The Effects of Different Watering Levels on the Physiology of Two Varieties of Tomato (Lycopersicon esculentum Mill.) in Nigeria

*M. T. V. Adeleke C. W. Minimah
Department of Plant Science and Biotechnology, Rivers State University,
Nkpolu-Oroworukwo, Port-Harcourt, Nigeria

Abstract
A greenhouse experiment was conducted to ascertain the effects of different watering levels on the physiology of two varieties of tomato cultivated in different parts of Nigeria. The *Beske* (round) variety cultivated in Kajola and the Hausa (oblong) variety cultivated in *Sokoto*. These varieties were planted, using Randomized Complete Block Design, on the same day and given different watering regimes in intervals of: one, two, four, six and eight days respectively. Plant height and leaf area were used to determine the physiological effect of this treatment. Analysis of variance was used to analyze the data collected $_{\alpha=0.05}$. Results show that the *Besk*e variety adapted more to all the watering regimes, whether much or little with no significant difference ($p>0.05$) between treatments. The *Sokoto* variety on the other hand showed significant difference in the plant height and leaf area between treatments ($p<0.05$). There was no growth at all in the Every Day Watering (EDW) treatment.
Keywords: Tomato, variety, watering, greenhouse.

1. Introduction

Tomato is among the vegetable crops cultivated worldwide with great nutritional value. There are a lot of tomato cultivars, and they vary a great deal in size, shape, colour, pulp content and growth requirement. They are also adapted to a wide range of climate (Ghanem, *et al*., 2009). In Nigeria, eco-geographical differences have been used to determine the distribution of diversity in tomato crop (Ezekiel, *et al,* 2011). Different tomato cultivars from different parts of the country are available in the markets at different seasons and times of the year. Tomato varieties produced at the peak of the dry season usually contain more pulp/puree and less water. Worthy of note is the cultivar known as "iron seed", "UTC" or "Derica" which is produced by irrigation during the dry season, compared to the variety available in the peak of the rains which has more of water than pulp content.

Tomato is a highly perishable crop which has gained wide use in every Nigerian home. In tomato production Nigeria is the fourth in Africa and leads in West Africa sub region with an estimated output of 1.10 metric tonnes and average yield of 10 tonnes ha−1 (Isah, et al., 2014). Nevertheless, over 80% of tomato consumption comes from processed products such as tomato paste. It has become obvious that depending on natural climatic conditions for the production of tomato would not be sufficient in meeting up with consumption demand of the teaming population of the nation.

In developed countries, crops like tomato are grown under controlled environments in large green houses. Here, appropriate watering and day lengths, amongst others, can be simulated for all-year-round production of disease-free cultivars that have good pulp content and big size.

This study is therefore to ascertain the optimum watering levels for two tomato varieties in the green house.

2. Materials and method

The experiment was carried out in the green house of the Department of Applied and environmental Biology, Rivers State University of Science and Technology, Port Harcourt.

Two different tomatoes varieties: *Beske* variety cultivated in Kajola and the Hausa variety cultivated in Sokoto, were gotten from the "fruit garden" market in Port Harcourt.

The Hausa variety cultivated in Sokoto is enlongated in morphology, and is not fully red in colour when ripe; some parts are yellowish and the content has much water and less pulp. This variety is grown during the wet season.

The Tiwantiwa variety cultivated in Kajola also known as Beske variety, is round in structure, dark red in colour and contains more pulp. This variety can be grown during the wet season and can also survive during the dry season with some considerations.

The tomato seeds were separated from the pulp and air-dried at room temperature.

Soil was collected from a farming site in the Rivers State University of Science and Technology environment. A sample of the soil used was analysed. The soil was bagged in 3kg capacity polyethylene planting bags. A total of 30 planting bags were used, 15 bags for each variety. Each planting bag was watered with 100ml of water and the seeds were planted 2cm deep in each bag.

The experiment was a Randomized Complete Block (Gomez and Gomez, 1983) design involving two varieties and five treatments. The five treatments are:

Everyday watering (EDW);

Every two days watering (E2DW);
Every four days watering (E4DW);
Every six days watering (E6DW); and
Every eight days watering (E8DW).
Germination counts were made and measurements taken of plant height and leaf area over time.

