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ORIGINAL RESEARCH

EFFECTS OF DIFFERENT WATERING REGIMES ON THE GROWTH OF TALINUM TRIANGULARE JACQ. (WATER LEAF)

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Abstract:

Introduction: Climate change is an ecological challenge faced by the whole world especially Lagos state. This has resulted into water stress problems faced by plants and animals; thus, reducing their availability, production and yield.

Aims: *Talinum triangulare* (water leaf) growth is hinged on the availability of optimum water in soil. It is against this that this requirement study tends to determine the effects of different watering regimes on the growth of water leaf.

Materials and Methods: Seeds obtained from Lagos State Agricultural Inputs Supply, Ojo, Lagos State were planted in pots filled with loamy soil. Watering regime experiments viz adequately watered (control), moderately water stressed, strongly watered stressed and very wet were carried out on the growth of *T. triangulare* for 7 weeks at the greenhouse, Department of Botany, Lagos State University.

Results: The data collected were analyzed and results revealed that the adequately watered (control) and moderately water stressed (dry treated) seedlings performed better in terms of stem height, root and shoot dry weight, number of leaves and total biomass. The strongly watered stressed seedlings also experienced growth which was rapid initially but later slowed down abruptly. The very wet treated seedlings had stunted growth but flowered first alongside the strongly watered stressed seedlings. It was also observed that the control and strongly water stressed seedlings contained higher mineral nutrients.

Conclusion: Adequately watered (control) and moderately water stressed (dry treated) treatments are the best watering regimes for the growth of *T. triangulare*.

To Keywords: water stress, watering regime, *Talinum triangure*, growth parameters, mineral nutrients.

All co-authors agreed to have their names listed as authors.

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1. INTRODUCTION

Climate change is an ecological challenge faced by the whole world. Climate change is a persistent fluctuation in the climatic elements for a considerable length of time, which shows significant difference in the behaviour of climatic conditions of an area or areas due to the growing accumulation of greenhouse gases in the atmosphere [1]. Climate change involves the systematic observation, recordings, and processing of the various elements of climate such as rainfall, temperature, humidity, air pressure, wind, clouds and sunshine before any standardization of the climatic means or average can be arrived at. Climate change is a monumental factor which affects all living organisms (plants and animals). Thus, one of its effects is seen in water stress faced by the plants. Plant water stress is a condition caused by either drought or soil water logging which induces plant physiological dysfunctions that is capable of causing a decline in plant survival capacity thereby leading to scanty flora of the world [2]. Plant water stress often time caused by drought and constant water logging do have major impact on plants growth and development thereby resulting in lower yield and possible crop failure [3]. Also, inadequate water supply to the roots may be caused when transpiration rate becomes intense [4]; but when excess water occurs, it results in reduction of seed germination and seedling establishment [3]. It can be suggested that from dawn of agriculture, mild to severe drought and water logging have been major production limiting factors. Water stress creates inadequate situation in the rhizophere, lower plants water potential and turgor pressure to the extent that the plants face difficulties in executing normal physiological functions. However, a wide variety of plants are known for the tolerance of water drought stress and oxygen deficiency during the adult stages of their life cycle [5, 6].

All plants have tolerance to water stress, but the extent varies from species to species [5]. For example, flood sensitive plants like *Lycopersicum esculentum*, *Glycine max*, and *Heliantus anus* are killed in the waterlogged conditions, while plants like *Oryza sativa* can withstand water-logging for a considerable time. However, continuous submergence of *Oryza sativa* is also deleterious resulting in death and decay of the plant [7]. Rapid change in soil properties takes place following soil water-logging. As water saturates the soil pores, gases are displaced; a reduction in gas diffusion occurs and phyto-toxic compounds accumulates as anaerobic prevailed; while under drought, many plants will dehydrate and die. Water stress in plants reduces the plant cell water potential and turgor, which elevate the solute concentration in the cytosol and extracellular matrices. As a result, cell enlargement decreases leading to growth inhibition and reproductive failure. This is followed by accumulation of Abscissic acid (ABA) and compatible osmolytes like proline which causes wilting [8, 9], cellular damage, light imbalance and denaturing of functional and structural macromolecules [10, 11].

