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Research Article
Effect of Watering Regimes on Early Seedling Growth of *Solanum macrocarpon* L. (Solanaceae)

Damilola Grace Ogunrotimi and Joshua Kayode

Department of Plant Science and Biotechnology, Faculty of Science, Ekiti State University, Ado Ekiti, Nigeria

Abstract

Background and Objective: Solanum macrocarpon is green leafy vegetable which requires sufficient water especially in its early seedling growth. Water is an abiotic factor which is of utmost important in vegetable crops and its lack or excess may limit plant development. The present study was conducted to assess the effect of watering regime on early seedling growth of *Solanum macrocarpon.* **Materials and Methods:** Seedlings were raised from seeds in germination trays, transplanted to plastic pots and subjected to watering at 200 mL (full capacity) everyday (W_1), thrice a week (W_2), twice a week (W_3) and once a week (W_4). The growth parameters assessed were leaf area, plant height, stem diameter, leaf number, relative growth rate as well as shoot and root weights. **Results:** Watering regimes had no significant effect ($p \leq 0.05$) on growth parameters. Shoot and root weights were highest in seedlings subjected to watering everyday. Furthermore, the highest leaf area, stem diameter and leaf number were obtained in seedlings subjected to watering everyday. However plant height was highest in seedlings watered once a week while the relative growth rate by plant height and leaf area was highest in seedlings watered thrice a week and twice a week respectively. **Conclusion:** Thus, watering everyday at full capacity per plant is recommended for raising *S. macrocarpon* seedlings.

Key words: African eggplant, biomass, growth, *Solanum macrocarpon*, watering regime

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Corresponding Author: Damilola Grace Ogunrotimi, Department of Plant Science and Biotechnology, Faculty of Science, Ekiti State University, Ado Ekiti, Nigeria Tel: +234(0)8064066205

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Water is required by all living organisms and plants are not an exception. Plant stress usually occurs due to lack or excess water during drought and flood incidences. Water stress due to drought remains the most significant abiotic factor limiting plant growth and development as it drastically decreases fresh and dry weight, leaf number, total leaf area and stomatal conductance[1,2]. Emmanuel[3] opined that leaves of plants growing in water stressed environment are small both in number and size. Although, drought-tolerant plants are known to posses extensive root systems so as to absorb sufficient water necessary for growth, on the other hand seeds of some crop species sensitive to flooding are negatively affected during germination[4]. The recent changes in climate have triggered adverse weather conditions which have engendered several responses from plants and animals alike. The changing rainfall pattern with its attendant unpredictable flooding and drought conditions around the globe necessitates a new approach to research in the cultivation of important species[3].

Vegetable species are plants of great nutritional and medicinal importance especially to man, even though some of these species are gradually being eroded. Physiological and ecological information needed on these plant species include flowering and fruiting patterns, seed germination and growth requirement in order to facilitate domestication and improvement of their potentials[5].

The genus *Solanum* is the type genus of the family Solanaceae and it is represented in Nigeria by 25 species[6]. Some of the species include *Solanum macrocarpon*, *Solanum nigrum*, *Solanum scabrum*, *Solanum aethiopicum*, *Solanum melongena* and others. It also contains wild and cultivated species; the cultivated species are important leafy vegetables and edible fruits that are rich in proteins, vitamins and minerals[7]. *Solanum macrocarpon* is an indigenous vegetable species native to Africa. It leaves are usually eaten as a relish to compliment starchy diets. It fruits which contains numerous seeds which are also known to be edible. It also contains appreciable amounts of antioxidants such as flavonoids, phenolics, ascorbic acid and tocopherols that have been shown to be scavengers of harmful radicals that are known to cause cellular damage, heart diseases, cancer, Parkinson's and Alzheimer's diseases[8,9].

A few authors have examined the phytochemical, nutritional and mineral composition of *S. macrocarpon*, in addition to the effect of pre-treatments on its nutritional and anti-nutritional composition. However, there is a paucity of data on the domestication potentials of *S. macrocarpon* especially as it relates to its watering requirements. The current study was therefore carried out to provide information on the effect of watering regime on the early seedling growth of *Solanum macrocarpon* L., this is with the aim of ensuring proper conservation, domestication and high biomass production of the species.