2.1 Physical & chemical properties of experiment soil

pH	P Phosphorus (mg/kg)	Ca^{2+} Calcium (mol/kg)	K potassium (mol/kg)	% N Nitrogen	% Total Organic carbon	% Sand	% Silt	% Clay	Soil Classification
6.5	8.30	2.51	0.45	0.295	0.84	81	8.5	10.5	SANDY/LOAM

3. Result

Germination was observed on the fourth day in at least one bag per treatment of *Beske* variety, but only in the E4DW and E8DW treatments of the *Sokoto* variety. There was no growth whatsoever observed in the EDW treatment of the *Sokoto* variety.

The E4DW treatment gave the highest plant height values in both varieties (Figs 1 and 2). This was clearly so for the Sokoto variety all through the growing period in this experiment; and it was followed closely by E6DW, then E2DW, and lastly E8DW which was the poorest in plant height (Fig. 1). The E2DW treatment however had the lowest leaf area index in Sokoto variety, while E4DW remained the highest (Fig. 3) followed by E6DW, then E8DW.

While no growth was observed in EDW with Sokoto variety, Beske variety on the other hand had greater plant height values initially, but it started falling behind from the fourth week after planting (WAP) and ended up as the least by 6WAP (Fig. 2). The same pattern was observed with the leaf area index in Beske with EDW treatment (Fig. 4)

The plant height and leaf area of the Sokoto variety are significantly different across treatments (Table 1 and 3), but those of Beske variety are not (Table 2 and 4).

4. Discussion

Many irrigation experiments have revealed that tomato is sensitive to moisture stress (Hayrettin, et al., 2014). The most important consideration in tomato watering is consistency (Bonnie and Oregon, 2015; Tya and Othman, 2014). Of all the watering regimes, the E4DW treatment gave the highest growth values both in plant height and leaf area in the 2 varieties (Fig. 1-4), and this is significant for *Sokoto* variety (Table 1 and 3). Ibrahim et al. (2012) arrived at similar results and recommended irrigation intervals of four and six days intervals because they produced seeds of greater vigour. Tomato requires a constant supply of moisture during the growing season, according to Bennett (2012), but excess water will lead to root death in anaerobic soil conditions. No wonder that under the same soil conditions, no growth was observed in all the replications of the EDW treatment of the *Sokoto* variety. There was however growth in all the treatments of the *Beske* variety, but not significantly different in plant height and leaf area between treatments. This could mean that this variety could be cultivated across a wider rainfall zone than the Sokoto variety. This implies therefore that tomato varieties vary in water requirement across ecological zones (Ibrahim et al., 2012). The production of commercial tomato is influenced by both genetic and environmental factors such as soil, climate, water and crop management (Hayrettin, et al.,2014). Among the environmental factors, soil water and inorganic nutrition are the most limiting factors in the production and quality of tomatoes. Irrigation scheduling is a crucial factor in tomato cultivation when soil moisture is limited.

A director of dams and reservoir operations in Nigeria (Essiet, 2015) has noted that irrigation farming is more productive than rain-fed farming because it is usually regulated and more focused. For instance, water stress treatment at some point increased fruit quality traits such as: flavor, total soluble solids, titratable acidity, vitamin C and total sugars (Bonnie and Oregon, 2015; Abdel et al., 2016; Yang et al., 2017).

With climate change, the weather is becoming increasingly harsh as weather patterns are shifting. Today, farms have been embracing large scale commercial greenhouse farming for about four years now (Yusuf, 2016). Though initially this is quite an expensive venture, it produces tomato all-year round; and each greenhouse can last for about 15 years. Furthermore, in the wake of dwindling water availability in arid and semi-arid areas like Sokoto and Ethiopia, it becomes imperative to maximize crop yield per unit of water *(Birhanu and Tilahun, 2010).*

5. Conclusion

Tomato is an important vegetable crop that needs to be more available all year round. Great care and much attention should be given to the atmosphere in which each variety is cultivated, as they differ significantly in their water requirement. Since the best tomato varieties from northern Nigerian, which have a lot of pulp, are produced in the peak of the dry seasons by irrigation, regulating irrigation intervals to once in every 4 to 6 days under greenhouse conditions should optimize the performance of the plants.