Water leaf (*Talinum triangulare*) is a cosmopolitan weed belonging to the family *Taliniaceae* and commonly found in humid tropics. It has been recorded for several countries in West and Central Africa; it is claimed to have South American origin but an African origin may not be doubted [12]. Water leaf is an erect glabrous perennial herb (80-100cm tall), usually strongly branched; roots are swollen and fleshy. The leaves are alternate, simple, almost sessile and succulent. Water leaf is eaten as vegetables throughout the tropics including many countries in West and Central Africa especially in preparations of slightly shiny soups and stews to complement the starchy main dish. In South West Nigeria, where it is called *Gbure*, it is commonly cooked as *Efo* soup with ingredients as a delicacy. In Cameroon, where it is called *Bolki* and used in the preparation of Belok-soup and as treatment for measles but in Asia (India), it is used for treating diabetes. It is also used as poultice on contusion, inflammations and tumors, decoctions are used for painful eyes and to aid recovery from blows and falls [13, 14, 15]. Water leaf has been made into tonic from its roots, also as fodder for raising snails. It is often planted as an ornamental plant or edging plants in gardens. Water leaf exhibits a whole range of biological and pharmaceutical activities such as anti-inflammation, anti-fungal and anti-bacterial properties [13, 14].

Talinum triangulare grows best under humid conditions at a temperature of 30 ^{0}C. Growth is fast during raining season but slows down considerably during the dry season. It's a shade and cloudy weather loving plant. They are mostly propagated through stem cuttings (10-15cm) but seed germination is inevitable [12, 16]. *T. triangulare* takes 3weeks from planting before first harvest; the first 1-3 harvest provides the best leafy quality for marketing. However, a rain-fed crop with good weeding, manure, watering and pest and disease management can remain on field for 60-180 days [17, 18]. The yield range is 10-60t/ha [19]. Thus, in order to fully achieve the best yield stated; water, an essential soil solvent is needed. Water dissolves nutrients in the soil for the plants. Hence, properly managed water application enables constant nutrients supply to the crops, improve soil quality and protect plant quality. It is specified that water application must not exceed agronomic application rate (amount less or equal to crop requirements) and not applied when soil is frozen, snow-covered or saturated.

However, in Nigeria especially Lagos State where there is increase in population, disturbance to natural ecosystem, flooding and high demand for vegetables (*Talinum triangulare*), many farmers are faced with the challenges of which watering regime is best for growing vegetables and thus, enhance productivity, availability, yield and financial remuneration. It is against this that this study tends to determine the effects of different watering regimes on the growth of *T. triangulare.*

2. MATERIAL AND METHODS

Experiments were carried out in a greenhouse of the Botanical garden, Department of Botany, Faculty of Science, Lagos State University, Ojo-Lagos, Nigeria. Seeds were obtained from Lagos State Agricultural Input Supply, Agric Bus-stop, Ojo-Lagos. The organic manure used was collected from a Poultry farm in Lagos and loamy soil from Botanical garden of Lagos State University.

Soil Preparation and Nursery

Soil preparation and nursery was done according to Metwally, *et al.* [20] with modification. Mature seeds of *T. triangulare Jacq* germinated in 10 days under normal conditions. Thus, experiment to quicken germination and emergence was carried out by soaking the mature seeds in hot water for about 2-3 minutes after wrapping them in cotton material. The seeds were brought out and allowed to dry after which were sown in a big bowl for three weeks. Sowing was done by mixing the seeds with a well dried clean loamy soil in a small container and was spread on the soil contained in the big bowl. It took 4 days for the seeds to germinate and watering done once in a day (to avoid being water-logged) till they reach maturity (time of transplanting). The seedlings were transplanted one week after planting.

Transplanting

Transplanting was done according to the method of Niu, *et al*. [21] with slight modification. Twenty (20) equally perforated plastics buckets were used. Each was filled with 8kg of loamy soil mixed with organic manure (3 part of soil to 1 part of organic manure). Four treatments which were: Control, moderately water stressed (Dry treatment), strongly water stressed (Very Dry treatment), and Very Wet treatments in five buckets for each treatment were used for the study. Transplants were made and allowed to grow and get established for three weeks after which the treatments were induced. In control treatment, each seedlings was supplied with 35cl of water once daily; in the moderately water-stressed treatment, each seedlings was supplied with 35cl of water once in two days; in the strongly water-stressed treatment, each seedlings was supplied with 35cl of water once in four days while, in very wet treatment, each seedlings was supplied with 35cl of water three times daily.

