Original Research Article

VEGETATIVE GROWTH PHASE IN LOCAL RICE LANDRACES AS AFFECTED BY MOISTURE STRESS

Abstract

Rice, has been part of the most essential food crop for almost half of the world's rapid growing population. At present, it is a valuable commodity of relevant importance which drives the change in the pattern of crop preference selection both in the urban and as well the rural areas (Khalil *et al.,* 2009). Water scarcity has been termed the most deepened single physiological and ecological factor controlling the effect of growth and development of plants than any known other factor (Kramer and Boyer, 1995). Experiments have been undertaken to determine the resultant effects of moisture stress during the vegetative growth phase in local grown rice landraces in North Eastern Nigeria. Seeds of two different local varieties namely BG doguwa, Mai-zazzabi and NERICA as control were obtained from local farmers as they are the widely grown rice cultivars in the region. There were three treatments of irrigating once in a day (control), irrigating after every 2 days (mild) and after six days (severe), respectively. The objectives are to assess whether moisture stress has effect on the physiological vegetative growth of two local rice cultivars and to evaluate whether moisture stress has effect on the biomass of the local rice landraces. Data collection was done on the following parameters; plant height (cm), number of leaves, root length (cm), stem diameter (cm), and shoot biomass (kg). The present study revealed significant reduction in plant growth and biomass accumulation because of severe water deficit. Mai-zazzabi was observed to be more tolerant to the moisture stress in terms of plant growth compared to the other two tested varieties and was able to accumulate higher biomass under the severe moisture stress condition.

Key: Rice; Landraces; Water/Moisture deficit

1.0 INTRODUCTION

One of the most manageable and prolific agricultural cropping system recognized in the world is rice farming. This is because, rice farming has adapted to varying environmental ecosystems from lowlands to highlands and from waterlogged swamps to uplands. Rice crop from ancient domestication is known to thrive in deep waterlogged soil been a semi-aquatic plant it requires a huge supply of water for its production. Rice production can be done in varying ecological conditions like irrigated lowlands, rainfed lowlands and highlands and deep-water conditions based on water availability (Hafeez *et al.,* 2007). In the World perception generally, irrigated rice is seen to have accounted for about 55 % of the whole productive farming system in its harvested area whilst contributing to about 75 % total production. Irrigated rice annual productivity has exceeded that of rain fed rice by more than 5 % (Fairhurt & Dobermann, 2002). For the meantime, acquiring resources for rice irrigation farming has come into a decline over the past years due to the rapid increase in development and industrialization which aggravates the problem of water scarcity (Gleick et al., 2002). An estimation of water required to attain 1 kg of rice grain is 1900 litters as reported presently by FAOSTAT (2013).

A distinguishing physiological and as well ecological factor which affects plant growth and development is water deficit, the effect is seen to be more predominant than any other environmental factor affecting plant growth (Kramer and Boyer, 1995). Water supply and availability is a critical requirement for plant but its deficiency results in the plant becoming stressed. At the initial stage of the vegetative phase of growth in plants, water deficiency has been established to be a very important limiting factor as it affects elongation and expansion in growth (Anjum *et al.,* 2003). Slow cellular enlargements, plant tillering capacity and reduction in stem lengths because of inhibited internodal elongation are all caused by water stress.

At different levels in the stages of development such as tillering phase, panicle initiation and heading, the rice plant responds differently to moisture stress (Botwright Acuna *et al.,* 2008; Kamoshita *et al.,* 2004), yet, some associated factors of the stress like timing, intensity and duration have harmful effect on plant growth. At the stage of reproduction, Liu et al., (2006) reported that flowering is more exposed to the intensity of the stress which at the end causes sterility in the spikelet.

Ample water is required to grow rice; rice grown in upland areas going rainless for a week and rice grown in shallow lowlands areas going rainless for 2 weeks will significantly cause a reduction in yield. Drought periods leading to low production and food scarcity were observed because of water scarcity on average yield production in rain fed conditions. Climate change onset has contributed to the intensity of frequency of droughts. Rain fed rice production in more than 23 million hectares of area in South and South West Asia has been affected by water scarcity (IPCC, 2007). Droughts recurring in Africa, have affected more than 80 % of the potential 20 million hectares of land set aside for rain fed lowland rice production (IFPRI, 2010). Increasing crop tolerance to water scarcity would be the most economic approach for maximizing productivity and to minimize agricultural use of fresh water resource. Recent studies have shown plants evolving numerous morphological, physiological, biochemical and molecular strategies to adapt to the adverse climatic effect. To fulfill this objective, a concise knowledge of the possible mechanisms lying behind water stress environment is a must.

