Growth responses of Okra (*Albemoschus esculentus*) and Jute mallow (*Corchorus olitorius*) to water stress and non-water stress conditions

Esther Abosede Ewetola^a, Temitayo Funmi Fasanmi^b

Ladoke Akintola University of Technology, P.M.B. 4000, Ogbomosho, Nigeria

E-mail address: ^aeaewetola@lautech.edu.ng, tfhelen@gmail.com

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ABSTRACT. Water stress is one of the abiotic stress factors that affect establishment, growth and yield of crop. Therefore, a screen house study was carried out to determine the effect of water stress on growth and yield of Okra and Jute mallow. 7 litre capacity each bucket was filled with 10 kg of soil and arranged in a completely randomized design with three replicates. There were four irrigation regimes based on field capacity; 100% FC (control), 75% FC, 50% FC, and 25% FC. Seeds from local source were sown at the rate of three seeds per pot and later thinned to two seedlings per pot two weeks after sowing (WAS). Data on growth parameters; plant height, stem girth and number of leaves were collected at two week interval up to 10 WAS while total fruit yield and biomass yield, for okra and jute mallow respectively, were determined at harvest. Data collected were subjected to analysis of variance (ANOVA) and the means were separated using least significant difference at $p < 0.05$. Okra growth and fruit yield were significantly ($p < 0.05$) affected by field capacities; 75% FC produced significantly ($p < 0.05$) tallest plant at 10 WAS (25.3 cm) while 25% FC gave shortest plant height (13.9 cm). Number of leaves at 10 WAS followed similar trend as plant height. Irrigation regimes did not significantly ($p < 0.05$) affect fruit yield however, 75% FC recorded highest fruit yield than other field capacities. At 10 WAS, jute mallow plant height under 100, 75 and 50% FC were significantly ($p < 0.05$) tallest height than at 25% FC. Stem girth followed the same trend as plant height. However, at 10 WAS, 75% FC produced significantly ($p < 0.05$) higher number of leaves and biomass yield than other treatments. It could be concluded from the study that 75 % FC was best for growth, fruit yield and biomass yield of okra and jute mallow production.

1. INTRODUCTION

Water stress (Drought) is one of the most important limiting factors in crop production and it is becoming an increasing severe problem in many region of the world [1, 2]. Since, the world supply is limiting, future food and fodder demand for rapidly increasing population pressures are likely to increase the importance of water stress studies [3]. The severity of water stress is unpredictable as it depends on many factors such as occurrence and distribution of rainfall, evaporative power demands and moisture storing capacity [4]. Drought is one of the major physical parameter of an environment which determines the success or failure of plants establishment [5]. Generally water stress occurs when the available water in the soil is reduced and atmospheric conditions cause continuous loss of water by transpiration or evaporation [6]. The plants under dry condition change their metabolic activities to overcome the change in environmental conditions. Water stress reduces leaf size, stems extension and root proliferation, disturbs plant relations and reduces water use efficiency [7].

Okra (*Albemoschus esculentus*) originated in tropic Africa and was grown in Mediterranean region. It is now grown in all parts of the tropics and during summer in the warmer parts of the temperature region. It is classified as semi-tolerant vegetable crop [8]. The young tender pods of okra are cooked in curries, stewed and roasted and used as substitute for coffee [9]. Okra is a very nutritive vegetable and it is eaten in many part of Nigeria especially, in the southern guinea savanna

region. Jute mallow (*Cochorus olitorius*) is widely distributed in tropical and sub-tropical region. It is an important leaf vegetable in south west Nigeria, which propagated by seed [10]. It is commonly cooked as soup.

[11] documented that, okra plant was significantly reduced by water stress. He observed that plants subjected to a low level of stress (watered once a week) performed better than those moderately stressed. Water stress is one of the limiting factors in crop growth and yield which reduces dry matter production, yield and yield components through decreasing leaf area and accelerating leaf senescence [12]. Also, [13] emphasized the importance of time of irrigation and number of irrigation in increasing yield at better quantity. Despite the nutritional quality of these crops, their large production is limited to the rainy season owing to scarcity of water supply during off season. This study therefore, attempted to determine the effect of soil moisture stress on growth of Okra (*Albemoschus esculentus*) and Jute mallow (*Cochorus olitorius*) under water controlled environment.