Harvesting/ Agronomic Data Collection

Seedlings were harvested by carefully removing and washing the soil particles from the roots, after which the plants parts were separated into shoots and roots [20]. The first harvest was carried out one week after commencement of treatment while the last harvest was carried out 6 weeks after commencement of treatment. During the experiment measurements of growth parameters like number of leaves, leaf length, leaf breadth, leaf area, stem height, stem girth, fresh and dry weights were taken from three replicates. Plants heights were taken with meter rule, while the stem girths were taken with vernier caliper. The dried weight of roots, stems and leaves of plants were taken after oven drying (in Botany Research Laboratory) at temperature of 80 ^{0}C for 2 days and cooled. At the end of these harvests, the leaf area (cm^2), leaf weight ratios, stem weight ratios, root weight ratio and shoot-root weight ratios were determined.

Atomic Absorption Spectrophotometric Analysis

A digest preparation of water leaf (*T. triangulare Jacq*) for analysis was adopted using Khalil and Manan [22] method. 1g of freshly excised water leaves (5th and 6th) positions on main branches were weighed into 100ml of Nitric acid (HNO_3) and perchloric acid; and the aliquots were used for the determination of the mineral elements (Zinc, Lead, Chromium, and so on) concentration. The mixture was placed on a hot plate at 50 ^{0}C for 15 minutes and the temperatures were raised slowly up to 200 ^{0}C. Heating continued until white dense fumes of perchloric acid disappeared after digestion, the content were cooled and filtered through a filter paper and then transferred to a 50 ml volumetric flask and diluted with de-ionized water up to the mark. The digest produced were transferred into a Beck-man atomic absorption spectrophotometer model 1233 equipped with hollow cathode lamp for the determination and or analysis of calcium, magnesium, zinc, phosphorus, sodium concentrations. The instrument parameters were adjusted according to manufacturer's instruction. The gas used was acetylene with 20pa pressure and air, 45pa pressure. The instrument was calibrated with standard solution and samples were introduced to it by means of capillary tube and concentrated readings on the display unit were recorded.

Data analysis

All data collected were subjected to Standard Mean Error analysis using Microsoft excel package, 2007.

3. RESULTS

Effects of different watering regimes on the vegetative growth characters of *T. triangulare*

In this study, Table 1 showed the mean value of stem height, number of leaves, leaf area and stem girth which were taken at four days intervals after treatment. The data collected on the 4th and 8th days showed that the control, dry and very dry treated seedlings had good growth but the very wet treated seedlings had stunted growth. Between 12-24days of the experiment increased growth parameters were manifested in the control and moderately stressed plants. The strongly water-stressed and very wet plants showed little or no growth during this period (Table 1).

As from the second harvest, there were significant differences in the fresh and dry weights of *Talinum* *triangulare* with the control being the highest, followed by moderately water-stressed plants, and then very wet treated plants and strongly water stressed coming last (Table 2).There were no significant differences between the plant heights of well-watered (control) and moderately water-stressed plants and all other treatments between the first and fifth harvests (Table 2). However, there were differences in the plant heights of strongly water-stressed and very wet treatment plants throughout the harvest periods.

The leaf weight and stem weight ratio of well-watered and moderately water-stressed plants were significantly greater than those of strongly water-stressed and very wet plants throughout the harvesting periods. However, the leaf weight ratio and stem weight ratio of the well-watered and moderately water-stressed plants were not significantly different from each other and they did not follow any consistent pattern. Similarly, the leaf weight ratio of strongly watered-stressed and very wet plants did not differ from each other (Table 2).
The strongly watered-stressed plants had higher root weight ratio than the other treatments during the harvest periods (Table 2). Except for the first harvest when moderately watered- stressed plants had higher value than control and very wet treatments, all these three treatments had similar root weight ratio throughout the experimental period. The very wet plants had higher shoot/root ratio than other treatments from the third to fifth harvests (Table 2). The well-watered (control) and moderately water-stressed plants had similar values for shoot/root ratio which in turn were higher than strongly water- stressed plants. Hence, the strongly water-stressed plants invested the lowest dry matter into its shoots than its roots.

Effects of different watering regime on the chemical composition of *Talinum triangulare*

The chemical analyses of the different watering regimes on *T. triangulare* were done and the various quantities of macro and micro nutrients of the watering regimes were recorded. Table 3 showed the quantities of each of the macro and micro nutrients found (N, Na, K, Mg, Cu, Zn, and so on) in the plant samples; thus, it revealed that seedlings generally have low concentration of Nitrogen but there are higher values of other mineral elements in moderately water-stressed seedlings followed by seedlings in control than those in strongly water-stressed seedlings while very wet treated plants had the lowest.

