Journal of Agripreneurship and Sustainable Development (JASD)
www.jasd.daee.atbu.edu.ng; Volume 2, Number 2, 2019
ISSN (Print): 2651-6144; ISSN (Online): 2651-6365

EVALUATION OF THE EFFECTS OF DEFICIT IRRIGATION ON WATER USE EFFICIENCY AND CUCUMBER GROWTH UNDER GREENHOUSE MANAGEMENT, NIGERIA

[1]Shani, B. B. and [2]Musa, A.
[1]Department of Crop Science, Faculty of Agricultural Sciences,
National Open University of Nigeria, Kaduna, Nigeria.
[2]Department of Soil Science, Faculty of Agricultural Sciences,
National Open University of Nigeria, Kaduna, Nigeria.
Corresponding Authors' E-mail: bshani@noun.edu.ng. **Tel.:** +234(0)8054404423

ABSTRACT
Water use efficiency (WUE) increment and reduction in amount of irrigation are important role played by deficit irrigation. Deficit irrigation is a well-accepted practice to optimize increase water use, thereby saving cost, by allowing crops to withstand mild water stress with no or only marginal decreases in yield and quality. Greenhouse experiments were conducted using a deficit irrigation program on cucumber crops under drip irrigation during 2018–2019 growing season, to determine the crop water requirements in greenhouse and WUE of cucumber crop using a deficit irrigation program at different stages of growth. Irrigation treatments consisted of 12 levels of ETc (20%-100%), deficit irrigation tested at different growth stages (initial, mid and late stage of growth) for a total of 12 treatments at each experiment. The maximum amount of water applied to the crop was 455 mm for the 20% ETc treatment while the minimum water applied was 247 mm for 100% ETc treatment. The ETc ranges between 223 and 407 mm for the different treatments. The results indicated that, cucumber could stand a shortage of water during the growth and water use efficiency (WUE) and water productivity (WP) values increased when water amounts decreased; these values decreased to 45.6 and 24 kg/m3, respectively. Water resource management under water scarcity bring about different policies aim at reducing the non-beneficial water uses, particularly those corresponding to water consumption and to the non-reusable fraction of the diverted water.

Keywords: Crop Response Factor, Drip Irrigation, Deficit Irrigation, Water Use Efficiency, Water Productivity.

INTRODUCTION
Water limitation and further decline in water resources coupled with population growth which gave rise to demand for water in agriculture and other sectors has forced farmers and policy regulators to change their irrigation practices and water management for measures to conserve water in irrigation. In Nigeria, both farmers and governmental agencies start changing the irrigation strategies from an open field to greenhouse using surface and subsurface drip irrigation.

One of important method to save irrigation water and increase WUE is deficit irrigation (DI) (Agele *et al.*, 2011). If crops have certain phenological phases in which they are tolerant to water stress, DI can increase the ratio of yield over crop water consumption (evapotranspiration) by either reducing the water loss by unproductive evaporation, and/or by increasing the proportion of marketable yield to the totally produced biomass (harvest index), and/or by increasing the proportion of total biomass production to transpiration due to hardening of the crop, although this effect is very limited due to the conservative relation between biomass production and crop transpiration, and/or due to adequate fertilizer application and/or by avoiding bad agronomic conditions during crop growth, such as water logging in the root zone, pests and diseases (Agele *et al.*, 2011).

Crop water productivity (WP) or water use efficiency (WUE) expressed in kg/m³ is an efficiency term, expressing the amount of marketable product (e.g., kilograms of grain) in relation to the amount of input needed to produce that output (cubic meters of water). The water used for crop production is referred to as crop evapotranspiration. This is a combination of water lost by evaporation from the soil surface and transpiration by the plant, occurring simultaneously. Except by modeling, distinguishing between the two processes is difficult. Representative values of WUE for cereals at field level, expressed with evapotranspiration in the denominator, can vary between 0.10 and 4 kg/m3 (Amer *et al.,* 2009).