Though rice is affected by some environmental factors such as moisture, pH, temperature, soil type etc. rice plant was observed to develop some mechanism to overcome or escape those unfavorable conditions. And that's the reason why it is important to study and find out moisture effect on the growth of such local landraces of rice.

2.0 METHODOLOGY

2.1 Experimental site

The study was carried out at Federal College of Horticulture, Dadin Kowa nursery site. The College is situated at Dadin Kowa along Gombe to Biu/Maiduguri road in Yamaltu Deba Local Government Area of Gombe State. Dadin Kowa is about 35 kilometers away from Gombe and is in the Sudan Savannah ecological zone of Nigeria.

The plant was grown on a well-established bed in the nursery where required field environmental factors such as light, CO_2 concentration and temperature conditions were mimicked. Seeds of two different local varieties namely BG doguwa, Mai-zazzabi and NERICA as control were obtained from local farmers as they are the widely grown varieties in the region. The local rice varieties have not been subjected to any data baseor germplasm depository as they now been tested for preliminary researches based on farmer usage and consumers consumption. The soil was dug from the College nursery site, three beds (for the control and drought treatments) of two by two meters were established with two replicates each and watered to field capacity for three days, and the seeds were soaked for a day prior to planting to facilitate germination. Five hills of each variety with 4 seeds per hill were sown. The experiment was a 3 x 3 factorial. The experimental set-up was a randomized complete block design (RCBD). The treatments were; irrigating once in a day (control), after every two days (mild), and after six days (severe), respectively. For the first three weeks the plants were subjected to daily irrigation with the same amount of water per bed. The beds were kept weed free by handpicking the weeds and also weeding with hoe.

2.2 Data Measurements

All experimental plants were subjected to before (data taken from 1 week after germination till harvest) and after harvesting agronomic measurement of data as listed below.

Plant height (cm): Measurement commenced twenty-one (21) days after planting and subsequent measurements were taken after every 7 days.

Number of leaves: This was done by counting the tillers/number of leaves on each individual plant.

Stem diameter (cm): The stem diameter was measured using a thread which is tied to the stem of the plant and then placed on a meter rule to take the measurement.

Wet shoot weight (kg): This was determined immediately after harvesting using a mini kitchen scale weighing balance.

Dry shoot biomass weight (kg): The shoots were harvested and then neatly folded and placed in brown paper bags and placed to dry at 80^{0}C in an oven, the shoot biomass was then weighed using an electronic weighing scale in the laboratory.

Root length (cm): The plants were gently uprooted and soaked in water to wash off soil particles. The length of the root was determined by using a meter rule. Measurements were taken from the stem base to the longest root tip of the tap root.

Dry root biomass weight (kg): The roots were harvested and then neatly folded and placed in brown paper bags and placed to dry at 80^{0}C in an oven, the roots were then weighed. The root biomass was then weighed using an electronic weighing scale in the laboratory.

3.0 DATA ANALYSIS

Data collected were subjected to analysis of variance (ANOVA) using statistical computer package Minitab(c) V. 17 (State College PA) to determine treatments effects if significant. The treatment and variety mean were separated using the test known as Tukey Pairwise Comparisons. The level of significance was set at 95 % confidence interval ($P<=0.05$).
Results presented are data collected and analysed from the fifth week after germination as no significant differences ($P>0.05$) or effects were observed before then on all parameters measured.

A general decline in plant height was observed in relation to increasing water deficit (figure 1). There was a significant difference ($P<0.05$) in plant height among the watering regimes in W6 and W7 but not in W8 and the first and third regimes has the tallest plants (Table 1). These may be since the plant has developed tolerant mechanism and the reason why the growth in height continued. The reduction in plant height in relation to increased water deficit was more pronounced in BG doguwa and NERICA (figure 1).