4. DISCUSSION

Water stress is an abiotic factor that affects all living things (plants) thereby reducing their yield, productivity and development. It can either be absence or excess of water supply. Hence, this study- effect of different watering regimes on the growth of *Talinum triangulare* showed contrasting results on the morphological characters (number of leaves, leaf length, leaf breadth, and so on) measured. Table 1 showed the values of stem height, number of leaves, leaf area and stem girth taken at 4 days intervals after treatment; thus, all the seedlings experienced growth most especially the seedlings under strongly water-stressed treatment which started flowering just four days after treatment. This rapid growth and flowering of seedlings under the above mentioned treatment within four days of not getting water into their soil agrees with the result of Kramer and Boyer [23] when they studied the effects of drought on some plants in the family *cucurbitaceae*. They reported that plants showing improved growth with limited water supply are considered to tolerate drought and thus, will devise strategies for survival such as rapid elongation before the onset of drought, quick flowering, and postponement of dehydration by developing deep roots which ensures access to water left in the soil. Quick flowering was also observed in seedlings subjected to very wet treatment; this is because they are also water stressed.

However, the results from the 12 days after treatment (Table 1) showed that control and moderately water stressed treated seedlings had significant increase in their morphometric characters except stem height in control treated seedlings while strongly water-stressed and very wet treated seedlings had stunted growth. It was also observed that the strongly water-stressed and very wet treated seedlings had reduction in number of leaves, showing the occurrence of senescence; thus agreeing with the work of Al-Imran and Timothy [24] when they worked on *Triticum aestivum* (wheat) and they attributed the reduction in numbers of leaves and leaf area to facilitated senescence and abscission of leaves while Rahman [25] reported that it is due to reduction in stomata conductase leading to stomatal resistance. Also, Vurayai and Moseki [26] reported that it was as a result of reduction in rate of cell division within the leaves while Silvestre [27] reported that it was as a result of induced ethylene in a variety of plant species. Reduction in stem height and stem girth experienced by seedlings subjected to strongly water-stressed (very dry) and very wet treatments may be due to reduced photosynthetic activities since both seedlings in these conditions suffered water deficit and low oxygen level in the soil, thereby leading to reduced root permeability [28, 29].

Table 2 showed that the weight root ratios of seedlings under the strongly water-stressed (very dry) treatment for the five harvests had the highest values because the more plant is deprived of water, the deeper the roots will develop which is an adaptive features of plants undergoing drought [30]. More so, the root/shoot ratios showed insignificance for seedlings under strongly water-stressed (very dry) and moderately water stressed (dry) treatments, because the smaller the value of the shoot/root ratios, the larger the value of the masses of the root. The seedlings of very wet treatment showed the highest value of shoot/root ratios because the higher the value, the smaller the masses of the roots; this was supported by the work of Ismail and Coker [30] and Malik [31] on the mechanisms of waterlogging tolerance in *triticum aestivum*. They were of the opinion that adaptation of plants to waterlogging reduces growth of seminal root and promotes the production of numerous adventitious roots with aerenchyma to trap in oxygen.

Reduction in mineral nutrients concentration was also observed in water stressed *T. triangulare* as shown in Table 3; the result reveals the effects of the different watering regimes on the mineral concentration of *T. triangulare*. This finding agreed with findings of Silvestre [27] who observed a decrease in the mineral element concentration in various plants due to water stress. Thus, mineral nutrients are absorbed by plants in solution and since seedlings under very wet and strongly water-stressed (very dry) treatments both suffered water deficits; then it is expected that water entering the plants is reduced, the mineral nutrients uptake by the plants will also be reduced and this is one of the reasons for their slow growth and development when compared to the plants subjected to control and moderately water-stressed (dry) treatments.