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Test of hypothesis

Table 1: Plant Height for *Sokoto* variety-Tests of Between-Subjects Effect

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1502.488[a]	7	214.641	16.431	.000
Intercept	3626.125	1	3626.125	277.584	.000
Block	515.730	3	171.910	13.160	.000
Treatment	986.758	4	246.689	18.884	.000
Error	156.758	12	13.063		
Total	5285.370	20			
Corrected Total	1659.246	19			

a. R Squared = .906 (Adjusted R Squared = .850)

Table 2: Plant Height for *Beske* variety- Tests of Between-Subjects Effect

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	948.806[a]	7	135.544	14.334	.000
Intercept	9526.612	1	9526.612	1007.476	.000
Treatment	46.665	4	11.666	1.234	.348
Block	902.142	3	300.714	31.802	.000
Error	113.471	12	9.456		
Total	10588.890	20			
Corrected Total	1062.278	19			

a. R Squared = .893 (Adjusted R Squared = .831)

Table 3: Leaf Area for *Sokoto* variety-Tests of Between-Subjects Effects

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	65299.850[a]	7	9328.550	7.826	.001
Intercept	68328.050	1	68328.050	57.326	.000
Treatment	19467.700	4	4866.925	4.083	.026
Block	45832.150	3	15277.383	12.817	.000
Error	14303.100	12	1191.925		
Total	147931.000	20			
Corrected Total	79602.950	19			

a. R Squared = .820 (Adjusted R Squared = .716)

Table 4: Leaf Area for *Beske* variety-Tests of Between-Subjects Effects

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	33298.096[a]	7	4756.871	36.521	.000
Intercept	53251.200	1	53251.200	408.832	.000
Block	31738.496	3	10579.499	81.223	.000
Treatment	1559.600	4	389.900	2.993	.063
Error	1563.024	12	130.252		
Total	88112.320	20			
Corrected Total	34861.120	19			

a. R Squared = .955 (Adjusted R Squared = .929)

