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GROWTH AND YIELD OF OKRA UNDER SPRINKLER IRRIGATION SYSTEM IN OWO, SOUTH-WESTERN NIGERIA

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ABSTRACT

The growth and yield of okra under sprinkler irrigation system was investigated at Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria during the 2016/2017 dry season period. The aim of the study was to characterize the effect of sprinkler irrigation on yield and yield components of okra as well as its water use efficiency. Okra seeds were planted and subjected to two regimes of treatment, that is, full irrigation and no/zero irrigation (control). Water was applied to the plants by using over-head tank gravity sprinkler irrigation system. Rainfall was measured using rainguage and soil moisture content was obtained using gravimetric method twice weekly. Height, stem and number of leaves were determined on weekly basis using a -2 meter rule, Vernier calliper and physical counting of stem and leaf, respectively. In addition the biomass yield was obtained on dry matter basis. The coefficient of determination (R^2) for plots of plant leaves against height were 0.9671 and 0.9122 for treatment and control, respectively, while the total biomass yield were 2423.24 kg/ha and 822.17 kg/ha for treatment and control, respectively. Furthermore, water use efficiency of 1.28 kg/m^3 was obtained for the entire growing period for full and control irrigation respectively. This preliminary results suggest that sprinkler irrigation can lead to increase productivity of okra and is, therefore, recommended for supplemental irrigation of okra, particularly in Owo, and in the sub-humid south-western Nigeria.

Keyword: Sprinkler Irritation, Growth, Yield, Yield Components, Water Use

INTRODUCTION

Efficient use of irrigation water is becoming increasingly important (Jayapiratha et al., 2010) and alternative water application methods such as drip and sprinkler, may contribute substantially to the best use of water for agriculture and improving irrigation efficiency. Moreover, recent increase in competition for water amongst the various sectors of the world economy requires that each sector should make a prudent use of the water available. This is more so considering the challenges posed by the recent global warming to the world and, more importantly, in the African region which has been predicted to face the most critical negatives impacts of climate change (Callaway, 2004; IPCC, 2007; Konyeha and Alatise, 2013). However, the extent of water shortage or scarcity varies around the world (Oloruntade, 2017); the cost of energy required to make water available for agriculture and particularly for irrigation purposes is generally high and could be escalating (Konyeha and Alatise, 2013). In this regard, operators of any irrigation systems must ensure that there is high return on the capital invested. Thus for this to be achieved, irrigation water application should take cognizance of the need to secure maximum output for each drop of water in terms of crop yield.

Allen et al. (1998) observed that appropriate innovations are needed to improve water efficiency of available water while Panigrahi et al. (2011) stated that the financial return per every drop of irrigation water should be enhanced while considering the best water use efficiency (WUE) associated with any crop. Okra *(Abelmoschus esculentum L.)* is an annual herb and vegetable crop grown throughout the tropical and subtropical parts of the world either as a sole crop or intercrop with maize or any other crop (Emuh et al., 2006). The crop is said to have been originated in Asia and Africa

(Absar and Siddique, 1992). Global okra cultivation covers an area of 0.78 million hectare from which an output of about 4.99 million MT and average yield of 6.39 t/ha are obtained yearly (Thanavendan and Jeyarani, 2009). Okra plays an important role in human diet by supplying carbohydrate, protein, fats, minerals and vitamins that are usually deficient in most staple foods. Besides the consumption of the fresh pods as boiled vegetable, its dried form is used as soup thickener or in stew (Yadev and Dhankhar, 2002). The green fruits are rich sources of vitamins, calcium, potassium, and other minerals (Lee et al., 2000). Therefore, the nutritional importance of okra pod has reawakened interest in bringing the crop into commercial production.