Table 1: Effects of different watering regimes on Vegetative Characters of *T. triangulare*

	Treatments	Mean stem Height (cm) ±S.E	Mean stem Girth (cm) ± S.E	Mean number of leaves(cm) ± S.E	Mean leaf area (cm^2) ± S.E
4th Day	CON	22.17±0.15	1.87±0.06	34.67±1.53	30.60±0.10
	MWS	19.50±0.50	1.67±0.06	43.33±1.53	30.50±0.10
	SWS	23.27±0.06	1.77±0.06	37.33±1.53	42.63±0.15
	WET	14.50±0.06	1.47±0.06	21.00±2.52	19.73±0.12
8th Day	CON	24.77±0.06	2.30±0.00	49.00±1.00	37.17.0±.15
	MWS	24.84±0.06	2.07±0.06	59.00±1.00	44.63±0.12
	SWS	24.40±0.10	2.30±0.00	37.00±1.53	46.70±0.20
	WET	14.53±0.06	1.47±0.06	17.67±3.21	19.73±0.10
12th Day	CON	24.77±0.06	2.40±0.00	51.33±1.15	37.50±0.10
	MWS	25.20±0.10	2.17±0.12	60.33±0.58	44.77±0.15
	SWS	24.40±0.10	2.30±0.00	36.67±1.53	46.70±0.20
	WET	14.53±0.05	1.47±0.06	17.33±3.06	19.73±0.17
16th Day	CON	24.83±0.12	2.53±0.06	53.33±1.53	38.17±0.12
	MWS	27.70±0.17	2.36±0.06	61.67±1.53	45.20±0.17
	SWS	24.47±0.06	2.30±0.00	32.00±2.65	45.20±0.17
	WET	14.53±0.06	1.47±0.06	17.67±3.21	19.73±0.10
20th Day	CON	25.07±0.15	2.67±0.06	55.66±1.15	38.53±0.15
	MWS	27.97±0.06	2.53±0.06	64.33±1.15	45.47±0.15
	SWS	24.47±0.06	2.30±0.00	32.00±2.65	46.70±0.20
	WET	14.57±0.06	1.47±0.06	16.00±2.65	19.75±0.15
24th Day	CON	25.37±0.25	2.67±0.06	57.67±1.15	38.73±0.15
	MWS	28.27±0.23	2.53±0.06	66.67±1.15	45.77±0.15
	SWS	24.47±0.06	2.30±00	32.00±2.65	46.70±0.20
	WET	14.57±0.06	1.47±0.06	16.00±2.65	19.75±0.15

The results are represented as Mean± S.E of three replicates;

Key: CON=Control, MWS= Moderately Water-stressed, SWS= Strongly Watered-Stressed, WET=Very Wet Treatment

Table 2: Effects of different watering regimes on the Fresh and Dry weight of *T. triangulare*

Parameters		1st Harvest (8days after treatment)	2ndHarvest (16days after treatment)	3rd Harvest (24days after treatment)	4th Harvest (32days after treatment)	5th Harvest (40days after treatment)
Mean Fresh weight (g)	CON	41.09±1.48	39.63±9.85	79.81±9.42	84.43±14.37	85.78±9.26
	MWS	40.36±1.31	35.95±1.32	48.37±22.03	48.46±11.48	48.39±11.78
	SWS	10.33±1.23	8.73±2.38	10.57±2.38	10.56±4.02	10.45±3.12
	WET	27.83±1.74	16.68±1.52	15.88±1.52	15.92±2.04	15.58±2.09
Mean Dry weight (g)	CON	4.93±0.26	6.52±0.56	7.72±1.79	7.94±1.67	8.61±2.30
	MWS	6.06±1.14	6.02±0.59	6.25±1.62	6.27±1.22	6.45±1.58
	SWS	3.42±0.55	2.55±1.25	3.23±0.46	3.02±0.42	2.80±0.56
	WET	2.82±0.31	2.73±0.52	2.60±0.05	2.58±0.45	2.57±0.13
Mean Plant height(cm)	CON	23.60±0.12	25.70±0.21	25.74±0.16	26.80±0.17	26.90±0.28
	MWS	23.80±0.22	25.90±0.29	25.90±0.29	26.88±0.33	26.90±0.17
	SWS	20.20±0.20	20.10±0.29	20.20±0.29	20.00±0.33	20.10±0.25
	WET	14.90±0.29	14.59±0.17	14.60±0.13	14.72±0.58	14.80±0.21
Leaf weight Ratio (g) (expressed as a % of Total dry weight)	CON	46.48±2.53	46.48±4.01	30.66±1.68	32.64±3.44	28.50±5.33
	MWS	32.06±0.22	47.37±8.00	19.92±4.54	31.44±10.76	29.85±6.87
	SWS	17.93±11.2	19.71±8.57	14.57±7.98	11.88±9.42	11.00±8.93
	WET	18.32±0.89	13.54±13.3	18.59±0.34	10.11±3.09	13.10±0.75
Stem weight Ratio (g) (expressed as a % of Total dry weight)	CON	49.34±4.57	41.62±1.99	63.30±1.53	62.21±2.84	71.65±8.03
	MWS	40.37±5.22	44.06±6.24	60.98±1.92	59.09±13.86	57.92±9.03
	SWS	24.88±3.85	16.56±5.52	13.05±3.29	13.02±1.88	7.64±5.79
	WET	18.42±1.08	18.40±1.10	18.30±1.04	18.40±1.06	17.90±1.21
Root weight Ratio (g) (expressed as a % of Total dry weight)	CON	8.21±6.16	8.72±5.32	6.95±1.62	6.98±1.70	6.99±1.70
	MWS	22.99±15.4	9.20±4.47	8.08±4.78	8.68±2.60	12.23±2.88
	SWS	58.57±15.4	64.07±11.2	73.61±12.33	75.10±13.25	81.37±14.27
	WET	6.25±0.73	6.25±074	3.31±1.29	6.08±0.81	2.84±0.28
Shoot/Root Ratio	CON	22.30±12.70	13.12±6.62	16.69±4.84	14.86±3.67	21.94±9.06
	MWS	7.52±9.34	11.44±4.91	15.19±15.11	11.34±4.14	7.45±1.77
	SWS	0.79±0.46	0.59±0.26	15.69±14.07	0.36±0.25	0.26±0.25
	WET	23.46±7.16	15.33±8.80	32.98±14.85	20.04±3.22	34.43±7.24