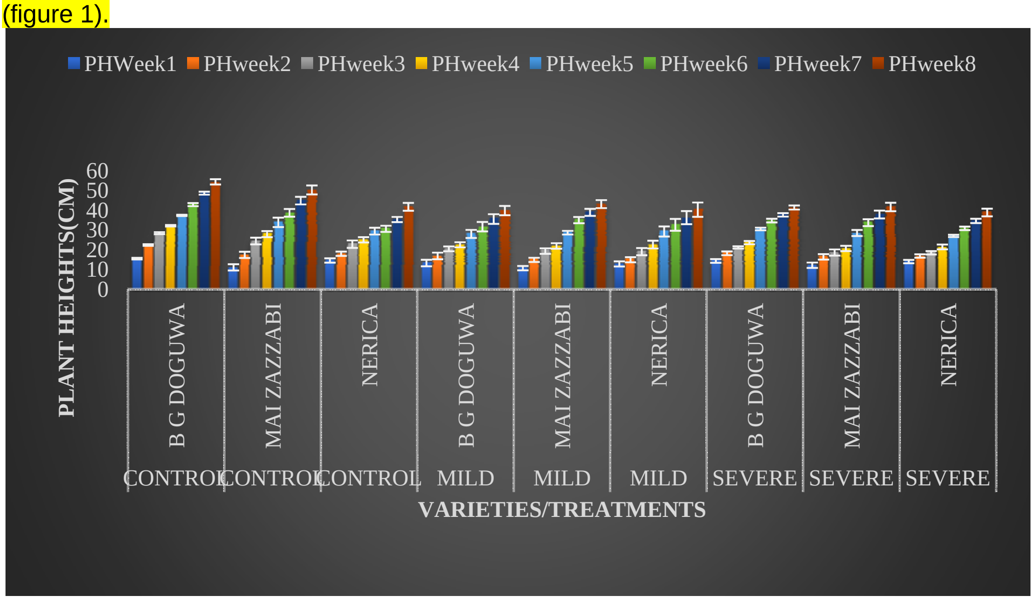

Figure1: Effect of different watering regimes on the plant height of BG doguwa, Mai zazzabi and NERICA rice land races at week 1 to week 8 (PHWeek1 to PHWeek8). Values are means of two Replications ± Std error.

Table 1: General linear model for the interaction between all the parameters versus Treatment, Varieties

Parameter	Treatment	Varieties	Treatment *Varieties
Plantheight(cm) Week 5	0.001	0.045	0.107
Plantheight(cm) Week 6	0.007	0.002	0.015
Plantheight(cm) Week 7	0.001	0.002	0.012
Plantheight(cm) Week 8	0.001	0.014	0.060
NL Week 5	0.001	0.001	0.191
NL Week 6	0.001	0.001	0.091
NL Week 7	0.001	0.001	0.054
NL Week 8	0.001	0.001	0.047
Stem diameter(cm)	0.002	0.014	0.181
Root length(cm)	0.027	0.232	0.349
Biomass weight(kg)	0.001	0.001	0.043

*Note. NL=Number of leaves, coloured fonts indicate significant P values < 0.05

Table 2: Interaction between Parameters versus Treatment

Parameter		Treatments		
	Control	Mild stress	Severe stress	P-value
Stem diameter(cm)	1.60^{a}±0.19	1.46^{b}±0.19	1.39^{b}±0.13	0.006
Root length(cm)	14.33^{a}±1.85	13.08^{ab}±1.99	12.34^{b}±2.11	0.029
Biomass(kg)	2.60^{a}±1.30	1.43^{b}±0.46	1.47^{b}±0.61	0.001

Key: Means that do not share a letter are significantly different, coloured fonts indicate significant P values < 0.05

Number of leaves decreased under water deficit (figure 2). Control treatment recorded higher number of leaves than plants in treatment 2 (mildly stressed) and treatment 3, (severe stress) respectively, the most pronounced reduction occurred with BG doguwa land race.

