Original Research Article

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

Abstract

Rice the staple food for more than half of the world's population and is now a commodity of strategic significance driven by changing food preference in the urban and rural areas and compounded by increase urbanization (Khalil *et al.,* 2009). Water deficit has been described as the single physiological and ecological factor upon which plant growth and development depends more heavily than other factors (Kramer and Boyer, 1995). A study was conducted to evaluate the effect 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 varieties in the region. There were three treatments of irrigating once in a day (control), irrigating after every two days (mild) and after six days (severe), respectively. The objectives are to determine whether moisture stress has effect on the growth of two local rice landraces and to determine whether moisture stress has effect on the biomass of the local rice landraces. Data collection was done on the following parameters; plant height, number of leaves, root length, stem diameter, and shoot biomass weight. The present study has shown that water deficit leads to a reduction in plant growth and biomass accumulation. In terms of plant growth Mai-zazzabi is the most tolerant among the two varieties and is able to accumulate higher biomass under soil moisture deficit condition.

Key: Rice; Landraces; Water/Moisture deficit

1.0 INTRODUCTION AND BACKGROUND OF THE STUDY

Rice farming is considered as one of the world's most sustainable and productive cropping system, as it is adapted to wide range of environment ranging from tropical low lands to mountains and from deep water swamp to uplands. In general, rice crop is semi aquatic and can thrive well in waterlogged soil and hence its production system relies on ample water supply. Based on the availability of water, rice can be grown in different ecological conditions such as low land rainfed, low land irrigated, deep water and upland (Hafeez *et al.,* 2007). In global scenario, irrigated rice is considered as productive farming system and has accounted for 55 % of total harvested area with a contribution of 75 % of total productivity. Further, annual productivity of irrigated rice is estimated to be 5 % more than that of rainfed rice (Fairhurt & Dobermann, 2002). Meanwhile, resource for irrigation has declined gradually over the past decades due to rapid urbanization and industrialization which exacerbates the problem of water scarcity (Gleick et al., 2002). Current rice production systems rely on ample supply of water and it is estimated that on average rice require 1900 liters of water to produce 1kg of grain (FAOSTAT, 2013).

Water deficit has been described as the single physiological and ecological factor upon which plant growth and development depends more heavily than other factors (Kramer and Boyer, 1995). Any shortage in water supply in relation to the requirement of plants results in water deficit hence plant become stressed. It has been established that water deficit is a very important limiting factor at the initial phase of plant growth and establishment. It affects both elongation and expansion growth (Anjum *et al.,* 2003). Water stress causes deceleration of cell enlargement and thus reduces stem lengths by inhibiting inter nodal elongation and also checks the tillering capacity of plants.

Different developmental stages of rice such as tillering phase, panicle initiation and heading are known to respond differently to moisture stress (Botwright Acuna *et al.,* 2008; Kamoshita *et al.,* 2004), however, factors such as timing, intensity and duration of stress have detrimental effect on plant growth. Liu et al., (2006) reported that reproductive stage, especially during flowering, is more vulnerable to stress and cause spikelet sterility.

Rice requires ample water to grow; rainless days for a week in upland rice growing areas and for about two weeks in shallow lowland rice growing areas can significantly reduce rice yields. Average yield reduction in rain fed, drought prone areas have ranged from 17 – 40 % insecure drought years leading to production losses and food scarcity. With the onset of climate change, the intensity of frequency of droughts, water scarcity affects more than 23 million hectares of rain fed rice production area in South and South West Asia (IPCC, 2007). In Africa, recurring drought affects nearly 80 % of the potential 20 million hectares of rain fed lowland rice (IFPRI, 2010). Increasing crop tolerance to water scarcity would be the most economic approach to improve the productivity and to minimize agricultural use of fresh water resource. Recent studies have shown that plants have evolved various morphological, physiological, biochemical and molecular mechanisms to cope up with adverse climatic effect. To fulfill this objective, a deeper understanding of the possible mechanisms under water stress environment is a must.

Though rice is affected by some environmental conditions such as Temperature, Moisture, pH., Soil type etc. rice plant has shown 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 the effect of moisture 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 situated in the field. 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 located in the Sudan Savannah ecological zone of Nigeria, on latitude 100^0 180E, longitude 110^0 310N, and on an altitude of 218 meters above sea level. The plant was grown on a well-established bed where light, CO_2 concentration and temperature conditions were controlled. 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 soil was dug from the College nursery site field, three beds of two by two meters were established with two replicate 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 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

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

Number of leaves: This was done by counting the 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 an electronic weighing balance.

Dry shoot biomass weight (kg): The shoots were harvested and then placed in paper bags and dried at 80^0C to constant weight in an oven, the shoots were then weighed.

Root length (cm): The plants were 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 placed in paper bags and dried at 80^0C to constant weight in an oven, the roots were then weighed.