Despite the nutritional value of okra, its optimum yields (2-3 t/ha) and quality have not been attained in most tropical countries partly because of declining soil fertility. Okra plant requires warm temperatures and unable to tolerate low temperature for long time or tolerate any threat of frosts. The optimum temperatures are in the range of 21-30 °C, with maximum temperatures of 180 °C and minimum of 35 °C. Okra is a high water crop use despite having considerable drought resistance. The plant forms a deeply penetrating tap root with dense shallow feeder root reaching out in all directions in the upper 0.45 m of soil. For high yields, an adequate water supply during the growing period in general has a beneficial effect on yield and the greatest reduction in yields occurs when there is a continuous water shortage until the time of first picking. The period is most sensitive to water shortage and soil water depletion in the root zone during this period should not exceed 25%. Water shortage just prior and during this period is greater under conditions of high temperature and low humidity. Nevertheless, controlled irrigation is essential for high yields because the crop is sensitive to both over and under irrigation (Al-Harbi et al., 2008).

In Nigeria, okra is also widely cultivated throughout the country either as a sole crop or in mixed cropping system probably as a results of its high adaptability to different soil types and general acceptability for use as vegetable in soups. Iremiren and Okiy (1999), stated that okra is one of the foremost vegetable crops in terms of consumption and production area in Nigeria. Additionally, production and marketing of okra provide means of livelihood to farmers and many produce sellers, respectively in Nigeria. This, therefore, underscores the importance of the crop in the country. Despite the foregoing, okra is majorly cultivated under rain-fed conditions in Nigeria amongst farmers and occasionally with the aid of the traditional method of water application using the watering can. However, this has really put limit to its yearly output since production is mostly restricted to the raining season. Sasani et al (2004) stated that water stress is usually the main physical limitation to yield and growth of vegetables.

In view of the foregoing, there is the need to embark on irrigation to provide water especially during off-seasons, in order to increase the output of okra in Nigeria through all-year-round production. However, application of water through irrigation systems should be managed to prevent wastage and ensure maximum output. Aiyelaagbe and Ogbonnaya (1996) had reported that excessive or sub-optimum irrigation can both have detrimental effects on productivity parameters of okra. Although the use of water balance techniques in combination with the analysis of historical climate data (Phene et al., 1992) has been recommended for irrigation scheduling, it was further stated that the question of when to irrigate can be approached in three broad ways – the use of plant indicators, soil indicators and water balance techniques. In addition, measurements of yield and water use efficiency provide veritable data on the response of okra to irrigation water application. Hence, the aim of the present study is to investigate the growth and yield response of okra to water application using sprinkler irrigation system in Owo, South-western Nigeria

MATERIALS AND METHODS

Study Location

The study was carried out at the Demonstration Farm site of Agricultural and Bio-Environmental Engineering Department, Rufus Giwa Polytechnic Owo, Ondo State, Nigeria. It lies between longitude 5°.18′ west and latitude 7°.13′ north, South-Western Nigeria. The climate is within the tropical humid with two discernible seasons (Dry and Wet season). It is relatively dry from November to March and wet from April to October with annual rainfall range of 140 mm – 240 mm of which raining season accounts for about 65 % and the month of April signals the commencement of rainfall. The source of water used for the experiment is a hand-dug well located within the Demonstration Farm; the well is circular in shape, 15 m deep and diameter 1 m. Before planting, necessary land preparation operations were performed on the plots. Okra seeds were planted at equal distance of 30 by 60 cm at both plots during the day, and 10.2 cm apart at depth of 1.3 cm one per point. The okra seeds were soaked overnight before planting to make the germination process quicker. Weeding was done manually using hoe and cutlass in both plots throughout the study, while the moisture content of the soil was measured by gravimetric method using the formula:

$$\theta = \frac{(W_2 - W_3)}{(W_3 - W_1)} \times 100$$

Agronomic Measurement

The agronomic data of okra plant which include the plant height were measured and recorded on weekly basis using meter rule, calliper for the stem diameter, while both the branch and leave numbers were obtained by counting (see plate 1, 2 and 3, respectively). Water supplying to the treatment site using the sprinkler irrigation system was achieved with the aid of sprinklermounted riser pipes laid in a triangular shape at the spacing of 2.5 – 5.0 m covering about 14.40 m diameter at 360° rotation. Water was supplied to the farm under uniform pressure discharge which ranged from 154 to 163 m^2, while irrigation was carried out once daily in the evening. Rainfalls were measured during the periods of the experiment with the aid of rain gauge on every rainfall. Pests and diseases controls were carried out using appropriate agro-chemicals. The fruits of okra were picked every three-day at the sites and weighed at fresh, then oven dried at temperature of 60 °C for 24 hours, and then re-weighed and the values were recorded.