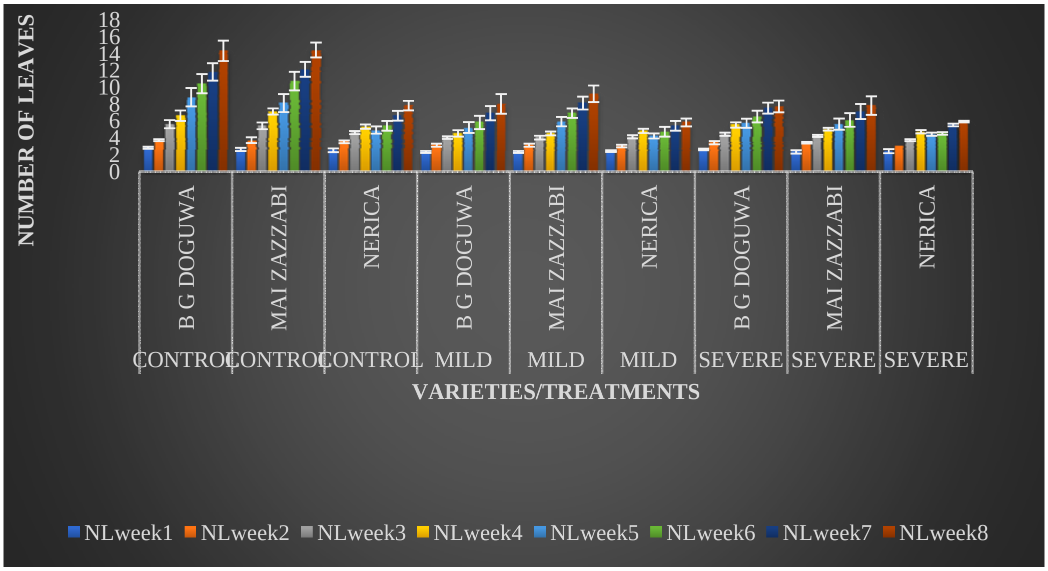

Figure 2: Effect of different watering regimes on the number of leaves of BG doguwa, Mai zazzabi and Nerica rice land races at week 1 to week 8 (NLWeek1 to NLWeek8). Values are means of two Replications ± Std error.

Root length noticeably reduced in relation to increased water deficit (figure 3). Plants of the Control treatment recorded higher root lengths than plants of treatment 2 (mildly stressed) and treatment 3, (severe stress) respectively. The more pronounced reduction occurred with BG doguwa. Stem diameter and biomass (kg) reduced in relation to the increase in water deficit (figure 3). Plants watered daily (Control) had higher stem diameters(cm) and biomass(kg) accumulation than plants of the other watering regimes.

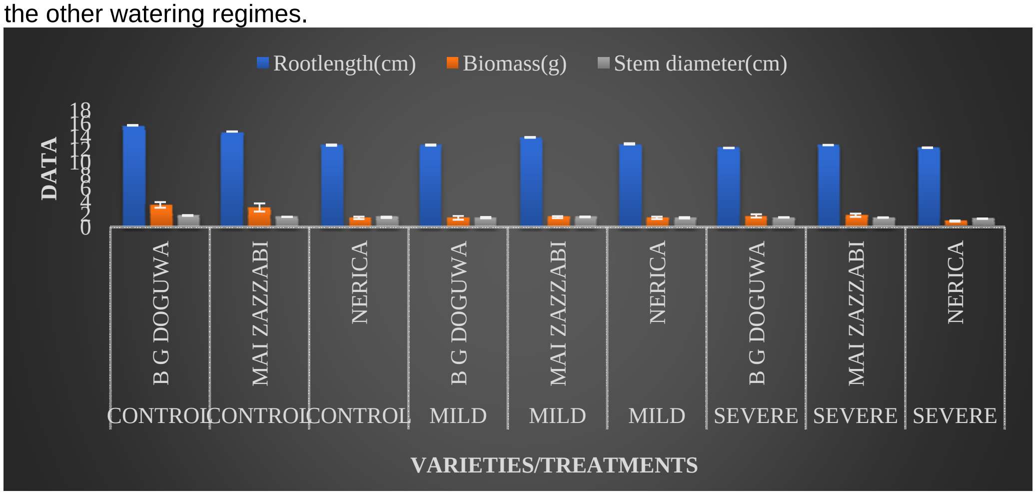

Figure 3: Effect of different watering regimes on the root length(cm), biomass weight(kg) of shoot, and stem diameter(cm) of BG doguwa, Mai zazzabi and Nerica rice land races. Values are means of two Replications ± Std error.

