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Effect of foliar application of moringa leaf extract and salicylic acid on growth and yield of okra under moisture stress conditions

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Abstract
The experiment was carried out in a naturally ventilated Poly house condition at College of Horticulture, Anantharajupeta, Dr. Y.S.R. Horticultural University, and Andhra Pradesh during late *kharif*- 2022. The experiment was laid in a split-plot design with three main plots and six subplots, each replicated three times. The main plot treatments consisted of three moisture stress levels i.e., M_1: Moisture stress at 20 DAS (up to 50% FC), M_2: M_1+ Moisture stress at 40 DAS (up to 50% FC) and M_3: M_1+M_2+ Moisture stress at 60 DAS (up to 50% FC). Subplot treatments included S_1: Control (Distilled water), S_2: 10% MLE at weekly once, S_3: 20% MLE at weekly once, S_4: 30% MLE at weekly once, S_5: SA @ 1.0 mM at 20, 40 and 60 DAS, S_6: SA @ 2.0 mM at 20, 40 and 60 DAS. Among the moisture stress levels, M_1 recorded significantly highest value for plant height (99.16 cm), total fresh weight (109.30 g), number of pods per plant (22.00) and pod yield per plant (0.54 kg). The findings revealed that (S_4) foliar application 30% MLE on moisture stress levels exhibited the greatest plant height, total fresh weight, total dry weight, no of pods per plant and pod yield per plant and the lowest values has been found under (S_1) control.

Keywords: Okra, moisture stress and moringa leaf extract, salicylic acid

1. Introduction
Okra, also known as Lady's finger, belongs to the Malvaceae family. It is commonly called bhendi and gumbo in various regions. Okra's cultivation is believed to have originated in Ethiopia and was later grown by Egyptians around the 12th century. It gradually spread to the Middle East and North Africa. Okra primarily thrives in tropical and subtropical regions but is sensitive to frost, low temperatures, waterlogging and drought.

Moringa Leaf Extract (MLE) serves as a bio-stimulant and is rich in macro and micronutrients, amino acids, ascorbic acids, minerals, and growth-enhancing elements, including cytokinin-type hormones, as highlighted in the study by Makkar *et al*. in 2007 [11]. When applied as a growth hormone spray, it can lead to plants becoming sturdier and more resilient against pests and diseases. MLE is known to contain approximately 46 antioxidants, with key ones including ascorbate, carotenoids, phenols, and flavonoids, as noted in the research by (Fuglie *et al*. 2000) [4].

Salicylic acid (SA) is a natural plant growth regulator (PGR) that plays a role in various morpho-physiological and biochemical functions. SA is particularly important for enhancing a plant's ability to tolerate abiotic stress, and it has garnered significant attention within the scientific community for its capacity to establish defense mechanisms in plants against such stresses. Numerous studies have provided evidence of the positive effects of SA on various crops that have been exposed to abiotic stresses, including salinity, drought, and heavy metal toxicity, as supported by research by Maity *et al*. (2009) [7].

The current experiment is aimed to investigate the effect of application of moringa leaf extract (MLE) and salicylic acid (SA) on growth and yield characteristics of okra under conditions of moisture stress conditions.

2. Materials and Methods
The experiment was carried out in a naturally ventilated Poly house at College of Horticulture, Anantharajupeta, Dr. Y.S.R. Horticultural University, Andhra Pradesh during late *kharif*- 2022 on Arka Anamika variety of okra with split plot design with three main plots i.e., M_1: Moisture stress at 20 DAS (up to 50% Field capacity), M_2: M_1+Moisture stress at 40DAS (up to 50%

Field capacity), M_3: M_1+M_2+ Moisture stress at 60 DAS (up to 50% Field capacity) and six subplots i.e., S_1: Control (Distilled water), S_2: 10% MLE at weekly once, S_3: 20% MLE at weekly once, S_4: 30% MLE at weekly once, S_5: SA @ 1.0 mM at 20 DAS, 40 DAS and 60 DAS, S_6: SA @ 2.0 mM at 20 DAS, 40 DAS and 60 DAS.