MATERIALS AND METHODS

Study area: Soil was collected at the Parks and Gardens Unit of Ekiti State University, Ado-Ekiti, Nigeria and mature fruits of *Solanum macrocarpon* were harvested from residential areas during field surveys in Ekiti State. The experiment was carried out in the greenhouse (latitude 24°33'S and longitude 25°54'E) of the Department of Plant Science and Biotechnology, Ekiti State University, Ado Ekiti between May and July, 2017.

Growth experiment: The freshly harvested seeds were removed from their capsule, air-dried and then sown in germination trays. After a period of two weeks, seedlings at two-leaf stage were transplanted from germination trays into experimental pots filled with topsoil. Seedlings were arranged in Completely Randomized Design (CRD) with four replicates and allowed to stabilize for 3 weeks after which growth assessment commenced.

The seedlings were subjected to the following watering regimes:

- Everyday (W_1)
- Thrice a week (W_2)
- Twice a week (W_3)
- Once a week (W_4)

Early seedling growth parameters such as plant height, stem collar diameter, leaf number, leaf length and leaf breadth were assessed weekly. Plant height was measured from the collar to the tip of the apical bud using a ruler calibrated in centimeter, leaf length and breadth were also measured using a meter rule, stem diameter with the aid of a digital vernier caliper while leaf number was obtained by physical counting. Leaf area was determined using the non destructive method[10] and computed using the equation:

$$\text{Leaf area} = 0.75\ (\text{Leaf length} \times \text{Leaf breadth})$$

The Relative Growth Rate by plant height (RGR_{ph}) of the seedlings was also calculated using the methods of Hoofman and Poorter[11] and Kayode and Tedela[12]. Leaf area was also determined according to the method of G badamoshi[3]:

$$RGR(PH) = \frac{\ln H1 - \ln H2}{T2 - T1}$$

$$RGR(LA) = \frac{\ln A1 - \ln A2}{T2 - T1}$$

Where:

H2 = Final height of the plant
H1 = Initial height of the plant
A1 = Initial leaf area of the plant
A2 = Final leaf area of the plant
T2 = Final time
T1 = Initial time and
In = Natural logarithm

At 9th week after transplanting, the experiment was terminated, seedlings were carefully uprooted, washed and separated into shoot and root, after which they were weighed using an electronic weighing balance (Trooper Count TC15RS, Ohaus corporation, Pine Brook, NJ, USA). The shoot and root components were then put into separate envelopes for ease of identification. The envelopes together with their contents were oven dried for 24 h at 80°C. The samples were removed and reweighted to get the dry weights.

Statistical analysis: Data obtained from various treatments were subjected to statistical analysis using SPSS 20. A one way analysis of variance was used to compare the means of each treatment. Means were segregated using Duncan's Multiple Range Test. The means were treated as significantly different at $p \leq 0.05$.

RESULTS AND DISCUSSION

Leaf area (cm^2): The effect of watering regime on leaf area is shown in Fig. 1. The effect of watering regime was not significant ($p \leq 0.05$) on the leaf area, this is contrary to Dauda *et al.*[13] who reported that the leaf area of Myrobian seedlings was significantly affected by watering frequency. The seedlings watered everyday (W_1) had the highest mean leaf area of 230.00 cm^2 while those watered thrice a week (W_2) had 200.50 cm^2 and once a week (W_3) had 198.75 cm^2. The lowest mean leaf area (184.25 cm^2) was obtained in seedlings watered twice a week (W_4). This finding shows that *Solanum macrocarpon* might require much water as seedlings watered everyday had the highest leaf area. Gbadamosi[3] opined that