3.0 RESULT AND 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 Turkey Pairwise Comparisons.
Results presented are from the fifth week after germination as no significant differences or effects were observed before then on all parameters measured.

There was a general decline in plant height with 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 due to the fact that the plant has developed tolerant mechanism and that's why the growth in height continued. The reduction in plant height with increased water deficit was more pronounced in BG doguwa and NERICA as shown in (figure 1).

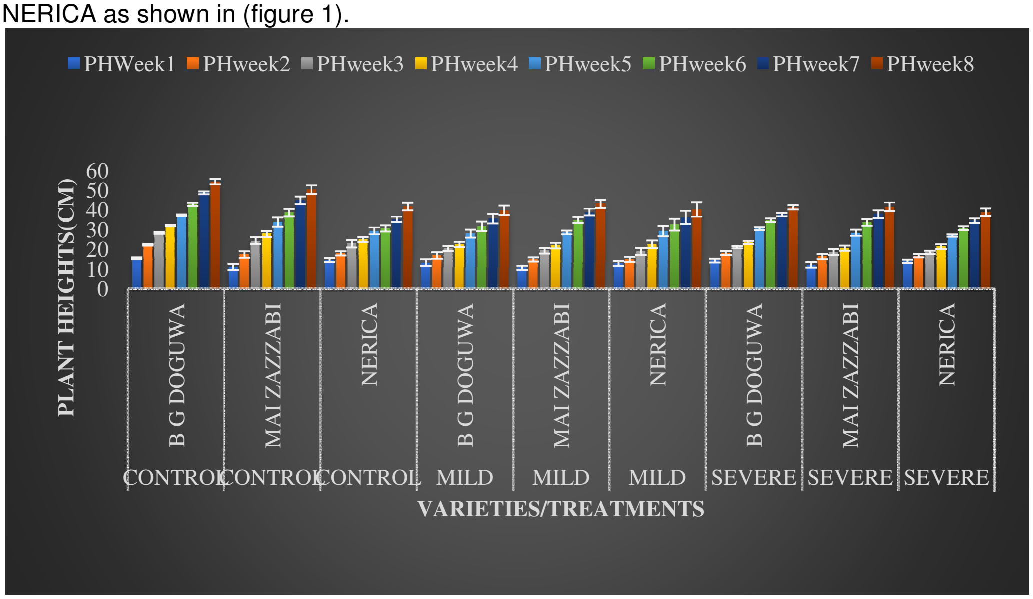

Figure1: Effect of different watering regimes on the plant height of BG doguwa,
Mai zazzabi and NERICA rice land races at week 1 to week 8 (PHWeek1 to PHWeek8). Values are means of two Replications ± Std error.

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

Parameter	Treatment	Varieties	Treatment *Varieties
Plantheight(cm) Week	0.001	0.045	0.107
5	0.007	0.002	0.015
Plantheight(cm) W6	0.000	0.002	0.012
Plantheight(cm) W7	0.000	0.014	0.060
Plantheight(cm) W8	0.000	0.001	0.191
NL W5	0.000	0.000	0.091
NL W6	0.000	0.000	0.054
NL W7	0.000	0.000	0.047
NL W8	0.002	0.014	0.181
Stem diameter(mm^2)	0.027	0.232	0.349
Root length(cm)	0.000	0.001	0.043
Biomass weight(kg)			

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

Table 2: Interaction between Parameters versus Treatment

Parameter	Treatment			P-value
	control	Mild	Severe	
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(g)	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.

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.