2.1 Collection and preparation of Moringa leaf extract (MLE)

Young leaves of moringa (PKM-1) were collected from young full-grown trees located at Vegetable farm, College of Horticulture, Anantharajupeta. For preparation of MLE, young leaves of about 100 g were taken into a mortar with a pinch of water (10 ml/100 g fresh material) and ground with a pestle. The juice was extracted by hand pressure and was filtered through a cheese cloth followed by re-filtering using Whatman filter paper No.2. Following the method developed by (Fuglie *et al*. 2000) [4] the extract was diluted with distilled water at a ratio of 1:32 (v/v) and then sprayed directly onto the okra plants. The remaining extract was stored at 0 ºC temperature and only taken out when needed for use.

2.2 Foliar application of Moringa leaf extract (MLE) on Okra plants

The prepared MLE was sprayed as per the treatment @ 10%, 20% and 30% at a frequency of weekly once starting from 20 days after sowing. Spraying in the late afternoon using hand sprayer with special attention for complete coverage of plants with MLE. Water was sprayed in the control plots instead of MLE and special attention was given by putting newspaper barricade between the treatments to avoid drifting of MLE spray from one treatment to another.

2.3 Preparation of Salicylic acid

For preparation of 1 mm of SA, 138.121 mg of salicylic acid was added into 1 lit water which gives 1 mM of SA solution. The required amount of solution was prepared just before the spray. Similarly, 2 mM of SA was prepared by adding 276.242 mg of salicylic acid was added into 1 lit water.

2.4 Foliar application of Salicylic acid on Okra plants

The prepared SA @ 1.0 mm and 2.0 mm was sprayed on okra plants at 20 DAS, 40 DAS and 60 DAS as per the treatment. SA @ 25 mL plant^{-1} was applied using a hand sprayer with special attention for complete coverage of plants. Water was sprayed in the control plots instead of SA and special attention was given by putting newspaper barricade between the treatments to avoid drifting of foliar spray of SA from one treatment to another.

3. Results and discussion

The results pertaining to effect of foliar application of MLE and SA under moisture stress conditions on growth and yield parameters of okra cv. Arka Anamika were statistically analyzed and presented in Table 1, 2& 3 and Fig. 1, 2, 3, 4 & 5. Results showed significant effect of moisture stress levels, foliar applications of MLE and SA and their combinations on growth and yield of okra.

3.1 Growth parameters

3.1.1 Plant height

Among the moisture stress levels, the highest plant height of 29.38 and 99.16 cm was recorded with M_1 and the lowest plant height of 24.06, and 88.09 cm was observed under M_3 at 30 and 70 DAS respectively. In the same way among the foliar sprays, foliar application of S_4-30% MLE at weekly once showed maximum plant height of 31.82 and 103.77 cm, while the lowest value has been found under control i.e., S_1 (23.22 and 86.58 cm) at 30 and 70 DAS respectively. Among the interactions, the highest plant height of 34.51 and 109.65 cm was recorded with the treatment combination of M_1S_4 and the lowest plant height of 19.80 and 80.74 cm was found under M_3S_1 at 30 and 70 DAS, respectively.

The results from this study showed that plant height was influenced by moisture stress at different levels. The decreased plant height potentially limits the irrigation period to 50% field capacity as observed by Kwajaffa *et al*. (2015) [6] in okra. To address the issue of moisture stress, employing techniques such as foliar application of moringa leaf extract (MLE) and salicylic acid (SA) has been explored. Moringa leaf extract contains, zeatin a naturally growth, enhancing substance and can be used as a natural source of growth promoter, recognized as an extensive cytokinin presence in moringa leaves, as indicated by Sohel Rana *et al*. (2019) [9] in cauliflower.