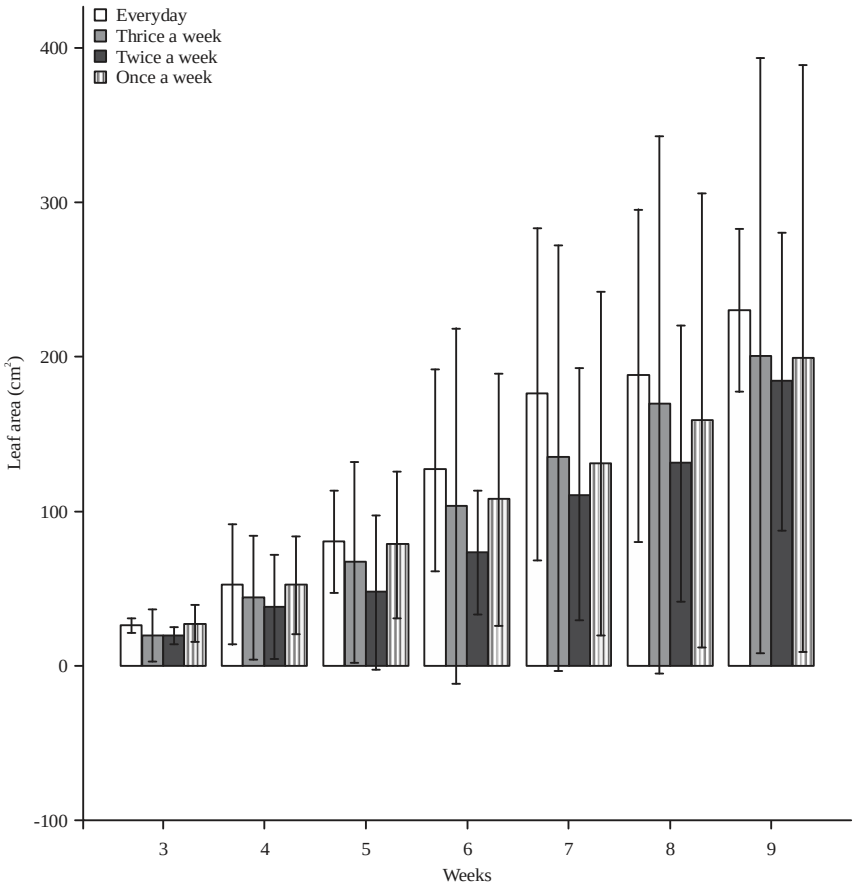

Fig. 1: Effect of watering regimes on leaf area of *S. macrocarpon* seedlings
Error bars: 95% CI

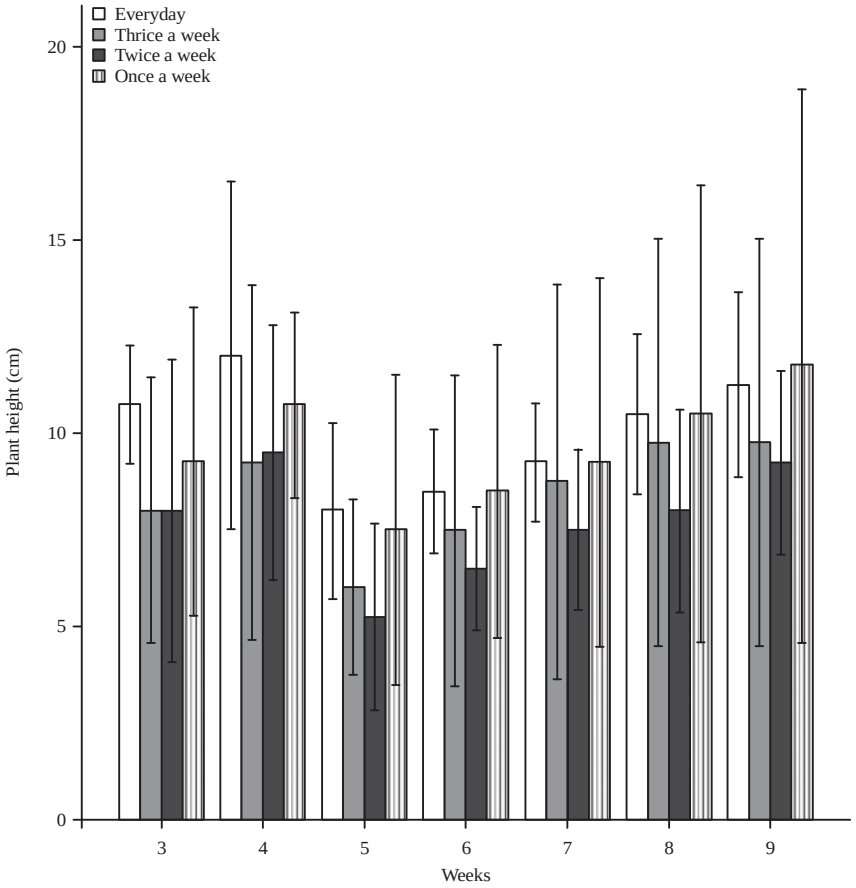

Fig. 2: Effect of watering regimes on plant height of *S. macrocarpon* seedlings
Error bars: 95% CI

