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Effects of Climate on Growth of Rice (*Oriza sativa*) in Greater Yola

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I. Introduction

Climate is a critical factor influencing production of crops and other human activities in any region. Generally, there are many physical factors influencing crop production because they are often human related factors and these include soil, relief, climate and diseases among others but climate is the most important (Adebayo, 2010). In relation to climate, rainfall is the dominant controlling variable in tropical agriculture since it supplies soil moisture for crops and grasses for animals. David and Mark (2007) reported that climate is fundamental to crop growth. They stated that, moisture and temperature stimulates seed to germinate and the time emergence and that, the rate of growth of roots stems and leaves depend on the rate of photosynthesis which in turn depends on Sun light, temperature, moisture and carbon dioxide (CO_2). They again stated that, temperature and day length determine when plant produce leaves, stems and flowers, and consequently the filling of grain or the expansion of fruits. The yield of grain crops depend on the grain number and grain weight at harvest which in turn depend on climatic factors. Climatic factors also influence farmer's behaviors, growth and yields of a crop, incidence of pests and diseases and water needs. Thus, there is no aspect of crop culture that is devoid of the effect of climate.

Rice (*Oryza sativa*) production is not spared from the effect of climatic factors, as climatic elements can also lead to change in its production. For example, Gumm (2010) noted that, Production of rice, will be thwarted as temperatures increase in rice-growing areas, He further stated that, unforeseen changes associated with temperature, relative humidity and rainfall are expected to affect rice production negatively leading to low yield of the crop. Ramirez (2010) stated that, increase in temperature, due to climate variability, adversely affects rice crop physiology and decreased crop yield and grain quality.

In Nigeria, rice is one of the major crops cultivated within the nation, which clearly showed that, change in its production as a result of climatic factors will affect its general production in the nation (Akinbile, 2010). Cultivation of rice is also being affected by the impact of climate in various locations in Nigeria. For example, Ogbuence (2010) stated that, climatic variability such as rainfall and temperatures are major threat to rice growth which leads to drop in quantity and quality of rice in Ebonyi State. He further stated that heavy rainfall and flood pose a serious impact on development of the early rice in the study area.

So far, from the research reports on rice production in the major rice producing area, there is an indication that climate has detrimental effects. This assertion therefore informs the need to carry out a study to examine the effect of climate on rice production in Yola, Adamawa State.

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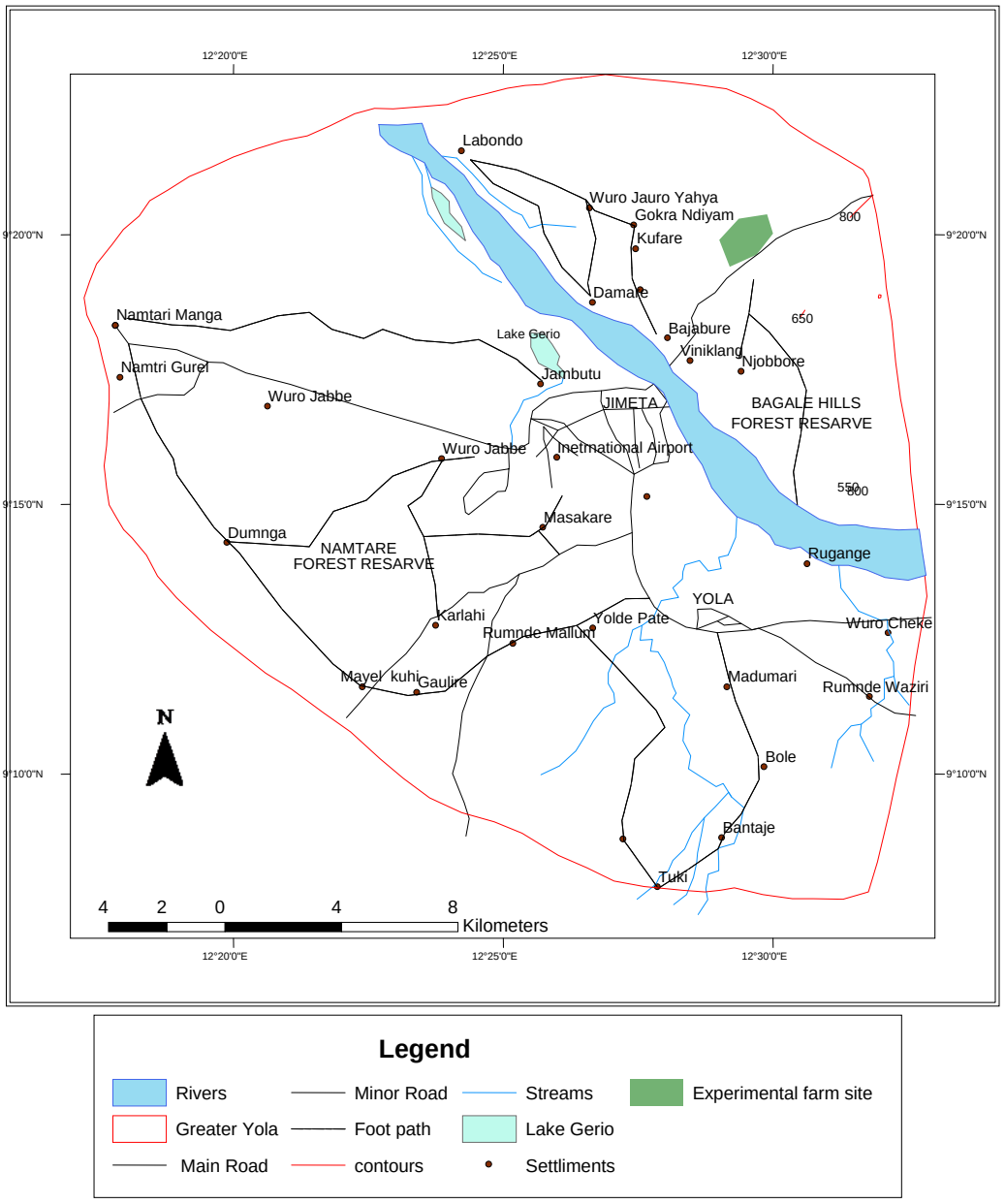
a) The Study Area

