Effects of soil moisture stress on the growth attributes and yield of three okra (*Abelmoschus esculentus* L.) cultivars in the sandy regosols

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1. Introduction

A water deficit stress is one of the major environmental constraints limiting agricultural productivity. Drought severely affects plant growth and development with substantial reduction in crop growth and biomass accumulation. Water stress on plants directly impacts the reduced fruit dry matter and yield of the plant (Bahadur et al., 2009). Drought decreases Leaf Area Index (LAI) in crop plants in general. Hussain et al. (2009) have reported decline in LAI of sunflower exposed to drought at budding and flowering stages. Drought also suppresses leaf expansion and reduces leaf area due to early senescence. Li et al. (2009) have stated that under moisture stress condition, total dry weight and their components will be reduced.

Okra is one of the most important vegetable crops belonging to the family Malvaceae. It is cultivated in the dry zone as a monocrop in irrigated uplands as well as in rice-based cropping systems during the '*Yala*' season and also in well drained highlands during the '*Maha*' season. Okra cultivation faces severe limitations and the main one is the lack of water which limits severely the potential production of Okra (Nana et al., 2014). Gunawardhana and Silva (2011) reported that water stress showed highly significant effect on growth, pod diameter and yield of okra. Therefore, the objectives of this study was to focus on the physiological parameters and agronomic performance of three okra varieties under moisture deficit conditions and identifying the most drought tolerant okra cultivar which can produce substantial yield under water limited situation.

2. Materials and Methods

This experiment was conducted at the Agronomy farm of the Eastern University, Sri Lanka. The type of soil of this area is Sandy Regosols and these soils are characterized by more than 85% sand and less than 5% clay in the top soil with the pH of 6.84. The annual mean temperature varies from 28 to 32°C. The mean annual rainfall is between 1800 to 2100 mm. A number of one hundred and ninety-two polyethylene bags (36 cm height and 45 cm diameter) were made for this experiment. These bags were filled with top soil, red soil and compost at the ratio of 1:1:1. The okra seeds cvs. 'Haritha', 'MI 5' and 'EUOK 2' were sown in these bags. The agronomic practices were followed based on the recommendation of the Department of Agriculture. Watering was done daily in the morning and evening until germination. Thereafter, it was applied at two days interval to field capacity, the soil moisture content remaining at field capacity was 21.0%.

Soil moisture stress was imposed for the okra cultivars for a period of 10 days during the flowering stage by withholding water completely at once. The control plants were watered to field capacity level at two days interval. The experiment was laid out in the 3×2 factor, factorial Randomized Complete Block Design with six treatments and four replications and the treatments T_1, T_3 and T_5 were 'Haritha', 'MI5' and 'EUOK 2' okra cultivars respectively watered at two days interval to Field Capacity. The T_2, T_4 and T_6 were 'Haritha', 'MI5' and 'EUOK 2' okra cultivars subjected to moisture stress during the flowering stage for 10 days.

Growth Measurements

Leaf Area Index

A number of two plants were randomly selected from each replicate of the treatments on the 10th day from the commencement of the stress during the flowering stage. These plants were uprooted and washed thoroughly with distilled water. The leaves of each plant were detached and the total leaf area per plant was measured by a leaf area meter (LICOR- 3100C). The Leaf Area Index (LAI) of each plant was calculated as follows:

$$\text{LAI} = \frac{Total\ leaf\ area\ of\ plant\ (Cm^2)}{Ground\ area\ occupied\ by\ the\ plant\ (Cm^2)} \times 100$$

Plant Dry Weight

The plants, uprooted to measure the LAI, were used for this purpose. The detached leaves of each plant along with its left out plant parts were used to measure the plant dry weight. These weights were obtained by drying in an oven at 105°C for 48 hours.

Yield

A number of two plants were randomly selected from each replicate of the treatments and the pods of these plants were collected on alternate days from the first to the eighth harvest. The fresh weights of these pods were recorded.

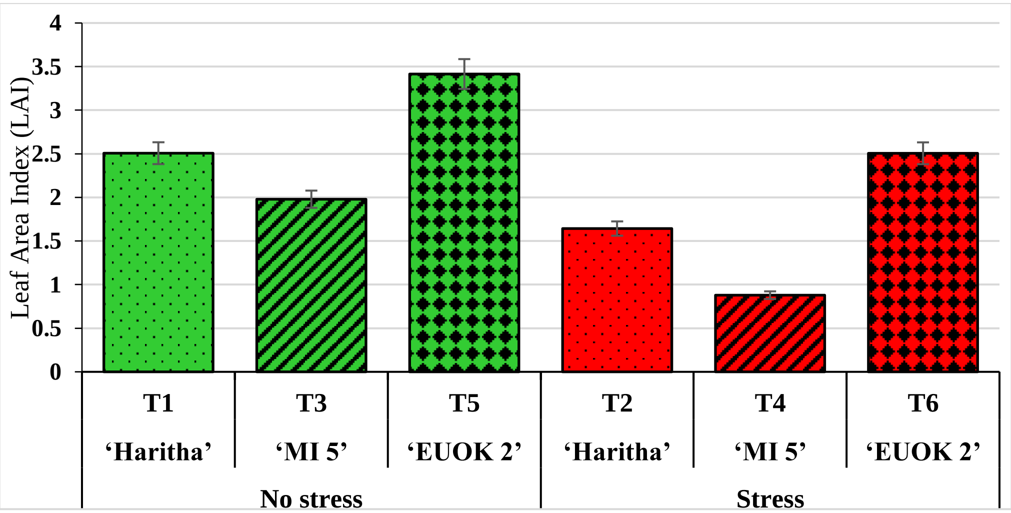
Statistical Analysis

All the analysis were carried out in triplicate and in randomized order with the mean values. The data were subjected to an analysis of variance (ANOVA), and the mean differences were compared using DMRT at probability level of P< 0.05.