3.1.2 Total fresh weight

Amid the main plots, maximum plant fresh weight was observed under M_1 i.e., Moisture stress at 20 DAS (35.16 and 109.30 g) whereas the least value was recorded under M_3 with a value of 27.64 and 98.90 g at 30 and 70 DAS respectively. A significantly highest value under the total fresh weight of the plant was noticed in S_4 (38.92 and 118.67gm) and the least value identified under S_1 (23.29 and 74.94g) at 30 and 70 DAS respectively. The maximum total fresh weight was noticed with the combination effect of M_1S_4 (44.57 and 125.90 g) which was followed by the treatment combination of M_1S_6, whereas the lowest total fresh weight was found under M_3S_1 (20.12 and 68.17 g) at 30 and 70 DAS respectively.

According to Ali *et al*. (2011) [1] in sorghum, the slight increase in growth observed could have been attributed to moringa leaf extract's role as a growth enhancer. It was also enriched with nutrients like vitamin C, potassium, calcium, and magnesium. These components collectively established it as an extraordinary enhancer of plant growth. The presence of growth-promoting hormones like auxins and cytokinin particularly zeatin, contributed to its capacity for promoting growth by enhancing processes such as cell division, multiplication and enlargement (Rady *et al*.,2015) [8].

3.1.3 Total dry weight

Among the moisture stress levels, the highest (10.01, 38.70 g and 8.61, 34.00 g) and lowest plant dry weight was recorded with M_1 and M_3 at 30 and 70 DAS respectively. From the foliar sprays, the highest plant dry weight was obtained under S_4 (11.09 and 41.87 g) and the lowest value in plant dry weight was recorded under control S_1 (6.66 and 21.35 g). Among the interactions, the highest plant dry weight was recorded under M_1S_4 (13.39 and 44.95 g) followed by M_1S_6 and the lowest value under M_3S_1 (6.32 and 18.98 g) at 30 and 70 DAS respectively.

The enhancement of the total plant dry weight of the okra plant could have been attributed to the influence of zinc and gibberellic acid within the moringa leaf extract, which was significant in biomass generation. According to Cakmak

(2008) [12] in cereal grains, the zinc content present in the MLE contributed to an increase in plant biomass production. Similar results were observed by Culver *et al*. (2012) [2] in tomatoe**s.**

3.2 Yield and Yield attributes

3.2.1 Number of pods per plant

Moisture stress severity reduced the pod number. As the severity of stress increased, pods per plant decreased. The maximum number of pods per plant (25.78) was recorded with less severe moisture stress treatment i.e., M_1-moisture stress at 20DAS and the lowest number of pods per plant (22.00) was recorded with more severe moisture stress treatment i.e., M_3. Regarding different concentrations of foliar applications of MLE and SA under moisture stress conditions, the maximum number of pods per plant (27.28) was recorded in S_4 followed by S_6 and minimum number of pods per plant (20.83) was observed under S_1- control. Among means interaction effect of main plots and subplots, the maximum number of pods per plant (31.00) was recorded with M_1S_4 followed by M_1S_6 whereas, the least number of pods per plant (19.96) was seen under M_3S_1.

The number of pods per plant was mainly dependent on the total production of flowers per plant, due to the presence of IAA and GA_3, micronutrients in moringa leaf extract leads to an enhancement in the pod count per individual plant as reported by Khandaker *et al*. (2018) [5] in okra.