Plate 1: Planting of okra seed

Plate 2: Growth of okra 15 days after planting (DAP)

Plate 3: Mature okra ready for harvested

RESULTS AND DISCUSSION

Morphological Development of Okra

Plant Height

The okra plant germinated 9 days of planting (DAP), having two leaves with a very thin stem in both the treatment and control plots, after which irrigation commenced. There was a significant difference in the height of okra plant in both plots (Fig. 1). For instance, at 14 DAP plant height was 11 mm and 8 mm for treatment and control, respectively and at 35 DAP, it was 185 mm, 125 mm for treatment and control, respectively and at 61 DAP it was 370 mm, 290 mm for treatment and control, respectively. However, in the treatment plot the height of the okra plant was higher compared to that of control, thus indicating a positive response of okra to sprinkler irrigation (Fig. 1).

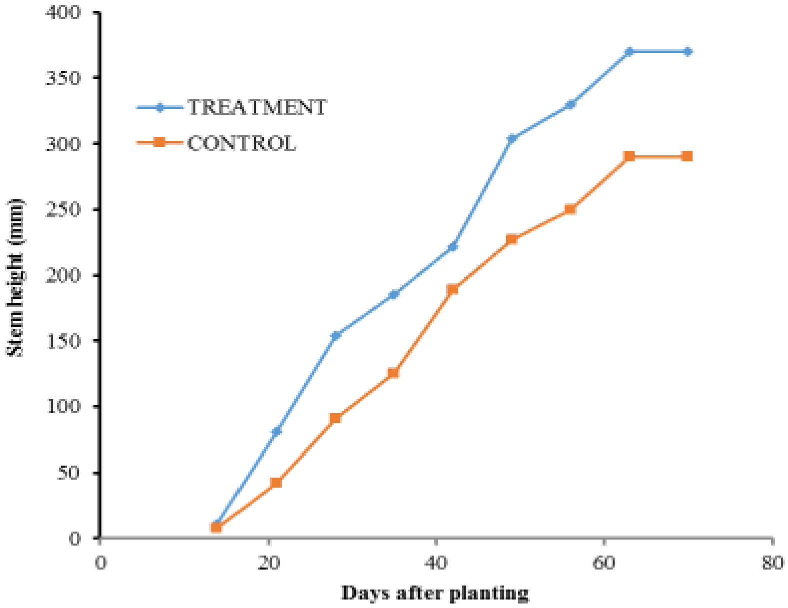

Fig 1: Graph of stem height days after planting (DAP)

Stem Diameter

There was a significant increase in the stem diameter of okra DAP in the treatment plot as compared to the control (Fig. 2). For example, at 14 DAP, the stem diameter was 0.81 mm and 0.72 mm; at 35 DAP, the diameter was 9.25 mm and 5.72 mm, and at 49 DAP, it was 16.31 mm and 13.4 mm for the treatment and control plots, respectively. However, the maximum stem diameter was 23.21 mm, 17.45 mm for treatment and control plot, respectively after 70 days. This also shows a positive response of okra to water application, especially sprinkler irrigation system, since plant diameter was higher throughout the period of growth in the treatment plot compared to the control (Fig 2).