The adoption of deficit irrigation required the knowledge of crop evapotranspiration (ETc), crop response to water deficit, critical stages of growth under water deficit and economic impacts of yield reduction. Agele *et al.* (2011) concluded that seasonal crop ET values were greater during reproduction growth stage in the crop. Amer *et al.* (2009) concluded that the cucumber yields significantly decreased in linear relationship with increasing water deficit. However, no significant changed when water applied above 100% ETc. Mao *et al.* (2003) and Alomran and Luki (2012) studied the effect of deficit irrigation on yield and water use of greenhouse grown cucumber in China and Saudi Arabia showed that, WUE decrease with increasing irrigation water application from stem, fruiting to the end respectively.

The deficit irrigation strategy has received very little attention in agricultural sector in Nigeria (Amer *et al.,* 2009), therefore; the main objectives of this study was to determine the effect of deficit irrigation on cucumber fruit, and water use efficiency under greenhouse drip irrigation system in Nigeria conditions.

MATERIALS AND METHODS

Greenhouse experiments were carried out at the greenhouse complex of National Open University of Nigeria (NOUN) Farm, 4km off Kaduna- Zaria expressway, Rigachikun, Kaduna State, in the northern Guinea savannah zone of Nigeria (altitude: 722 m above sea level, latitude 10.6321° N, and longitude 7.4706° E, from February to June 2019 for a total of 12 experiments. The cucumber greenhouse as well as the picture of the cucumber growing in the NOUN greenhouse is presented in Figure 1 and Figure 2.

Figure 1: *Researcher conducting study in NOUN cucumber greenhouse*

Figure 2*: Picture of the cucumber growing in the NOUN greenhouse*

The Soil salinity was determined before the trial set and at the end of the crop cycle, each 30-50 cm depth at the root level. Selected properties of the soil and irrigation water were determined by standard procedure as described by FAO (2008), that is, on guide to laboratory establishment for plant nutrient analysis.

The pH and CaCO3 of the soil were 7.9, and 18%, however sand% and clay% were 84% and 10%, respectively. The layout of the experiment was completely randomized design with four replicates. The irrigation treatments consisted of ten level of ETc in addition to the traditional farmers drip irrigation. At 60% and 80% treatments, the deficits irrigation was tested for different growth stages (initial, mid and late growth stage) for total of 12 treatments at each run of experiment. The main irrigation line was 63 mm and the sub irrigation lines were 16 mm in diameter; the length of sub irrigation lines was 70 m for each line and emitters built at 0.3m spacing with a distance of 0.75m between rows. Furthermore, gauges were installed for measuring the amount of applied water for each treatment.

RESULTS AND DISCUSSION

Effect of Deficit Irrigation on Water Use Efficiency

The concept of water use efficiency (WUE) and water productivity (WP) represent the productivity of water related to yield. From the results of Table 1, the T4-45 treatment was found to be the best treatment in terms of yield and water productivity, these values were 15.2 kg/m2 and 64.8 kg/m3 (Table 1); Moreover, decreasing irrigation water to 45% ET caused very high-water productivity however decreases the final yield. Generally, the water use efficiency (WUE) and water productivity (WP) values increased when water amount decreased, these decreased values were 84.0 and 71.9 kg/m3, and 58.9 and 52.3 kg/m3 for WUE and WP in T12 and T1 treatments, respectively, similar results were obtained by Oweis and Hachum (2004) and Zhang *et al.* (2004).