part of a plant survival strategy to reduce water loss during periods of severe water stress is reduction in leaf area, the formation of new leaves or shedding old ones, this is similar to the result in the present study as seedlings watered twice a week had the lowest leaf area. A study by Lawlor and Leach[14] also opined that a decrease in leaf area is majorly a common effect of drought.

Plant height (cm): The effect of watering regime was not significant ($p \leq 0.05$) on the plant height (Fig. 2). This is similar to the findings of Oladeji *et al.*[5] who reported that plant height of *Dialium guineense* was not significantly affected by watering regime. Seedlings subjected to watering once a week had the highest plant height of 11.75 cm followed closely by those watered everyday (11.25 cm). The result of the present study is contrary to the findings of Ayeni *et al.*[15] who reported that seedlings of *Abelmoschus esclentus* watered everyday produced the least plant height, this may be due to the fact that the authors cultivated the plant on a degraded soil which was already depleted of plant nutrients.

Stem diameter (mm): As Fig. 3 showed the effect of watering regime on stem diameter of *S. macrocarpon*. The highest stem diameter (2.42 mm) was recorded in seedlings watered everyday and the lowest in seedlings watered twice a week (1.89 mm). Transport of materials in plants are carried out within the stems and as such healthy plant stems are necessary to aid distribution of fluids to the root and shoot, store nutrients, support leaves and flowers as well as produce new tissues.

Leaf number: The effect of watering regime on leaf number is shown in Fig. 4. The number of leaves was significantly affected by watering regime. This is in accordance with the report of Dauda *et al.*[13] who reported that the leaf number of Myrobian seedlings was significantly affected by watering frequency. In the present study, the rate of increase in leaf number can be said to be directly proportional to the frequency of watering regime as seedlings watered everyday produced the highest number of leaves (6.75) and the lowest was obtained in seedlings watered once a week (5.75).