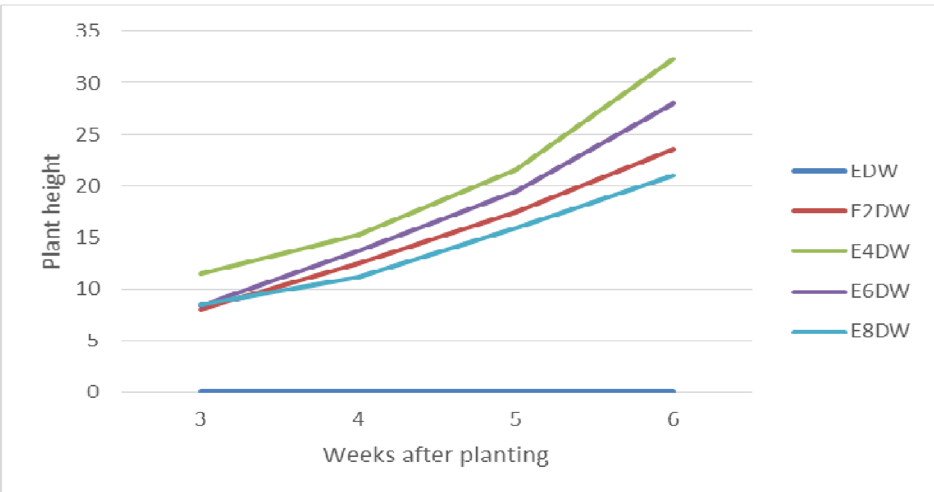

Figure 1: Plant height of *Sokoto* variety

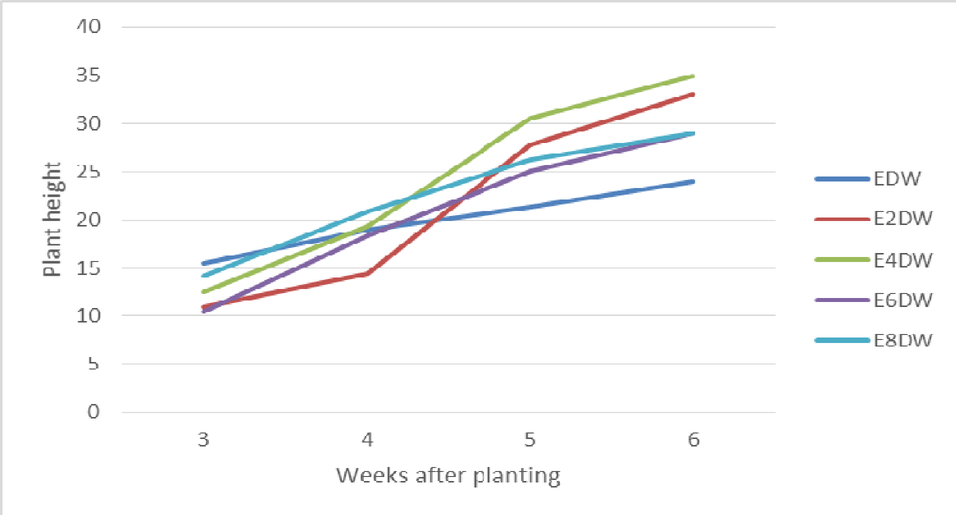

Figure 2: Plant height of *Beske* variety

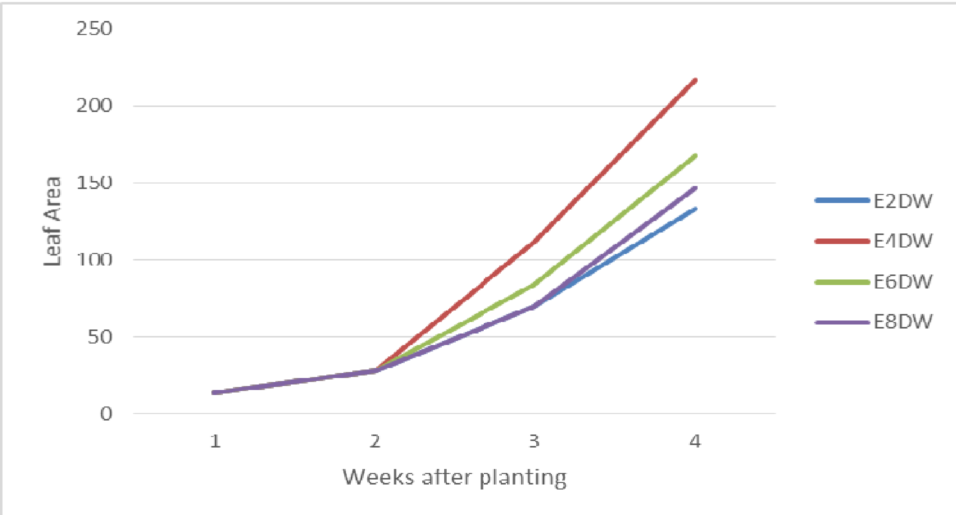

Figure 3: Leaf Area of *Sokoto* variety

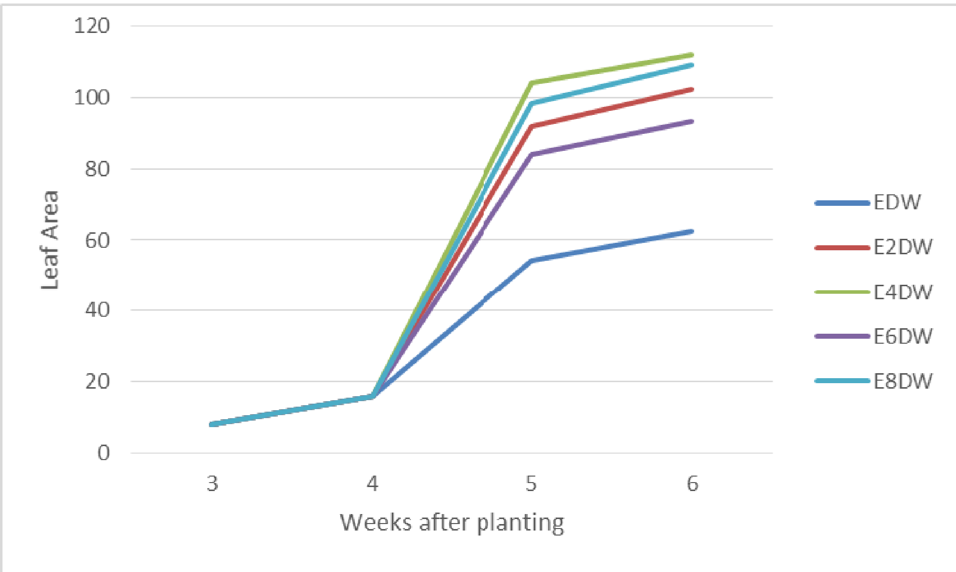

Figure 4: Leaf Area of *Beske* variety

Plate 1: *Sokoto* variety *Beske* variety