Table 1: Results of Deficit Irrigation Treatments at Different Growth Stages of Cucumber as Affected by Certain Parameters

Deficit irrigation treatment (%)	Average days per season	Yield (kg m-2	ETc (Mm)	AW (Mm)	AW (Mm day-1)	WUE (kg m-3)	WP (kg m-3)
T1-20	108	16.0	407	455	4.3	58.9	52.3
T2-35	108	14.8	345	383	3.6	66.3	58.8
T3-40	108	14.2	356	395	3.7	61.6	54.7
T4-45	108	10.1 g	223	247	2.4	84	71.9
T5-50	108	15.6	369	409	3.9	64.3	57.2
T6-60	108	14.5	360	400	3.8	61.9	55
T7-65	108	12.4	284	313	3	72	63.5
T8-75	108	15.2	359	399	3.8	64.8	67.5
T9-80	108	13.4	310	343	3.3	69	61
T10-85	108	13.7	332	367	3.5	64.7	57.6
T11-90	108	12.5	313	346	3.3	64	56.7
T12-100	108	10.1	223	247	2.4	64	71.9

Effect of Deficit Irrigation on Cucumber Growth Stages

The results of cucumber yield for different deficit irrigation treatments (Table 1) indicated that the highest yield was obtained in the treatment T1-20 (16.0 kg/m3) and the lowest yield was in the treatment T12-100 (10.1 kg/m3). A polynomial function was fitted between (Y) and (AW) for the season under review (Fig. 3) with an r^2 value of 0.963 and indicated also of a well correlated index. According to the mathematical analysis of the crop water production function (CWPF), the predicted maximum yields were 19.49 and the corresponding calculated applied water was 600 for the dry. The result collaborated with the ones obtained by Zhang and Oweis (1999) and Mao *et al.* (2003).

In this study, treatment T1-20 had the highest yield and treatments T3, 4, 5, 6-and T12-100 gave fairly good marketable yield with economically saving water, fertilizers and pesticide. The result also indicated that the water productivity (WP) increased with decrease in the amount of applied water, the WP were 52.3 and 71.9 kgm-3 for T1-20 and T12-100, respectively. Even though lack of irrigation as in treatments T12-100 led to very high-water productivity however it also led to poor quantity and quality of yield (Figure 3).

Figure 3: *Cucumber being harvested*

Relationship between Total Cucumber Yield and Applied Water

The results in Figure 4 indicated that, the deficit irrigation at 75% of ETc was more efficient in saving irrigation water with a good marketable yield compare to traditional irrigation and 100% ETc. In addition, the deficit drip irrigation is beneficial for the farmers because it reduces the cost of water and prevents a loss of crop yield (for certain crops) later on in the growing season due to drought. It is also a well-accepted practice to optimize increase water use, thereby saving cost, by allowing crops to withstand mild water stress with no or only marginal decreases in yield and quality.