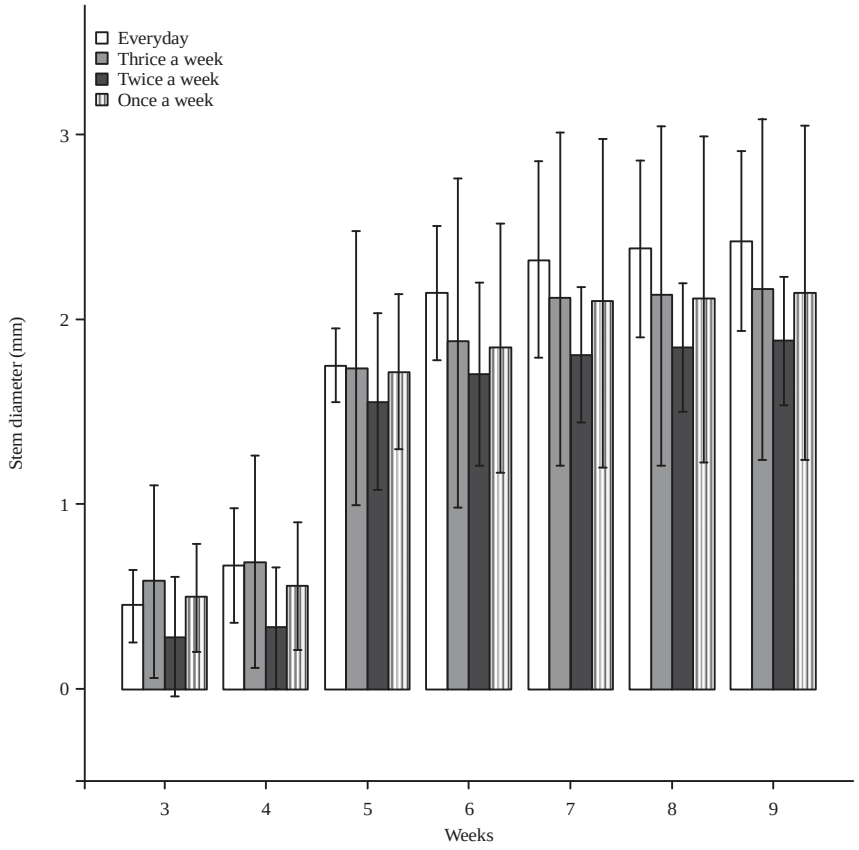

Fig. 3: Effect of watering regimes on stem diameter of *S. macrocarpon* seedlings
Error bars: 95% CI

Table 1: Biomass production of *Solanum macrocarpon* under varying watering regimes

Watering regime	Fresh shoot	Fresh root	Dry shoot	Dry root
Everyday	18.63±2.15[a]	2.21±0.29[a]	2.98±0.39[a]	0.78±0.12[a]
Thrice a week	12.59±3.51[a]	1.42±0.51[a]	1.87±0.55[a]	0.47±0.17[a]
Twice a week	17.50±3.16[a]	2.03±0.67[a]	2.62±0.34[a]	0.61±0.24[a]
Once a week	11.98±2.61[a]	2.25±0.74[a]	2.06±0.50[a]	0.70±0.34[a]

*Means within a row with same superscripts indicate that they are not significantly different ($p<0.05$)

Biomass yield and Relative Growth Rate (RGR): Biomass yield to a vegetable farmer is the means to the ultimate objective of increasing productivity. The biomass yield of *S. macrocarpon* seedlings as affected by varying watering regimes is shown in Table 1. In the present study, fresh shoot weight (18.63 g) was highest in seedlings watered everyday while the least value was obtained in seedlings watered once a week (11.98 g). The fresh root weight (2.21 g) weight was highest in seedlings watered everyday while the least (1.42 g) was recorded in seedling subjected to watering thrice a week. Guoxiong *et al.*[16] have reported that an extensive root growth is an adaptive feature under drought stressed conditions. Concurrently, the highest dry shoot weight (2.98 g) was also obtained in seedlings watered everyday while the least value (1.87 g) was obtained in seedling subjected to watering thrice a week. This supports the findings of Sakio[17] that increased watering frequency reduces the total dry weight increment in some plant species. Seedlings watered everyday produced the highest dry root weight (0.78 g) while the least (0.47 g) was obtained in seedlings watered twice a week. Vandoorne *et al.*[2] also stated that water stress drastically decreased fresh and dry root weight, leaf number, total leaf area and stomatal conductance in *Cichoriumintybus* (var: *sativum*). The low root yield obtained in the present study can be attributed to the limited soil environment available to the seedlings. Mathers *et al.*[18] stated that growing plants in containers alters root growth and function and can change root morphology, as roots of container-grown plants are usually subject to