3.2.2 Pod yield per plant

An increase in moisture stress levels decreases pod yield in Okra. Among the stress treatments, the maximum pod yield (0.79 kg) was recorded in less severe stress treatment i.e., M_1 and the minimum pod yield (0.54 kg) per plant was found under severe stress treatment i.e., M_3. Regarding foliar sprays of MLE and SA, S_4 recorded the highest pod yield per plant (0.96 kg) followed by S_6 and the lowest pod yield per plant (0.47 kg) was found under S_1 -Control. A significant interaction effect was seen among the main plots and subplots. A combination treatment of M_1S_4 gained the highest pod yield per plant (1.23 kg) followed by M_1S_6, whereas the lowest pod yield per plant (0.41 kg) was obtained under M_3S_1. The foliar application of moringa leaf extract shows a significant positive impact on the yield of okra. Micronutrients play a crucial role in various physiological processes within plants, such as activating enzymes, facilitating electron transport, chlorophyll synthesis and regulating stomatal activity. These processes collectively lead to an enhanced photosynthetic activity and the accumulation of carbohydrates which results in overall vegetative growth lead by flower and fruit retention and ultimately increased okra yield by 20 to 35% (Fuglie, 2000) [4]; Thomas and Howarth (2000) [10]. Similar results were reported by Emongor *et al*. (2015) [3] in snap bean.

Table 1: Effect of foliar application of moringa leaf extract and salicylic acid under moisture stress conditions on plant height (cm) of okra

Main Plot Sub Plots	Plant height (cm)							
	30 DAS				70DAS			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	26.52	23.35	19.80	23.22	91.76	87.25	80.74	86.58
S_2	27.76	25.74	23.45	25.65	91.20	88.95	84.34	88.16
S_3	29.22	28.43	26.27	27.97	98.40	93.57	88.69	93.55
S_4	34.51	32.03	28.93	31.82	109.65	102.53	99.15	103.77
S_5	24.50	23.35	21.82	23.22	96.24	92.67	86.68	91.86
S_6	33.74	28.86	24.08	28.89	107.73	96.48	88.93	97.71
Mean	29.38	26.96	24.06		99.16	93.58	88.09	
	SE (M)		CD		SE (M)		CD	
MP	0.43		1.72		0.43		1.72	
SP	0.36		1.04		0.36		1.04	
S at M	0.63		1.81		0.63		1.81	
M at S	1.02		3.27		1.02		3.27	

M1: Moisture stress at 20 DAS (up to 50% FC)
M2: M1+ Moisture stress at 40 DAS (up to 50% FC)
M3: M1+M2+ Moisture stress at 60 DAS (up to 50% FC)

S1: Control (Distilled water)
S2: 10% MLE at weekly once
S3: 20% MLE at weekly once
S4: 30% MLE at weekly once
S5: SA @ 1.0 mM at 20, 40 and 60DAS
S6: SA @ 2.0 mM at 20, 40 and 60 DAS

Table 2: Effect of foliar application of moringa leaf extract and salicylic acid under moisture stress conditions on total fresh weight (g) and total dry weight of okra

Main Plots Sub Plot	Total fresh weight (g)								Total dry weight (g)							
	30DAS				70DAS				30DAS				70DAS			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M1	M2	M3	Mean
S_1	25.15	24.60	20.12	23.29	81.13	75.52	68.17	74.94	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_2	31.12	26.13	23.66	26.97	108.50	100.73	97.13	102.12	6.95	6.72	6.32	6.66	24.78	20.28	18.98	21.35
S_3	35.06	32.50	27.60	31.72	113.97	110.74	107.74	110.82	8.69	8.27	7.88	8.28	37.88	35.76	33.56	35.73
S_4	44.57	39.15	33.05	38.92	125.90	118.80	111.30	118.67	9.48	8.97	8.52	8.99	41.17	39.91	38.34	39.81
S_5	35.55	32.45	30.20	32.73	107.40	103.77	100.37	103.84	13.39	10.05	9.82	11.09	44.95	41.28	39.38	41.87
S_6	39.50	34.60	31.20	35.10	118.90	116.70	108.67	113.42	10.20	9.99	9.63	9.94	40.25	37.44	36.64	38.11
Mean	35.16	31.57	27.64		109.3	104.4	98.9		11.40	9.88	9.50	10.26	42.54	41.08	37.10	40.24
	SE (M)		CD		SE (M)		CD		SE (M)		CD		SE (M)		CD	
MP	0.47		1.92		0.70		2.81		0.08		0.31		0.32		1.30	
SP	0.59		1.70		1.08		3.12		0.11		0.33		0.47		1.35	