2. MATERIALS AND METHODS

Experimental location

The experiment was carried out at the screen house of the Department of Agronomy at Ladoko Akintola University of Technology, Ogbomoso, Nigeria located on N08°10' E04°10' altitude 341m above sea level. A composite sample from topsoil (0-15 cm) was collected at four locations under secondary forest planted with teak (*Tectonia grandis*) trees behind the Central library of the University. The field capacity of the soil was determined *in situ* on oven dry basis. Sub-sample of the soil was air-dried, sieved through a 2 mm mesh and taken to the laboratory for routine analysis. Ten kilograms of the sieved soil was weighed into pots, each of seven litres capacity perforated at the bottom to allow unimpeded drainage. There were two test crops (Okra and Jute mallow), four irrigation regimes representing different field capacities including; 100% (control), 75%, 50% and 25% equivalent to 1.77, 1.328, 0.885 and 0.443 litres of water respectively. There were three replications laid out in completely randomized design.

Sowing and agronomic practices

Okra and Jute mallow seeds source were sown at the rate of three seeds per pot and later thinned to two seedlings two weeks after sowing (WAS). At the start, irrigation was done at 14 days, later reduced to 7 days, 5 days, and 4 days with increase in age of plant. This is because plants have low transpiration and metabolism rates at their early stage of growth. Data on growth parameters of okra and jute mallow were collected at two weeks interval on plant height stem girth, numbers of leaves, leaf length and breadth to calculate leave area. At maturity, okra fruits were harvested at five days interval and average total fruit yield (g/plant) was determined, Jute mallow was harvested 10 WAS to determine total average biomass yield (g/plant). The experiment was repeated in order to validate the data collected.

Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) using SAS Package [14]. Means were separated by least significant difference (LSD) at 5% level of probability.

3. RESULTS

Physico-chemical properties of the soil used for the screen house study

The soil used for the experiment belongs to loamy sand textural class (Table 1). The pH of the soil is 7.3 which was slightly alkaline. Organic carbon in the soil is moderate with the value of 10.7 g/kg. This brought about medium total nitrogen content of 1.1g/kg in the soil. Available

phosphorus was 5.53 mg/kg compared with 10 mg/kg considered for south western Nigeria soil [15]. Exchangeable bases especially available potassium level in the soil was above the critical level resulting into moderate ECEC. The contribution of all this nutrients would have attributed the improved condition of the soil because the soil sample was collected under forest condition.

Influence of water stress on growth and fresh fruit yield of *Okra (Albemoschus esculentus)*

Okra plant height was significantly affected by water stress from 6 week (WAS) to 10 WAS (Fig. 1a). 75% field capacity (FC) produced significantly tallest plant at 6, 8, and 10 WAS than 100% FC (control). The mean plant height at 6, 8 and 10 WAS for 75% FC respectively, were 20.5 cm, 19.2 cm and 19.2 cm. However, 50% FC was not different from the control, whilst 25% FC had significantly ($p < 0.05$) shorter plants than the control.

Water stress had similar effect on stem girth of okra across the weeks amongst treatments (Fig. 1b). However, 25% FC produced thinner plants compared to other treatments.

Table 1: Physico-chemical properties of the soil used for the experiment

Property	Value	Critical value*
Sand (g/kg)	790	-
Silt (g/kg)	110	-
Clay (g/kg)	100	-
Soil pH (H ₂ O)	7.30	6.50
Organic carbon (g/kg)	10.70	30.0
Total Nitrogen (g/kg)	1.10	1.50
Available Phosphorus (mg/kg)	3.53	10.00
Exchangeable Calcium (cmol ⁺ /kg)	4.39	2.00
Exchangeable Magnesium (cmol ⁺ /kg)	0.69	0.40
Available Potassium (cmol ⁺ /kg)	0.28	0.20
Exchangeable Acidity (cmol ⁺ /kg)	0.00	-
Effective Cation Exchange Capacity (cmol ⁺ /kg)	5.86	-

The effect of water stress significantly affected okra number of leaves only at 10 WAS (Fig. 1c). 75% FC produced significantly highest number of leaves (15.1) than 100% FC (9). Similarly, 50% FC had significantly higher number of leaves than the control but 25% FC had lower number of leaves when compared to 100% FC and other treatments.

Leaf area of okra was not affected by water stress (Fig. 1d). All treatments except control produced statistically similar leaf area. However, at 8 and 10 WAS, 25% FC produced narrower leaf area compared to other treatments.