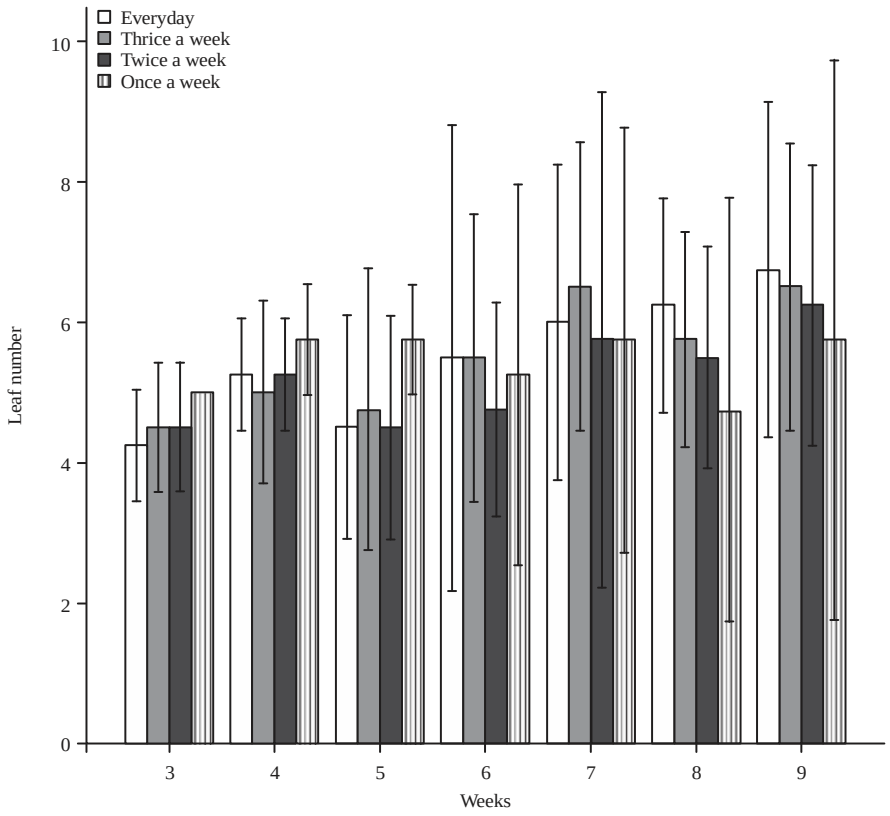

Fig. 4: Effect of watering regimes on leaf number of *S. macrocarpon* seedlings
Error bars: 95% CI

Table 2: Relative growth rates (RGR) of seedlings of *S. macrocarpon* under different watering regimes

Watering Regime	RGR_{PH}	RGR_{LA}
Everyday	0.008	0.362
Thrice a week	0.033	0.336
Twice a week	0.024	0.372
Once a week	0.008	0.328

RGR: Relative growth rate by plant height, RGR_{LA}: Relative growth rate by plant height

temperature and moisture extremes which in field conditions are usually moderate. The result shows that biomass yield increased with watering frequency, this can be attributed to the increase in water available during transpiration to support proper plant growth. This agrees with the opinion of Rauf[19] that a reduction in plant weight may occur due to a lower photosynthate production due caused by excessive loss of water through the leaves.

Relative Growth Rate (RGR) varied among the different watering regimes (Table 2). Relative growth rate by plant height (RGR_{PH}) was highest in seedlings watered thrice a week (0.033) while relative growth rate by leaf area was highest in seedlings watered twice a week (0.372). Relative growth rate has been stated to be an important factor in determining the success and distribution of a particular species in a vegetation[20].

It is therefore important to posit that major plant physiological processes take place in water medium[5] and adequate water application is of utmost necessity to prevent water stress either through flooding or drought. Vegetables are mostly abundant in rainy seasons while the few available ones during the dry season require efficient irrigation. Scheduling water application is very critical to produce high crop yield as excessive irrigation reduces yield while inadequate irrigation causes water stress and reduces production[15].

CONCLUSION

The varying watering regimes had effects on the early seedling growth of *Solanum macrocarpon* although not statistically significant. The results revealed that *Solanum macrocarpon* will grow maximally when watered everyday. However, further research can be carried out in order to investigate the plant's ability to thrive under flooding and drought conditions.

SIGNIFICANCE STATEMENT

The study reports the effect of different watering regimes on the early growth of *Solanum macrocarpon* seedlings, and of all the treatments those watered everyday produced the best result. Indigenous vegetables, of which *Solanum macrocarpon* is one are important sources of phytochemicals, vitamins and minerals which promote growth and prevent diseases in man, however in recent times these valuable plants are tending towards extinction due to over-reliance on exotic vegetable species such as cabbage, spinach and others. The present study is part of the efforts aimed at domestication of indigenous vegetables, and to achieve this, water is a necessary factor required for growth and development. Most importantly as it relates to *Solanum macrocarpon* this study will help vegetable farmers and other researchers to know the actual amount and frequency of watering at which it will grow best and also produce a high yield. Thus, the study provides a reasonable amount of information about the watering requirement of the vegetable, nevertheless it can be improved upon by other researchers in future study by considering seasonal variations and other abiotic factors and their effect on growth.

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