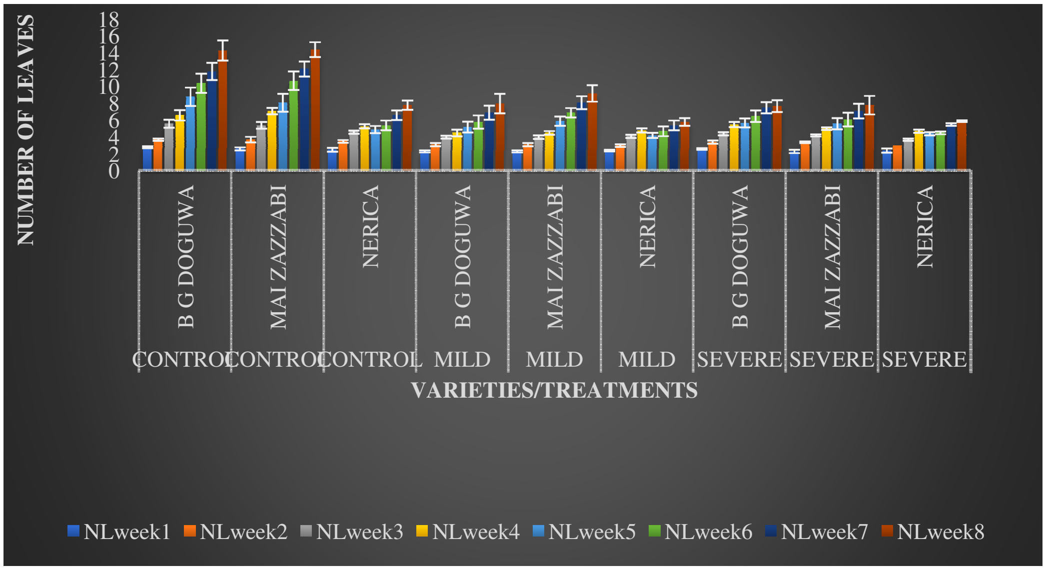

Figure 2: Effect of different watering regimes on the number of leaves of BG doguwa, Mai zazzabi and Nerica rice land races at week 1 to week 8 (NLWeek1 to NLWeek8). Values are means of two Replications ± Std error.

Root length noticeably reduced with 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. There was a reduction in the stem diameter and biomass (kg) with the increase in water deficit (figure 3). Plants that were watered daily (Control) had higher stem diameters(cm) and biomass(kg) accumulation than plants of the other watering regimes.

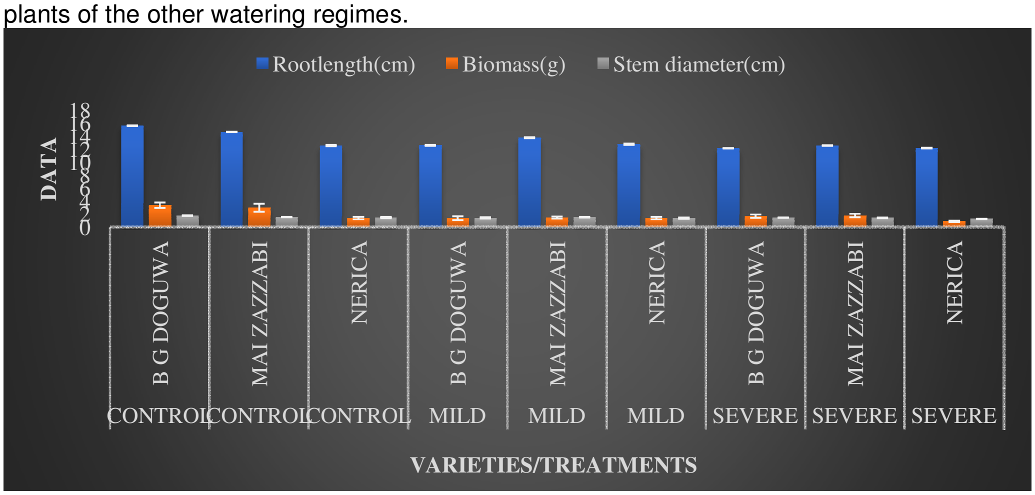

Figure 3: Effect of different watering regimes on the root length(cm), biomass weight(kg) of shoot, and stem diameter(cm) of BG doguwa, Mai zazzabi and Nerica rice land races. Values are means of two Replications ± Std error.

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}±0.21	1.52^{ab}±0.11	1.39^{b}±0.20	0.037
Root length(cm)				
Biomass weight(g)	13.49^{a}±2.81	13.72^{a}±1.56	12.55^{a}±1.70	0.279
	2.17^{a}±1.14	2.10^{a}±1.07	1.23^{b}±0.42	0.015

Key: Means that do not share a letter are significantly different.

4.0 DISCUSSION

The general reduction in plant height with increase in water deficit (Figure-1) in rice agrees with results of Siddique *et al.* (2000) in wheat. Growth involves both cell growth and development which is a process consisting of cell division, cell enlargement and differentiation and these processes are very sensitive to water deficit because of their dependence upon turgor (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 has shown that Mai zazzabi were generally taller than BG doguwa and Nerica at severe moisture deficit 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 shoot plant dry weights decreased with 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 (Sharp and Davies, 1985). This may be an adaptation of Mai zazzabi rice varieties for survival under drought conditions since increased root surface area allows more water to be absorbed from the soil. A reduction in shoot growth coupled with continued root growth would result in an improved plant water status under extreme water deficit conditions. In maize seedlings, root growth continues at very low water potentials which are completely inhibitory to shoot growth (Boyer, 1985). The three varieties may posses' mechanisms of biomass accumulation under moisture deficit conditions. In this study Mai zazzabi exhibits superior tolerance to water deficit in terms of biomass accumulation. Whole plant dry weight significantly declined with moisture deficit. This finding is in agreement with the results reported by Emmam et al. (2010). Water deficit may have influenced the height and leaf area per plant which ultimately influenced 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 shown that water deficit leads to a reduction in plant growth and biomass accumulation. In terms of plant growth Mai zazzabi is the most tolerant among the three varieties and is able to accumulate higher biomass under soil moisture deficit conditions.