Greater Yola lies between latitudes 9^0 07^1 to 9^0 23^1 N and longitudes 12^0 17^1 to 12^0 33^1 E. (Gongola Urban Areas Designation Order 1985 and Yola Topographical Sheet 48/48A, 1974). Generally, greater Yola is bounded to the south and east by Fufore, West by Demsa and North by Song, Local Government Areas. Greater Yola covers the expanse of three Local Government area; Yola North, Yola South, and Girei LGA. The Experimental farm site is located in Sangere village, Girei LGA; it is located on Latitude 9^0 $11^{'}$ $15^{''}$ N and longitude 12^0 $20^{'}$ $29^{''}$E. The settlement is situated along the Yola-Maiduguri highway and share border with Modibbo Adama University of Technology (formerly Federal University of Technology Yola), to the East and is about 4km away from Girei town, the Girei Local Government headquarter.

The climate of greater Yola area exhibits typical tropical climate (Adebayo, 1999; Zemba, 2010). The study area has average sunshine hours of about 7-8 hours daily and the wind speed average of 76.1Km/hr. It has monthly mean sunshine hours of about 220 hours from January to April. This decrease to a mean value of 207 hours between May and September due to increases in cloud cover during the rainy season. The mean sunshine hours increase again to about 255 hours between October and December. The average sunshine hours for the year as a whole stand at about 2750 approximately (Adebayo, 1999). The air temperature in the state as a whole is a typical West African Savannah Climate. Temperature in this region is generally high throughout the year. Yola has a seasonal change in temperature, from January – April; the temperature increase is because of the clearer sky view which permits the reception of solar radiation. The maximum temperature is 43^0C which occur in April and the minimum temperature is 18^0C between December and January. There is a distinct drop in temperature at the onset of rains due to the effects of cloud cover. The temperature decreases at the beginning of the raining season to the end which is as a result of the cloud effect. The temperature again increases after the cessation of the season (October - November) before the arrival of harmattan which leads to drop in temperature (Adebayo, 1999).

Greater Yola has two distinct seasons- the rainy and dry season. The rainy season runs from the months of May through October, while the dry season commences in November and ends in April/May. The average annual rainfall is put at about 960mm with the highest occurrence in August and September. In fact, in the past few years, the highest occurrence of the rainfall has shifted to September, as opposed to August previously. The wind direction in the area is characterized by northeast and westerly winds. The northeast trade winds bring harmattan from the north during November to March through the influence of tropical continental air mass while the influence of tropical maritime air mass from the south brings about rains during the period of May to October. Evaporation is generally high in the area due to high insulation. The monthly distribution pattern is similar to that of sunshine and temperature, which shows significant decline during the rainy season. A record of evaporation in Yola shows that, the minimum value of about 2.5ml occurs in August while the highest value is in March (about15ml) (Adebayo,1999; Zemba,2010).