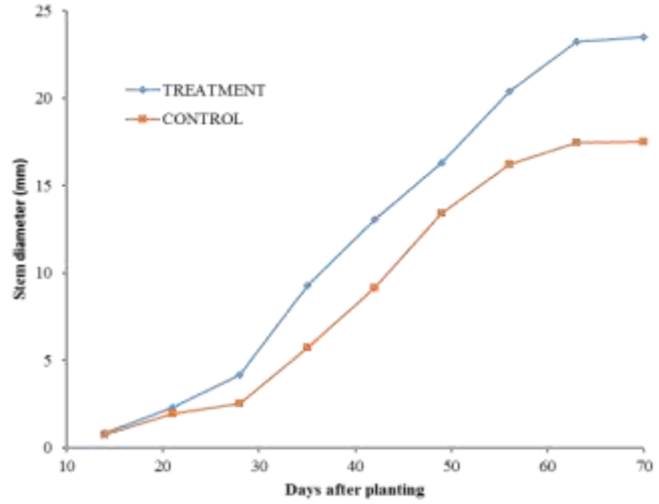

Fig 2: Graph of stem diameter days after planting (DAP)

Branch Number

There were also significant differences in the branch number of okra plant in the control and treatment plots (Fig. 3). As can be seen, during the first 28 DAP, the branch number was zero at both plots, but at 35 DAP, the branch number was 2 for the treatment and zero for the control plots, respectively. In addition, at 42 DAP, the branch number was 4 and 2 for treatment and control plots, respectively, and at 61 DAP, it was 5 and 3 for treatment and control, respectively, thus indicating a significant response of okra to water application through sprinkler irrigation system in the treatment plot.

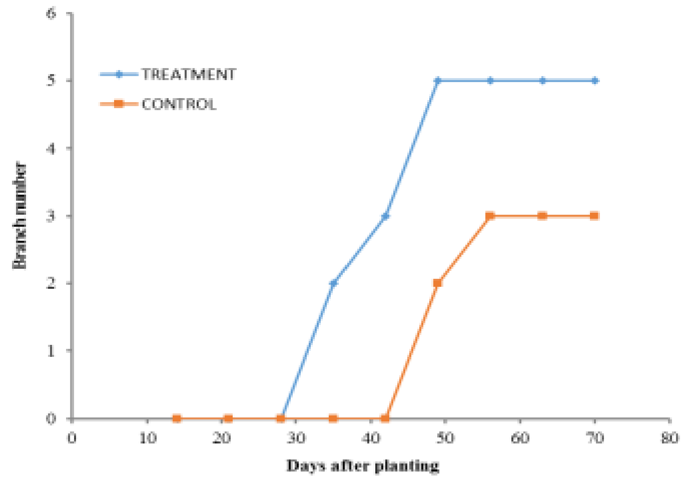

Fig 3: Graph of number of branch days after planting (DAP)

Number of Leaf

There was again significant variability in the number of leaf between the treatment and control plots (Fig. 4). Similar to the previous scenarios, at 14 DAP, the number of leaf was 2 at both plots, but at 35 DAP, there was difference in the number of leaf in both plots, 10 in treatment and 8 for control, respectively. Moreover, at 61 DAP, it was 24 and 15 for the treatment and control plots, respectively, also implying the positive response of okra to irrigation by sprinkler method.

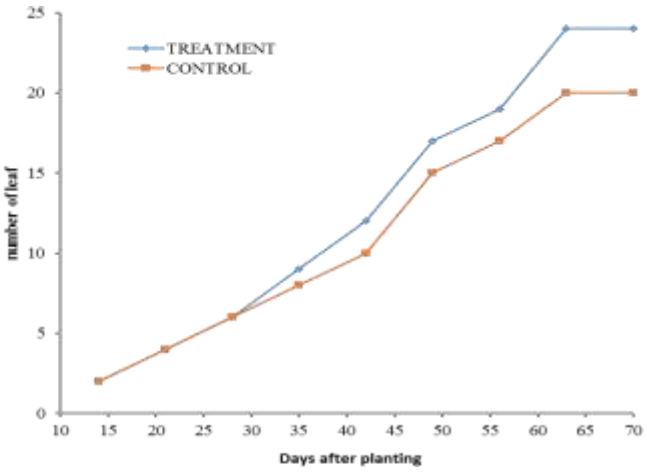

Fig 4: Graph of number of leaf of okra days after planting (DAP)

