooded)	PPT1	NERICA3	Faro 44
MC2 (0.1 bar)	Faro 44	PPT1	PPT1
MC (0.50 MAD)	Nerica3	Faro 44	NERICA3

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 is then be calculated and recorded using (Idris, Kaewrueng, Sreewongchai, & Tawornpruek, 2020).

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

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, 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 were collected in accordance with the standard evaluation system for rice provided by the International Research Institute of Rice (IRRI 2002). Pest was controlled chemically to prevent attack from various rice diseases and fertilizer were applied based on soil nutrient requirement.

Experimental Varieties

Pathum Thani 1 (PPT1): PPT1, is a semi-dwarf photoperiod insensitive low land rice variety, which can be grown all year round. It is widely grown in the dry season in Thailand's irrigated areas with a flooded water during the dry season (Sreethong, Prom-u-thai, Rerkasem, Dell, & Jamjod, 2018). New Rice for Africa (Nerica3) is a variety developed from crosses between *Oryza glaberirima* and *Oryza sativa* species which is specifically targeted at upland and dry areas of sub-Saharan Africa (Jones, Dingkuhn, Aluko/snm, & Semon, 1997). Federal Agricultural Research Oryza (Faro 44) is a conventional upland rice variety used in Borno state and most part of Northern Nigeria (M. Sokoto, 2014).

RESULT AND DISCUSSION

Crop water Use: The crop water use was recorded higher in PPT1 at all water content level with 5.11 mm/day at flooded water content, followed by FARO44 with 4.28 mm/day and the least was recorded in Nerica3 with 3.36 mm/day. Higher crop use was recorded in PPT1 in all MC followed by faro44 and the lease crop water use was recorded in Nerica3

Plant height was high in MC1, followed by MC2 and MC3 among all varieties. The highest plant height was recorded in Faro 44 among the varieties and the least height was recorded in Nerica3 among.

Filled grain percentage was recorded higher in MC1 among all varieties with PPT1 having 86%, followed by Nerica3 with 82.8% and faro44 with 75.4%. However, at MC2 and 3 highest filled grain percentage was recorded higher in Nerica3 compared to ppt1 and faro44, where 64% and 53% were recorded in MC2 and MC3 for Nerica3.

1000 grain weight was recorded higher in Nerica3 at all MCs compared to PPT1 and Faro44. 26.8g was recorded for 1000 grain weight in Nerica 3 at MC1, followed PPT1 and faro44, where 22.55 g and 21.86 g were recorded for PPT1 and Faro44 respectively.

Tiller number was recorded higher in PPT1 among varieties in MC1 and 2 followed by Faro44 and the least tiller number was recorded in was recorded in Nerica3. Reduction of tiller number was observed with reduction in MC in Nerica3. However, there was no difference in in tiller number among PPT1 in MC1 and MC2 but the tiller number decreases at MC3. Faro44 recorded higher tiller number in MC1 compared to MC2 and 3. The tiller decreases in decrease in MC.

Yield was recorded higher in MC 1 for all varieties with PPT1 having highest yield at 22.98 g pot^{-1} followed by faro44 with 22.78 g pot^{-1} and the least yield was recorded in

Nerica3 with 9.28 g pot $^{-1}$. At MC2 yield was higher in PPT1 followed by faro44 and Nerica3. However, at MC3 both PPT1 and Faro44 did not produced yield except Nerica3.

Statistically there is high significant difference among treatments in all the parameters at $P < 0.001$. This could be due to difference in response to interactions among varieties to different MC as the varieties are genetically different. Consequently, the higher coefficient variance (CV) recorded under yield could be due to difference in adoption to stress among the varieties as the adaption to stress differ among varieties (Ashraf, 2010).

This study is in accordance with finding of (Idris et al., 2020), whose conducted a pot experiment in a greenhouse reported that Nerica3 produce yield higher than other varieties with higher above ground biomass under low volumetric moisture content. Similarly, (Zhou et al., 2017) reported that at both field and pot experiment yield and above ground biomass of rice plant decreases with decrease in MC. However, this finding is contrary to (M. B. Sokoto & Muhammad, 2014) whose reported a high yield response to drought in Faro44, this could be due drought stress severity of this experiment as well as difference in drought tolerant variety selected in this experiment.

Table 2: Interactions among varieties at different MCs on growth and yield parameters

		Parameters					
Moisture Content	Variety	Crop Consumptive use (mm/day)	Filled grain (%)	1000 grain weight (g)	Plant Height (cm)	Tiller number	Yield (g pot $^{-1}$)
MC1	FARO44	4.28b	75.41abc	21.86a-e	129.67ab	7.67ab	22.78bc
	PPT1	5.11a	85.96a	22.55a-d	126.33abc	9.00 a	24.98a
	Nerica3	3.36d	82.81ab	26.81a	113.33a-h	3.00f-i	9.28gh
MC2	FARO44	2.76e	40.33hij	14.90g-j	120.67a-e	6.67a-e	14.90f
	PPT1	3.80c	47.46fgh	14.70hij	127.00abc	9.00a	16.94ef
	Nerica 3	2.21g	64.49cde	21.60b-e	87.67jkl	2.33ghi	6.77hij
MC3	FARO44	1.91i-n	4.90l	1.47op	96.33f-l	5.67 b-f	0.05o
	PPT1	2.21g	1.90l	2.67nop	94.67g-l	6.33a-e	0.63mno
	Nerica 3	1.79l-p	53.19efg	18.59d-h	97.33 f-l	2.00ghi	3.12k-n
CV		5.56	19.46	23.43	12.33	24.84	79.37
LSD		**	**	**	**	**	**

CONCLUSION

The study concludes that PPT1 has higher crop water use and higher above ground biomass and produced the highest yield. Faro44 has shown drought tolerant features by reduction of above ground biomass with decrease in moisture content and produces under moisture content tension. Nerica3 is more tolerant to drought and has low above ground biomass. Plant height decreases with decrease in moisture content among rice varieties.

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