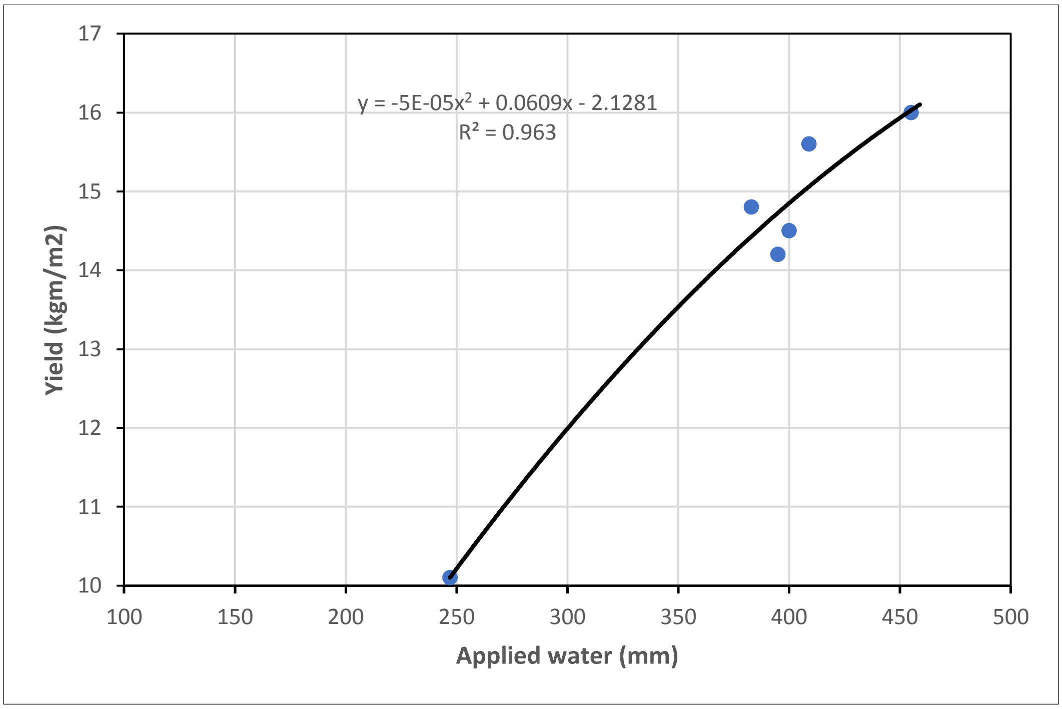

Figure 4: *The relationship between total cucumber yield and applied water*

CONCLUSION AND RECOMMENDATIONS

Water resource management under water scarcity brings about different policies. Generally, water management policies aim at reducing the non-beneficial water uses, particularly those corresponding to water consumption and to the non-reusable fraction of the diverted water. However, fully exploring these concepts, mainly for farmers at field scales, requires appropriate procedures to be developed. Reduced water demand can be achieved by adopting improved farm, irrigation systems and deficit irrigation. Climate change, water supply limits and continued population growth have intensified the search for measures to conserve water in irrigated agriculture, the world's largest water user. The study recommends policy measures that encourage adoption of water-conserving irrigation technologies are widely believed to make more water available for cities and the environment.

COMPETING INTEREST STATEMENT AND AUTHOR'S CONTRIBUTION

All the Authors declare that they have no competing interest. In terms of the authors' contributions, Dr. B. B. Shani conceived and designed the study while Dr. B. B. Shani and A. Musa conducted the experiment and performed the data analysis. Dr. B. B. Shani also wrote the manuscript. Finally, all the authors read and approved the final manuscript for publication.

ACKNOWLEDGEMENTS

This study was conducted without funding. Authors are thankful to Prof. Grace Jokthan, the Dean of Faculty of Agricultural Sciences, Umar Ringim, the Farm Manager and all the technical staff, National Open University of Nigeria, involved in this research, for their interest, skills and rousing guidance during this study.

REFERENCES

Agele, S. O., Iremiren, G. O. and Ojeniyi, S. O. (2011). Evapotranspiration, Water use efficiency and yield of rainfed and irrigated tomato. *Int. J. Agric. Biol.,* **13**: 469–476.

Alomran. A. M and Luki, I. I. (2012). Sustainable Irrigation and Drainage IV. *WIT Transactions on Ecology and the Environment,* **168**: 353-357.

Amer, K. H, Sally, A. M., and Jerry, L. H. (2009). Effect of Deficit Irrigation and Fertilization on Cucumber. *Agronomy Journal,* **101**: 1556–1564.

Mao, X., Liu, M., Wang, X., Hou, C. Z. and Shi, J. (2003). Effects of deficit irrigation on yield and water use of greenhouse grown cucumber in the North China Plain. *Agricultural Water Management,* **61**(3): 219-228. Doi:10.1016/S0378-3774(03)00022-2.

Oweis, T. and Hachum, A. (2004). *Water harvesting and supplemental irrigation for improved water productivity of dry farming system in west Asia and North Africa.* Proceeding of the 4th Int. Crop Sci. Congress, held at Brisbane, on the theme "Crop Science for Diversified planet". PP. 246-256.

Zhang, Y., Kendy, E., Qiang, Y., Changming, L., Yanjun, S. and Hongyong, S. (2004). Effect of soil water deficit on evapotranspiration, crop yield, and water use efficiency in the North China Plain. Agric. *Water Manag*ement, **64**:107-122.

Zhang, H. and Oweis, T. (1999). Water-yield relations and optimal irrigation scheduling of wheat in the Mediterranean region. *Agricultural Water Management,* **38**: 195-211.