Statistical Comparisons of Physiological Features of Okra

Stem diameter and number of leaf

A scatter plot of stem diameter and number of leaf under sprinkler irrigation treatment returned a coefficient of determination R^2 of 0.9854 (Fig. 5a). On the other hand, a similar graph plotted to compare the relationship between stem diameter and leaf number under zero irrigation treatment gave a coefficient of determination R^2 of 0.9814 (Fig. 5b). This indicates that under irrigation, there is greater proportionate growth between stem diameter and number of leaf in okra, which can enhance photosynthesis and other metabolic activities and, hence, leads to increased yield.

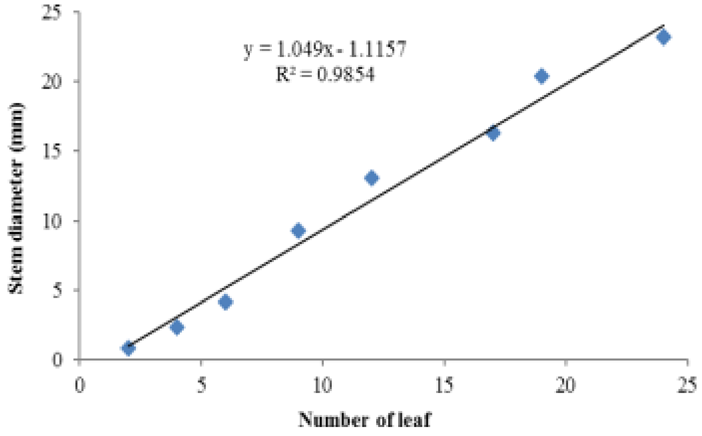

Fig. 5a: Graph of change in number of leaf with stem diameter for treatment plot

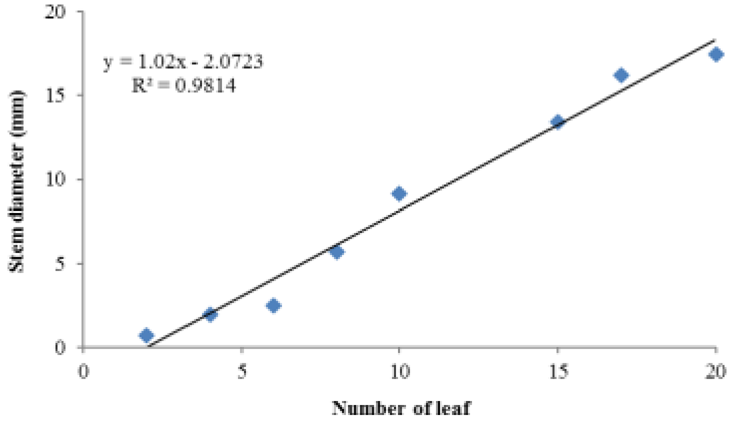

Fig. 5b: Graph of change in number of leaf with stem diameter for control plot

Plant Height and Leaf Number

Just like in the previous case, a scatter plot of the relationship between plant height and number of leaf under sprinkler irrigation treatment also gave a coefficient of determination (R^2) of 0.9671 (Fig. 6a). For the control (zero irrigation), similar graph comparing the relationship between plant height and number of leaf returned a coefficient of determination (R^2) of 0.9546 (Fig. 6b). These results suggest that water application using sprinkler irrigation techniques can positively affect the vegetative growth of okra which can lead to higher number fruits.