There was a significant difference ($P<0.05$) among the varieties in stem diameter (cm) and whole plant dry weight(kg) as shown in (Table 3). BG doguwa had the highest stem diameter (cm) and biomass (kg) in the first watering regime (control) followed by Mai-zazzabi, but Mai-zazzabi had the highest in the second (mild stress) and third (severe stress) watering regimes followed by BG doguwa.

Table 3: Interaction between Parameters versus Varieties

Parameter	Varieties			P-value
	BG doguwa	Mai-zazzabi	Nerica	
Stem diameter(cm)	$1.55^{a}\pm0.21$	$1.52^{ab}\pm0.11$	$1.39^{b}\pm0.20$	0.037
Root length(cm)	$13.49^{a}\pm2.81$	$13.72^{a}\pm1.56$	$12.55^{a}\pm1.70$	0.279
Biomass (kg)	$2.17^{a}\pm1.14$	$2.10^{a}\pm1.07$	$1.23^{b}\pm0.42$	0.015

Key: Means that do not share a letter are significantly different, coloured fonts indicate significant P values < 0.05

4.0 DISCUSSION

The trend in the reduction in plant height with increase in relation to water deficit (Figure-1) in rice agrees with results of Siddique *et al.* (2000) in wheat. Growth involves both cellular growth and development which is a process consisting of cellular division, cellular enlargement and differentiation and these processes are very sensitive to water deficit because they all depend on cellular turgidity (Jones and Lazenby, 1988). The inhibition of cell expansion is usually followed closely by a reduction in cell wall synthesis (Salisbury and Ross, 1992). This may have affected plant height of the rice. This study revealed Mai zazzabi to be generally taller than BG doguwa and Nerica at severe moisture stress conditions. This implies that Mai zazzabi can withstand higher levels of dehydration. In terms of plant height, Mai zazzabi is the most tolerant variety among the three varieties. The number of leaves decrease with increase in water deficit (figure 2). Water deficit might, inhibit photosynthesis and produce less assimilates which resulted in lower number of leaves this result agrees with the work of Hossain (2001). The plant shoot dry weights decreased in relation to increased water deficit. Similar results were obtained by Willumsen (1993). The reduction in shoot dry weight could be associated with reduced rate of leaf production hence low number of leaves. Reduction in leaf growth may also have been contributed by lower rates of cell division and cell extension in the leaves. Reduction in leaf growth leads to less photosynthesis hence retarded overall plant growth as the resources required for growth processes become limited in supply (Mwai, 2002). Plants show increased root: shoot ratio during soil moisture deficit (Boyer, 1985). Similar results have also been obtained in mango rootstock seedlings (Luvaha, 2005). The differential sensitivity of roots and shoots (with root growth being less sensitive to water deficits) leads to large increases in the root to shoot ratio in drought conditions (Sharp and Davies, 1985). This may be an adaptation of Mai zazzabi rice varieties for survival under water scarcity conditions since increased root surface area allows more water to be absorbed from the soil. Shoot growth decline coupled with continued root growth would result in an improved plant water status under extreme water deficit conditions. In maize seedlings, root growth is not affected by low water potentials which are in another way completely inhibitory to shoot growth (Boyer, 1985). The three varieties may posses' mechanisms of biomass accumulation under water stress conditions. In this study Mai zazzabi exhibits superior adpatation to water deficit in terms of biomass accumulation. Whole plant dry weight significantly declined with moisture deficit. This finding agrees with the results reported by Emmam et al. (2010). Water deficit may have played a role in influencing the increment in height and leaf area per plant which eventually influenced the increase in the shoot dry matter of plants. A reduction of photosynthetic surface by water deficit decreases the ability of plant to produce dry matter.

5.0 CONCLUSION

The present study has revealed the significance of water in rice physiological growth where water deficit has led to a reduction in plant growth and biomass accumulation. Relating to plant growth Mai zazzabi is the most tolerant among the three varieties and can accumulate higher biomass under water stress conditions.

Mai zazzabi can be recommended to farmers as the variety that is tolerant to moisture stresses especially those in the northern part of the country where there is low annual rainfall. And recommend that more research be conducted on rice to come up with improve variety that will be more tolerant and adapted to other environmental conditions not necessarily moisture to increase productivity and yield to meet up with the rapid increase in population growth and demand worldwide.

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