Source: Ministry of Land and Survey, Yola, 2001

Figure 1: Study Area Showing the Experimental farm site

II. Method of Data Collection

The Randomized Complete Block Design (RCBD) method was applied in plot design; the three selected varieties were planted and replicated three times on each plot at the onset of the season. The intra and inter spacing of the crop were equal in all the plots. The total size of the plot used was 10 x 10 meters which was divided into nine (9) separate plots with each variety replicated three times. The nine plots were spaced 0.5m apart (path way) from each other and were all sized 3x3 meters squared. The outside margin was spaced 1m away from the main plot and was planted with the corresponding variety of crop close to it so as to prevent the crop from animal interruption.

The method of rice farm management was uniformly applied to the farm throughout the growing season; the land was clear, thick bush were removed by hoe and cutlass while small debris and weed were left to be incorporated as manure. The land was plough by a tractor and then harrowed two weeks after ploughing to allow the weed to die; it was manually leveled for easy and uniform seed germination, growing and erosion control. Bund was constructed to accumulate water and to allow good drainage for plant growth. Three different varieties of rice were selected for the experiment, Nerica L20, FARO 44 and china as V_1, V_2, and V_3 respectively which were obtained from Adamawa State Agricultural Development Program (AADP) and Upper Benue River Basin Development Authority (UBRBDA) Gerio farm site.

The selection of the varieties was based on the fact that they were the common varieties of rice cultivated in the study area and the state in general, they also have maturity period that ranges from 90-130days (WARDA, 2005). Planting was done by dibbling of five seeds at a depth of 3cm for easy germination. Thinning was conducted at two stand of plant per hill after three weeks of planting, and spaced 20 x 20cm apart which gives a total plant density of 50 plants per m^2; this is to allow good weed control and adequate supply of solar radiation in between the plants. The first weeding was done two weeks after establishment followed by the first split of fertilizer (NPK 15:15:15) application. Second weeding was done four weeks after the first weeding followed by the second split of fertilizer (Urea) application for good yield.

Daily weather data were collected from Modibbo Adama University of Technology Yola, meteorological station throughout the growing season from June – October, 2014. Data on rice growth were collected from the selected rice varieties planted in the experimental farm site at seven (7) days interval throughout the growing season of the crop. Data on plant height, length of leaf, numbers of panicles, numbers of tillers, numbers of spikelet, yield per plot, weight of rice per plot, and total yield were measured to determine the growth and yield of the crop. All growth measurement was obtained from fifteen (15) randomly selected rice plants from each plot and was tagged for easy identification.

Both descriptive and inferential statistics were performed. The descriptive statistics involved the use of tables, percentage simple mean and graphs, while the inferential statistics are; Analysis of Variance (ANOVA), Correlation, Regression analysis (Stepwise regressions) and. Analysis of Variance (ANOVA) was used to test the variation in growth and yield of the three selected varieties of rice. The correlation analysis was used to test the relationship between climatic elements and Growth, and yield of rice at different developmental stages. To identify the climatic elements that influence rice yield, Stepwise regression analysis was employed; total yield of rice was expressed as dependent variable (Y) and climatic parameters as independent variables (X).

III. Results and Discussion

The climatic pattern as shown in Table 1 revealed that, during the growing season, rainfall increase as the month move toward August but letter drops in September and October. The high amount of rainfall was experience in the month of August; this is in line with the Nigerian rainfall distribution pattern in which rainfall has single maxima in the Northern part of the country. This result implies that, rice growth will have good productivity within that period. Maximum and Minimum temperature, sunshine hours and radiation shows an inverse relationship with rainfall, this is because all these parameters normally decrease as rainfall increases because of rain producing cloud during the rainy season which reflect much of the insulation from reaching the ground surface. Maximum and Minimum temperature decreases as the month moved toward August because of rainfall amount but letter increase as it move toward October. Sunshine hour and Solar Radiation also show a similar pattern of movement with Minimum and maximum temperature, their amount decreases as the month moved toward August and decreases after August, moving toward October. This also revealed the impact of rainfall on them in which they have inverse relationship. Relative humidity is the only climatic parameter that shows a direct relationship with rainfall in which as rainfall increase, Relative Humidity amount also increase.