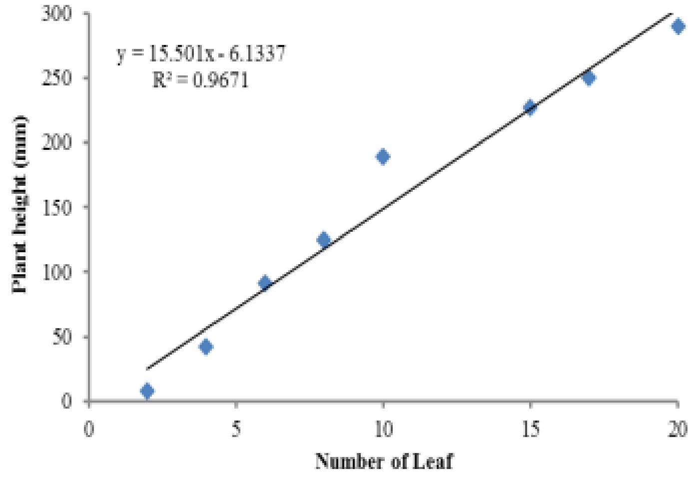

Fig. 6a: Graph of change in plant height with number of leaf in treatment plot

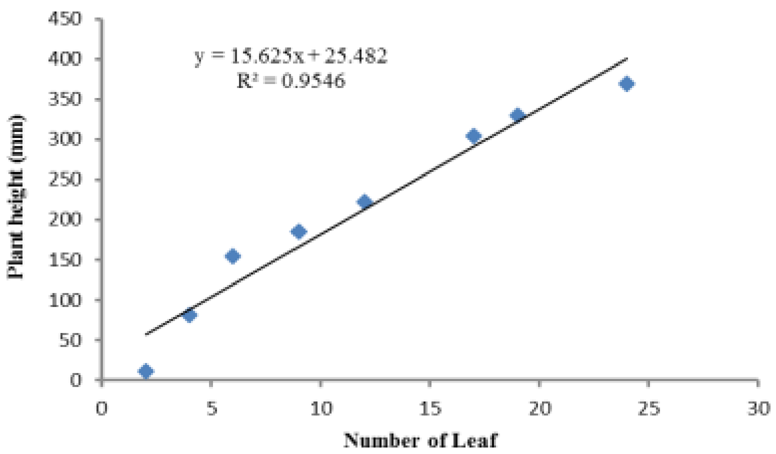

Fig. 6b: Graph of change in plant height with number of leaf in the control plot

Number of Branch and Leaf

In this same vein, the relationship between number of branch and number of leaf was evaluated for both the treatment and control plots. For the treatment plot, the coefficient of determination R^2 was 0.9122 (Fig. 7a), while, similar scatter plot comparing the relationship between stem diameter and number of leaf under zero irrigation (control) resulted in R^2 of 0.8472 (Fig. 7b). Given the higher value of R^2 for the treatment plot, it can also be inferred that irrigation water application can lead to greater number of branches in okra, which may invariably lead to increased plant yield.

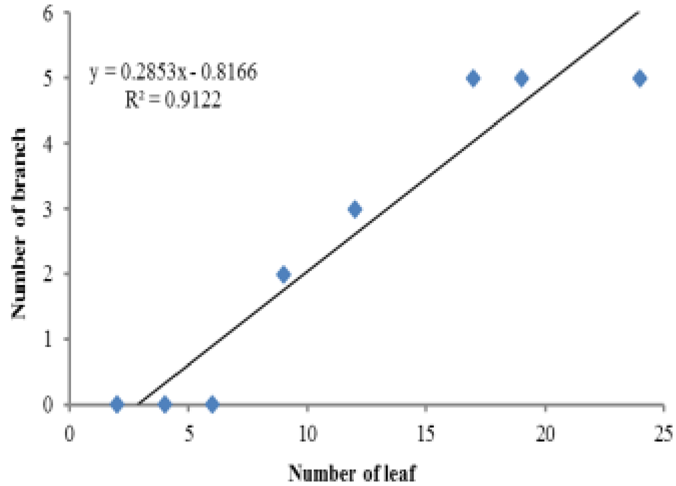

Fig. 7a: The graph of change in branch number with number of leave in irrigated plot