3. Results and Discussion

Leaf Area Index (LAI)

There were significant (*p <0.05*) differences between treatments in the LAI of tested okra cultivars when moisture stress was imposed during the flowering stage (Figure 1).



Values are the means of 8 plants in 4 replications.
Vertical bars indicate the standard error.

Figure 1. Effects of soil moisture stress on the LAI of three okra (*Abelmoschus esculentus* L.) cultivars during the flowering stage

The highest LAI (2.51) was obtained in the 'EUOK 2' okra cultivar and the lowest (0.89) was found in the 'MI 5' under moisture stress condition. Hence, moisture stress has reduced the LAI of all the tested okra cultivars. Leaf area expansion depends on leaf turgor and drought-induced reduction in leaf area is ascribed to suppression of leaf expansion through reduced photosynthesis. Diminished leaf area was attributed to the negative effect of stress on the rate of cell elongation which resulted in leaves reduced in cell volume and cell number (Kawakami *et al*., 2006). The highest LAI found in the 'EUOK 2' compared to the others under moisture stress condition signifies its inherent drought tolerance feature and the lowest LAI recorded in the 'MI 5' showed its susceptibility to drought.

Plant Dry Weight

There were significant ($p<0.05$) differences between treatments in the plant dry weights of tested okra cultivars when moisture stress was imposed during the flowering stage (Table 1).

Table 01. Effects of soil moisture stress on the plant dry matter of three okra (*Abelmoschus esculentus* L.) cultivars during the flowering stage

	Cultivars	Treatments	Plant dry matter (g)
No stress	'Haritha'	T_1	251.1 a
	'MI 5'	T_3	233.4 a
	'EUOK 2'	T_5	218.6 a
Stress	'Haritha'	T_2	142.9 b
	'MI 5'	T_4	102.5 c
	'EUOK 2'	T_6	176.3 a

Values in the same column followed by the same letter do not differ significantly ($p<0.05$).
Values are the means of 8 plants in 4 replications.

The highest plant dry weight was obtained in the 'EUOK 2' okra cultivar and the lowest was found in the 'MI 5' under moisture stress condition. Moisture stress therefore has reduced the plant dry weights of all the tested okra cultivars. Reduction in plant dry weight was due to reduced production of photosynthates on account of stress. Many studies have indicated the increase in drought stress could decrease plant dry weight (Omidi, 2010). The decrease in dry weights of stressed shoots reveals the influence of water on stimulating and regulating photosynthetic enzymes which thus influence dry matter production and weights. The highest plant dry weight obtained in the 'EUOK 2' okra cultivar under drought condition would have been due to its inherent drought resistance feature. 'MI 5' cultivar showed the lowest plant dry weight among the tested ones which is a drought susceptible character of this cultivar.

Yield

There were significant ($p<0.05$) differences between treatments in the yield of okra cultivars when moisture stress was imposed during the flowering stage. The highest yield (3.8 tha^{-1}) was obtained in the 'EUOK 2' and the lowest (0.4 tha^{-1}) was found in the 'MI 5'under moisture stress condition 2.4 t ha^{-1} yield was recorded in the 'Haritha' okra cultivar. Moisture stress therefore has reduced the yield of all the tested okra cultivars. The yield of okra is influenced by the availability of soil moisture during the vegetative and reproductive stages and crop experiencing drought during the reproductive phase shows significant ($p<0.05$) yield reduction. Drought stress during reproductive stages like flowering and podding is crucial for yield in okra and this reduction of crop yield depends on okra varieties and tolerant genotypes will be able to give a better yield considerably due to physiological and biochemical changes that are triggered during drought stress. Vaidya *et al*. (2015) have indicated a reduction of yield due to drought stress and it was highly significant ($p<0.05$) between genotypes, drought stress and their interaction. The highest yield obtained in 'EUOK 2' cultivar compared to the others under moisture stress condition shows its drought tolerance.

4. Conclusions

Soil moisture stress imposed during the flowering stage has reduced the measured physiological parameters, agronomic performances and yield of the tested okra cultivars. The highest growth performance in terms of Leaf Area Index, plant dry weight and yield was obtained in the 'EUOK 2' okra cultivar and the lowest was found in the 'MI 5' under moisture stress condition. Hence, 'EUOK 2' was identified as the drought tolerant okra genotype among the tested ones which produced substantial yield under water limited situation and it could be recommended for drought prone areas of the sandy Regosols.

5. References

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