Table 1: Mean Climatic Data for the Growing Period

	Rainfall	maximum temperature	minimum temperature	relative humidity	sunshine hours	Radiation
June	114.1	32.8	25.52	94.00	6.91	15.18
July	124.6	31.14	24.92	94.13	6.82	13.7
August	129.5	29.48	23.79	94.68	3.17	11.68
September	123.7	31.33	24.38	93.1	4.81	14.18
October	17.1	32.00	22.77	93.77	5.67	17.27

Source; Field Study, 2014.

IV. Variation in Rice Growth Parameter

In this aspect, variation in growth parameters of the selected varieties of rice was examined and presented in tables according to the parameters observed.

a) Variation in plant height

Table 2 shows the variation in plant height of the selected varieties at weekly basis after plant establishment. The result indicated that, plant height at Week 1, week 2, week 4 and week 5 varies significantly

within the three selected varieties of rice at P = 0.05 while week 3 and week 5 has no significant variation. In week 1 and week 2, V_2 and V_3 has no significant variation between them but varies significantly with V_1, while in week 4, V_2 and V_3 showed a significant variation between them where as V_1 shows no significant variation with V_2 and V_3. The mean result of variance in Table 2 shows that. V_1 and V_2 has the highest performance at week 1, week 2, and week 3 while, V_3 has the highest performance at week 4 and week 5. This result shows that V_1 and V_2 responded to climatic elements faster and positively than V_3 at the first three weeks but at week 4 and 5, V_3 reacted faster than the two varieties (V_1 and V_2), and the reason for this variation may be either genotype variation or respond to soil type .

b) Variation in plant leaves length

Variation in plant leave length as it responded to climatic variables is represented in Table 3 The result indicate that, all the selected varieties of rice varies significantly at P= 0.05 at week 1, week 2, week 4 and week 5 while week 3 shows no significant variation in leave length within the selected variety of rice. There is no significant variation between V_1 and V_3 but V_2 varies significant from V_1 and V_3 in both week 1 and week 2. V_2 and V_3 show no significant variation between them at week 4 and week 5 but vary significantly with V_1. The mean performance of the selected varieties as shown on Table 3 indicated that V_2 has the highest performance than V_1 and V_3 which clearly mean that V_2

c) Variation in culm diameter of rice

Variation in Culm diameter of the selected varieties of rice was displayed in Table 4. The result obtained showed that, there is no significant variation within and between the three selected varieties of rice in all the weeks of observation, this result indicated that, Culm diameter of the selected varieties of rice responded the same to the climatic variables in their development in the study area.

Table 2 : Mean Variation in Plant Height (cm) of three varieties of rice.

Treatment	Week 1	Week 2	Week 3	Week 4	Week 5
Variety 1	24.233a	43.533a	49.933a	69.467ab	72.467a
Variety 2	19.933b	35.867b	52.167a	62.967b	67.100a
Variety 3	18.667b	33.633b	46.800a	73.033a	75.967a
Mean	20.944	37.677	49.633	64.488	71.844
Probability level	0.037*	0.038*	0.134ns	0.049*	0.208ns

Source: Field Study, 2014.

Note; Means with the same letters (a or b or c) are not significantly different
**Variation is significant at 0.05, **Variation is significant at 0.01*
Ns= Not Significant Variation.

Table 3: Mean Variation in Leave Length (cm) of three varieties of rice.

Treatment	Week 1	Week 2	Week 3	Week 4	Week 5
Variety 1	8.067b	14.533b	21.100a	25.467b	27.100b
Variety 2	11.200a	20.167a	23.000a	32.033a	33.333a
Variety 3	7.867b	14.133b	19.733a	30.867a	32.100a
Mean	9.044	16.278	21.278	29.456	30.844
Probability level	0.036*	0.036*	0.114ns	0.037*	0.025*

Source: Field work, 2014.

Note; Means with the same letters (a or b or c) are not significantly different
**Variation is significant at 0.05, **Variation is significant at 0.01*
Ns= Not Significant Variation.

Table 4: Variation in Mean Performance on Culm Diameter (cm) of three varieties of rice.

Treatment	Week 1	Week 2	Week 3	Week 4	Week 5
Variety 1	0.107a	0.193a	0.273a	0.330a	0.053a
Variety 2	0.117a	0.213a	0.247a	0.343a	0.036a
Variety 3	0.100a	0.180a	0.247a	0.387a	0.407a
Mean	0.108	0.196	0.256	0.353	0.373
Probability level	0.299ns	0.299ns	0.552ns	0.328ns	0.384ns

Source: Field work, 2014.