The results are represented as Mean± S.E of three replicates;

Key: CON=Control, MWS= Moderately Water-stressed, SWS= Strongly watered-stressed, WET= Very wet treatment

Table 3: Effects of different watering regimes on Mineral concentrations of *T. triangulare*

Minerals	Mean concentrations (mg/100g) for CON ±S.E	Mean concentrations (mg/100g) for MWS ±S.E	Mean concentrations (mg/100g) for SWS ±S.E	Mean concentrations (mg/100g) for WET ±S.E
Nitrogen	2.5±0.10	2.40±0.10	2.33±0.15	2.20±0.20
Phosphorus	230±2.00	250.00±2.00	196.00±6.93	110.00±2.00
Potassium	87.33±2.08	100.00±2.00	78.00±2.65	65.33±1.53
Sodium	98.33±1.53	108.00±1.15	80.67±1.15	44.33± 1.53
Calcium	78.33±0.58	80.33±0.56	72.67±1.52	66.67±1.53
Magnesium	105.33±3.06	110.67±1.15	80.67±0.58	62.67±2.52
Manganese	90.33±1.53	96.00±1.00	64.33±0.58	61.33±4.16
Copper	45.33±3.06	46.00±2.00	39.67±1.52	35.33±2.52
Iron	2.00±0.20	4.40±0.36	1.43±1.12	0.83±0.15
Zinc	3.33±0.58	3.57±0.40	4.3±0.26	0.90±0.10

The results are represented as Mean± S.E of three replicates;

Key: CON=Control, MWS= Moderately Water-stressed, SWS= Strongly watered-stressed, WET= Very wet treatment

5. CONCLUSION

Talinum triangulare is a plant found almost everywhere; therefore it is prone to several watering conditions. Some of them are planted by people who need them and supply them with sufficient water, some grow in places where they suffer drought and some will be seen in water logged areas. The plant can survive everywhere but this study proves that the amount of water available to the plant will not stop it from surviving but will have effects on it growth including the mineral nutrient concentrations of the seedlings as the study reveals that the control and moderately water stressed (dry) treatments are the best watering regimes for the growth of the seedlings and as a matter of fact, the best kind of *Talinum triangulare* to be eaten is the control or dry treated one because it has more mineral nutrient value (most especially the dry treated one) when compared to those under the very dry and very wet treatments.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

Oluwole Surukite and Balogun Olusesan designed the study; Oluwole Surukite and Ogun Mautin supervised and managed the analysis and literature review. Ogun Mautin wrote the first draft of the manuscript. Ogun Mautin and Balogun Olusesan performed the statistical analysis. All authors read and approved the final manuscript.

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