S at M	1.02	2.94	1.87	5.41	0.20	0.57	0.81	2.34
M at S	1.16	3.62	1.77	5.41	0.20	0.62	0.81	2.46

M1: Moisture stress at 20 DAS (up to 50% FC)
S4: 30% MLE at weekly once
S5: SA @ 1.0 mM at 20, 40 and 60DAS
S6: SA @ 2.0 mM at 20, 40 and 60 DAS

M1: Moisture stress at 20 DAS (up to 50% FC)
M2: M1+ Moisture stress at 40 DAS (up to 50% FC)
M3: M1+M2+ Moisture stress at 60 DAS (up to 50% FC)

S1: Control (Distilled water)
S2: 10% MLE at weekly once
S3: 20% MLE at weekly once

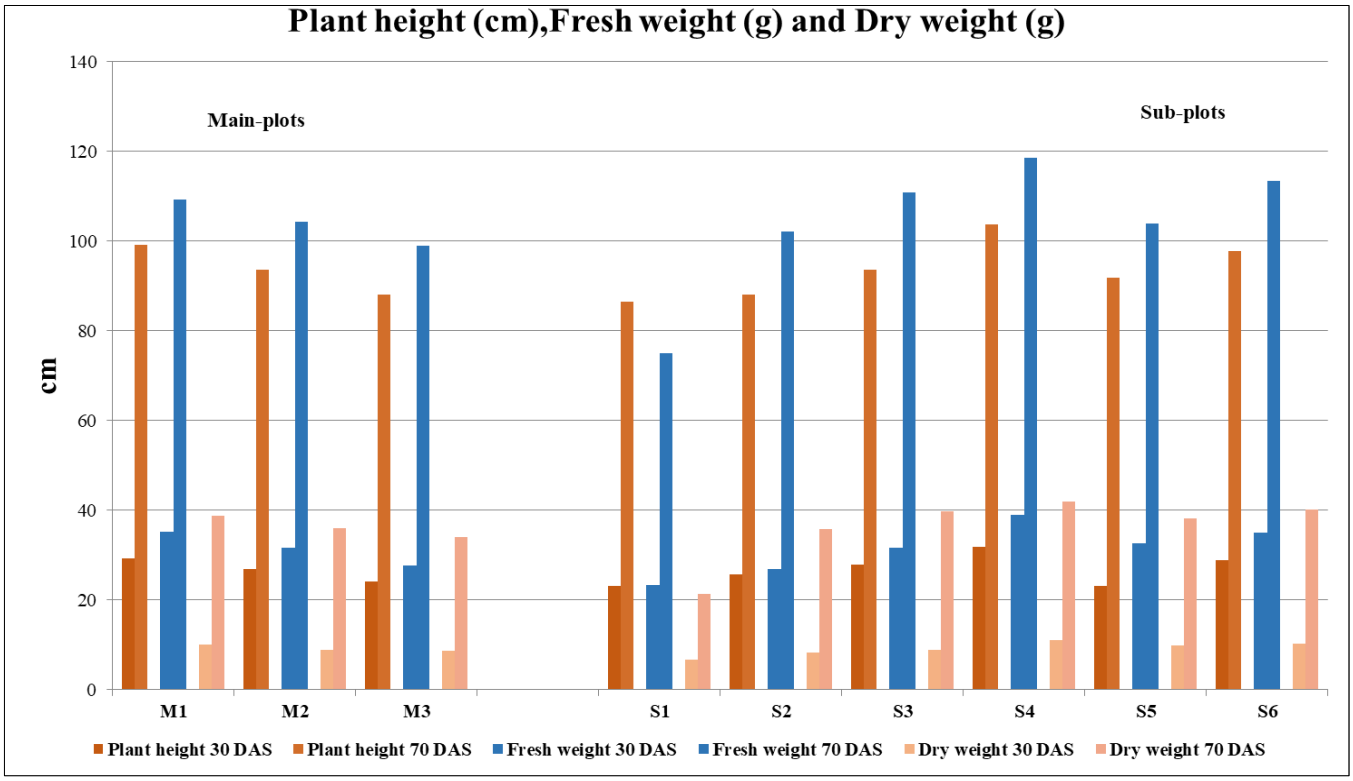

Fig 1: Effect of foliar application of moringa leaf extract and salicylic acid on plant height (cm), fresh weight (g) and dry weight (g) under moisture stress conditions

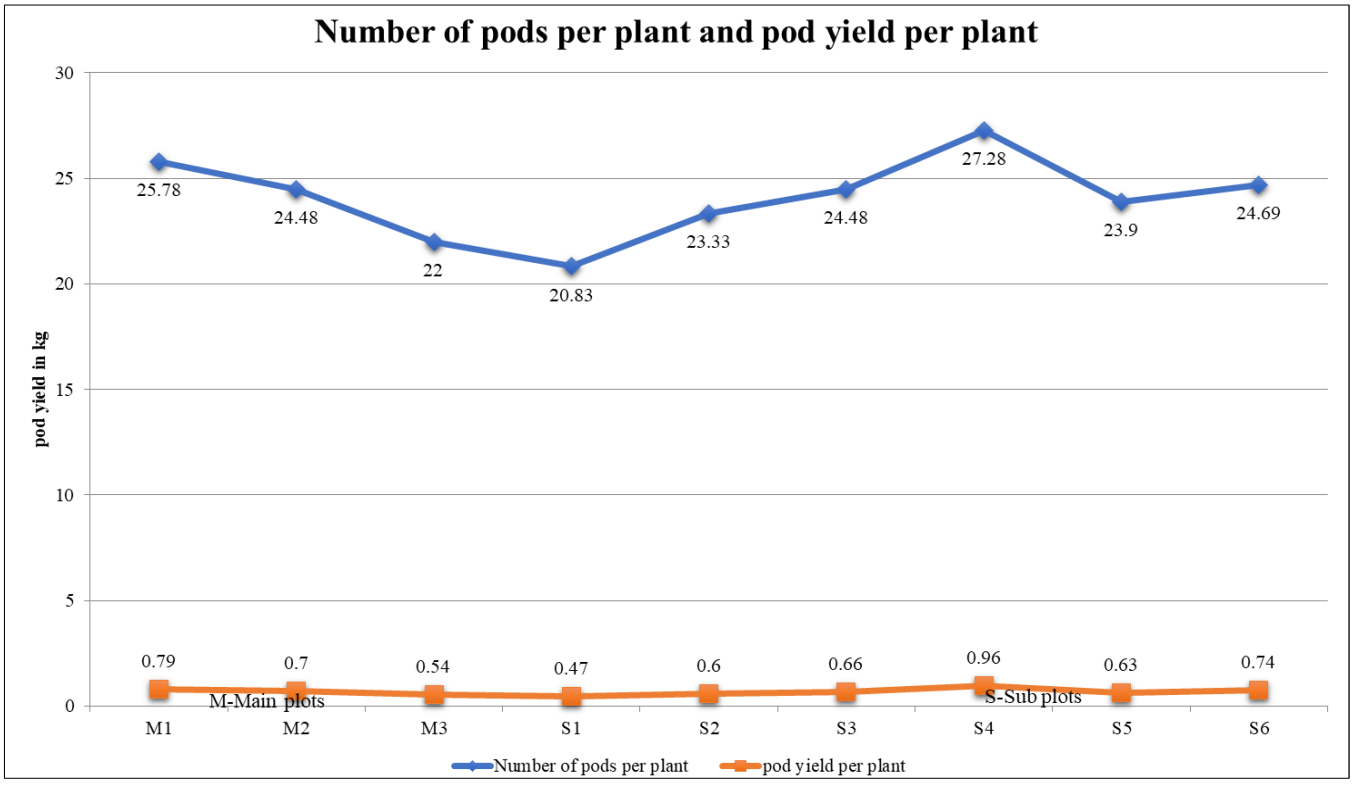

Fig 2: Effect of foliar application of moringa leaf extract and salicylic acid on mumber of pods per plant and pod yield per plant (g) under moisture stress conditions