Note; Means with the same letters (a or b or c) are not significantly different
**Variation is significant at 0.05*
***Variation is significant at 0.01*
Ns= Not Significant Variation.

V. Relationships Between Climatic Factors and Growth and Yield of Rice

Correlation between climatic factors and rice at different developmental stages was observed to see the significant of the relationship.

a) Effect of climate at planting to emergence of rice

At planting to emergence, only Rainfall shows a positive relationship of 0.483, minimum temperature and sunshine hours showed a highly negative relationship at P=0.05 as well as relative humidity at P=0.01. The positive relationship of rainfall and rice at emergence means that, rainfall amount support germination and emergence of rice and any deficiency of rainfall at that stage will affect rice development negatively.

b) Effect of climate at vegetative stage of rice

Vegetative stage is another developmental stage of rice in which climatic contribution is very important because it is at this stage that a variety is to be determined whether it has, short, medium or long term growing circle. In Table 5 the result clearly showed that rainfall and sunshine hours have highly positive significant relationship at P=0.05 with rice. Radiation also showed a highly significant positive relationship at P=0.01 with rice, whereas maximum temperature, minimum temperature and relative humidity shows a negative relationship on rice at this stage. This implies that, rainfall, sunshine hours and radiation supply are vary sufficient for rice development at vegetative stage and that, any decrease in their supply will affect rice production negatively which may lead to low yield of the crop, but increase in their supply will favor development of rice at this stage. The negative relationship of maximum temperature, minimum temperature and relative humidity showed that their supply for rice development at this level is not favorable, and any increase in their supply will affect rice production negatively at vegetative stage. Plant at vegetative is displayed on plate III.

Table 5: Correlation between Climatic Elements and Rice at Different Developmental Stages

	Rainfall	maximum temperature	minimum temperature	relative humidity	sunshine hours	radiation
Planting to emergence	0.482	-0.572	-0.750*	-0.868**	-0.673*	-0.195
Vegetative	0.899**	-0.007	-0.112	-0.375	0.804**	0.680*
Reproductive	0.731*	0.670*	0.519	0.770*	0.634	0.628
Ripening	0.731*	0.333	0.497	-0.025	0.517	0.877**

Source: Field Study, 2014.

**correlation is significant at 0.05*
***correlation is significant at 0.01*

c) Effect of climate at reproductive stage of rice

Reproductive stage of rice is another climate sensitive phase that determined the total yield of rice. Result displayed on Table 5 showed that all the climatic parameters have a positive relationship with rice development. Rainfall, Maximum temperature and Relative humidity displayed a highly positive relationship with rice at P=0.05. Minimum temperature, sunshine hours and radiation also showed a positive correlation of 0.519, 0.634 and 0.628 respectively. The positive relationship of all the climatic parameters at this level indicated that, the entire climatic elements amount are sufficient for rice development at reproductive stage and it will positively affect heading and flowering of rice as indicated by (Yan et al 2010). Plate I showed the Vegetative, Reproductive and Maturity stages of rice in the study area.

Plate III: Vegetative, Reproductive and Maturity Stages of Rice.

Plate II: Taking record at maturity stage of rice

d) Effect of climate at ripening stage of rice

Ripping stage is the last or final stage of rice development and is not spared from the impact of climatic elements. The result in Table 5 clearly shows that Rainfall has a highly positive significant relationship with rice at P = 0.01 as well as radiation at P=0.05. Maximum temperature, Minimum temperature and solar radiation are other climatic parameter that shows positive relationship with rice development at this stage while relative humidity is the only climatic parameters that showed a negative relationship with rice development which means relative humidity amount at this level is not favorable to support rice development as increase in it supply will negatively affect rice production at maturity stage. Plate V showed the ripening/maturity stage of rice in the study area.

Generally, the result on Table 5 indicated that only rainfall showed a highly positive significant relationship with rice at each developmental stage which implies that Rainfall is the most vital in all the development stages of rice in the study area, it also signified that, any deficiency in it supply, will affect rice development negatively as also viewed by (Wetherald, 1991).

VI. Conclusion

High amount of rainfall in the study area during the growing period was experience in the month of August, Maximum temperature Minimum temperature, sunshine hours and radiation has an inverse relationship with rainfall. The three varieties of rice vary significantly in height within them but show no variation in Culm diameter. Rainfall is has a positive relationship in all the stages of rice. While minimum and maximum temperature and relative humidity showed a negative relationship at planting to emergence and vegetative stage. Sunshine hour and radiation are has a positive relationship with rice at reproductive and ripening stage.

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