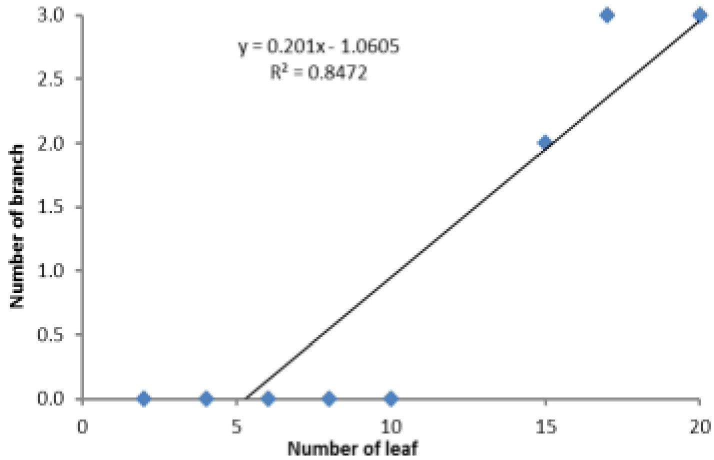

Fig. 7a: Graph of change in number of branch with number of leaf in control plot

Okra Yield and Water Use

There was a significant difference between the yield of okra in the treatment plot and the control plot (Fig. 8). For instance, at 41 DAP the yield of okra was 6.24 kg for the treatment plot, while it was 2.2 kg in the control. Similarly, at 43 DAP, the yield was 11.3 kg and 3.4 kg, respectively for the treatment and control plots, and at 45 DAP, the yield was 13.7 kg and 4.7 kg which was the highest yield in both plots, respectively. Moreover, the water use efficiency of okra in the present study was also computed as 1.284 kg/m. According to Calvache and Reichardt (1999), water deficit during vegetative growth leads to decline in yield. The results of this study agree with the findings of Kurunç and Ûnlükara (2009**)** who reported increased yield of okra with increasing irrigation water application.

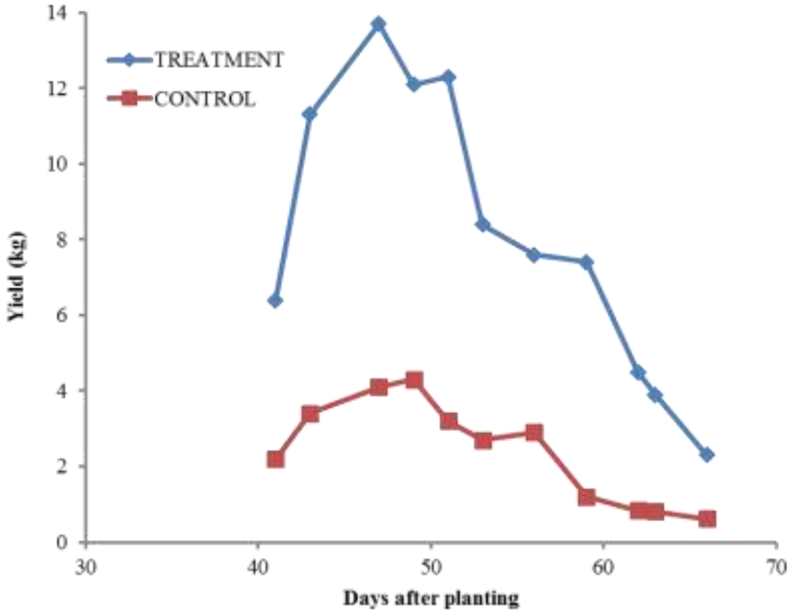

Fig. 8: Graph of Yield in Treatment and Control Plots Days after Planting (DAP)

CONCLUSION AND RECOMMENDATION

The growth and yield of okra under sprinkler irrigation was investigated in a sub-humid climate, South-western Nigeria. The results of the study show that okra responds favourably well to irrigation water application, especially using sprinkler method, considering the higher performance of the okra under treatment as compared to the control plot. This observation can be due to the fact that crops grown under irrigation has adequate moisture accumulation in the root zone to help cover evapotranspiration and other biochemical requirements. Hence, we conclude that, for improved yield of okra especially during the off-season, irrigation water application using sprinkler system should be adopted.

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BIOGRAPHY

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