Mean total fresh fruits of okra had no significant difference among the field capacities (Table 3). Nonetheless, 75% FC still produced higher fresh fruit yield than 100% FC while 25% FC was lowest compared to other treatments.

Influence of water stress on growth and biomass yield of Jute mallow (*Corchorus olitorius*)

Water stress had no significant effect on jute mallow plant height at 2 and 4 weeks after sowing [WAS] (Fig.2a). However, the treatment had significant effect on plant height of jute mallow at 6, 8 and 10 WAS. Water applied at field capacity of 75% had the tallest plant height at 6, 8 and 10 WAS with respective values of 6.37, 13.08 and 30.58 cm. Corresponding values of 3.10, 6.0 and 12.0 cm for shortest plants were recorded at 25% FC . .

Stem girth of jute mallow showed significance ($p < 0.05$) amongst treatments only at 2 WAS and 10 WAS (Fig.2b). Jute mallow 75% FC and 50% FC had thickest plant stem respectively, at 2WAS (0.6cm and 0.4 cm) and 10 WAS (1.1 cm and 1.0 cm) compared with 100% FC (0.2 cm and 0.95 cm). Conversely, 25% FC recorded significantly thinner plant stem compared to the control at 2 WAS (0.30 cm) and 10 WAS (0.90 cm).

Water stress had no significant effect on jute mallow number of leaves across the weeks (Fig 2c.). Although, 75% FC still produced highest number of leaves among treatments. Leaf area followed similar trend as in number of leaves (Fig. 2d). However, at 6, 8 and 10 WAS, 25% FC recorded narrowest leaf area with respective values of 2.92 cm^2 , 5.67 cm^2 and 11.62 cm^2 .

Biomass yield of jute mallow was significantly affected by different field capacities applied (Table 2). 75% FC and 50% FC recorded higher total biomass yield than 100% FC. However, 25% FC did not differ significantly from 100% FC. The mean biomass yield for 100, 75, 50 and 25% FC were 5.3, 26.9, 16.0 and 5.4 g/plant respectively.

4. DISCUSSION

In the study, *Okra* (*Albemoschus esculentus*) growth and fresh fruit yield was affected by different levels of irrigation. The response of this crop to irrigation was best at 75% FC which could be explained as the upper limit of soil available water. Growth was restricted at 100% FC due to waterlogged condition that caused physiological drought in the plant. Similarly, growth was retarded at low soil moisture (25% FC) that represented lower limit of soil available water. This result was similar to report of [16] on the effect of water stress on okra which was associated with a decline in the cell enlargement and more leaf senescence. The result also was consistent with many other previous works on the effect of water stress on plant height and number of leaves in different plant species. For example, *Sophora davidi* seedling subjected to three water regimes, 80%, 40%, and 20% FC was reported by [17] that water stress dramatically reduced plant height and number of leaves. The yield of jute mallow and okra were affected by water stress, which has similar result in comparison with other studies. [18] reported on levels of defoliation in maize due to water stress during early reproductive growth. Water stress reduces seed yield in soybean usually as a result of fewer pods and seeds per unit area [19].

Table 2: Effect of water stress levels on okra fresh fruit and jute mallow biomass yield

Irrigation regimes (% field capacity)	Okra Fresh fruit yield [g/plant]	Jute mallow Biomass yield [g/plant]
100	2.67	5.30
75	4.56	26.87
50	0.92	16.07
25	0.67	5.40
LSD $p < 0.05$	1.92	18.47

LSD = Least significant difference

Fig. 1: Effect of irrigation regimes (based on field capacity) on (a) plant height, (b) stem girth, (c) Number of leaves, and (d) Leaf area of Okra (*Albemoschus esculentus*). Vertical bars indicate the least significant difference at 5% probability

Fig. 2: Effect of irrigation regimes (based on field capacity) on (a) plant height, (b) stem girth, (c) Number of leaves, and (d) Leaf area of Jute mallow (*Corchorus olitorius*). Vertical bars indicate the least significant difference at 5% probability

5. CONCLUSION

The result have shown that reduced level of water to the plant below and above 75% FC has an increasing negative effect on the early growth, development, yield and plant survival depending on the magnitude of excess or deficit of the water. Field capacity of 75% was shown to give maximum performance for both *okra* and *jute mallow*. It does not only give highest performance in term of growth but also gave the highest yield. Therefore, it could be deduced that 75% FC would give the best performance for growth of the two crops and any deviation will result in a decline in the growth parameters and yield of these crops.

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