Mai zazzabi cane be suggested to farmers as the variety which is more tolerant to moisture stresses especially those in the northern part of the country where there is low annual rainfall. And also recommend that more research should be carried out on rice so as to come up with improve variety that will be more tolerant to other environmental conditions not necessarily moisture so as to increase productivity and yield to meet up with the increasing population growth and demand worldwide.

REFERENCE

Anjum, F., Yaseen, M., Rasul, E., Wahid, A., and Anjum, S. Water stress in barley (*Hordeum vulgare*): Effects on morphological characters. Pakistani Journal of Agricultural Science, 2003; 40:43.

Botwright Acuna,T.L., Lafitte, H.R., & Wade, L.J. Genotype and environment interactions for grain yield of upland rice backcross lines in diverse hydrological environments. Field Crops Research, 2008; 108, 2, 117-125. doi:10.1016/j.fcr.04.003

Boyer J. S. Water transports. Ann. Rev. Plant Physiol. 1985; 36: 473-516.

Emmam, Y., Shekoofa, A., Salehi, F., and Jalali, A.H., Water stress effects on two common bean cultivars with contrasting growth habitats. American- Eurasian Journal of Agriculture and Environmental Science, 2010; 9(5): 495-499.

Fairhurt, T.H., & Dobermann, A. Rice in the global food supply. In: better crops for international Special supplementary, 2002; 37.http://www.ipni.net/ppiweb/bcropint.nsf/$webindex/0E477FFC43BD62DA8525 6BDC00722F62/$file/BCI-RICEp03.pdf

FAOSTAT. (December, 2013) Food security: Global food. 2, URL http://Food-Security-Statistics@FAO.org.

Gleick, P.H., Wolff, E.L & Chalecki, R.R. (2002). The new economy of water: The risks and benefits of globalization and privatization of fresh water: Pacific Institute for studies in Development, environment and Security.Oakland CA., 48pp. ISBN No. 1-893790-07-X.

Hafeez, M.M., Bouman, B.A.M., Van de Giesen, N. and Vlek, P.Scale effects on water use and water productivity in a rice-based irrigation system (UPRIIS) in the Philippines. Agricultural Water Management. 2007; 92, 81–89.

Hossain, M.A. Growth and yield performance of some boro rice cultivars under different soil moisture regimes. M.S. Thesis, Dep. Crop Bot. Bangladesh Agric. Univ., Mymensingh,2001.

IFPRI. What is the irrigation potential for Africa? A combined biophysical and socioeconomic approach. IFPRI, 2010, Discussion Paper 00993. International Food Policy Research Institute, Washington, DC.

IPCC. Climate Change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J. and Hanson, C.E. eds). Cambridge University Press, Cambridge.

Jones B.M. and Lazenby A. The grass crop, the physiological basis of production. Chapman and Hall, London. 1988; pp. 226-240.

Kamoshita, A., Rodriguez, R., Yama auchi, A., & Wade, L. Genotypic variation in response of rainfed lowland to prolonged drought and re-watering. Plant Production Science, 2004; 7, 4, 406-420.

Khalil, H.I., Bari, A. Khan, S. and Zada, I. Genetic variation for yield components in rice. Agricultural and Biological Sciences, 2009; 4(6): 60-64.

Kramer, P.J. and Boyer, J.S. Water relations of plants. Academic Press New York, USA, 1995; Pp 495-496.

Liu, J.X., Liao, D.Q., Oane, R., Estenor, L., Yang, X.E., Li, Z.C., & Bennett, J.Genetic variation in the sensitivity of anther dehiscence to drought stress in rice. Field Crops Research, 2006; 97, 87-100. doi:10.1016/j.fcr.2005.08.019

Luvaha E. The effects of water deficit on the growth of mango (*Mangifera indica*) rootstock seedlings. M.Sc Thesis. Maseno University, Kenya, 2005.

Mwai.G.N. Growth response of spider plant (Cleome gynandra L.) to salinity. M.Sc. Thesis. Maseno University, Kenya, 2001.

Salisbury B. and Ross W. Plant physiology.4th edition, Wadsworth, Belmont, California. 1992; pp. 580-585.

Sharp R.E. and Davies W.J. Root growth and water uptake by maize plants in drying soil.Expt.Bot. 1985; 36: 1441- 1456.

Siddique, M.R., Hamid, A. Islam, M. Drought stress effects on water relations of wheat. Plant Physiology, 2000; 41: 35-39.

Willumsen J. Assessment of fluctuations in water and air content of pot substrates during plant growth. Acta.Hort. 1993; 295: 249-259.