Table 3: Effect of foliar application of moringa leaf extract and salicylic acid under moisture stress conditions on number of pods per plant and pod yield per plant (kg) of okra at the harvesting stage

Main Plot / Sub Plots	Number of pods per plant				Pod yield per plant (kg)			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	21.60	20.93	19.96	20.83	0.52	0.49	0.41	0.47
S_2	23.01	26.81	20.17	23.33	0.50	0.79	0.50	0.60
S_3	25.96	25.85	21.63	24.48	0.78	0.69	0.52	0.66
S_4	31.00	26.34	24.49	27.28	1.23	0.87	0.79	0.96
S_5	26.37	21.80	23.54	23.90	0.81	0.59	0.50	0.63
S_6	26.73	25.17	22.19	24.69	0.92	0.77	0.52	0.74
Mean	25.78	24.48	22.00		0.79	0.70	0.54	
	SE (M)		CD		SE (M)		CD	
MP	0.58		2.28		0.027		0.106	
SP	0.78		2.24		0.046		0.133	
S at M	1.34		3.88		0.080		0.230	
M at S	1.41		4.34		0.069		0.207	

M1: Moisture stress at 20 DAS (up to 50% FC) S1: Control (Distilled water) S4: 30% MLE at weekly once
M2: M1+ Moisture stress at 40 DAS (up to 50% FC) S2: 10% MLE at weekly onceS5: SA @ 1.0 mM at 20, 40 and 60 DAS
M3: M1+M2+ Moisture stress at 60 DAS (up to 50% FC)S3: 20% MLE at weekly onceS6: SA @ 2.0 mM at 20, 40 and 60 DAS

Conclusion

In the present investigation, morphological parameters and yield parameters were poor under severe moisture stress conditions and foliar application of 30% MLE at weekly intervals enhanced the morpho-physiological and yield parameters of okra followed by 2 mM Salicylic acid at three intervals.

Regarding morphological and yield parameters, it is concluded that moringa leaf extract @ 30% sprayed weekly once recorded the highest values in plant height, total fresh weight, total dry weight, number of pods per plant and pod yield per plant followed by Salicylic acid @ 2 mM, However MLE is recommended to the farmers due to its cheaper availability, non-toxic and eco-friendly nature.

References

1. Ali MA, Abbas A, Awan SI, Jabran K, Gardezi SDA. Correlated response of various morpho-physiological characters with grain yield in sorghum landraces at different growth phases. Journal of Animal and Plant Sciences. 2011;21(4):671-679.
2. Culver M, Fanuel T, Chiteka AZ. Effect of moringa extract on growth and yield of tomato. Greener Journal of Agricultural Sciences. 2012;2(5):207-211.
3. Emongor VE. Effects of Moringa (Moringa oleifera) leaf extract on growth, yield and yield components of snap beans (*Phaseolus vulgaris*). British Journal of Applied Science & Technology. 2015;6(2):114-122.
4. Fuglie L. New uses of moringa studied in Nicaragua. ECHO Development Notes. 2000;68:1-25.
5. Khandaker MM, Azam HM, Rosnah J, Tahir D, Nashriyah M. The effects of application of axeogenous IAA and GA3 on the physiological activities and quality of *Abelmoschus esculentus* (Okra) var. Singa 979. Pertanika Journal of Tropical Agricultural Science. 2018;41(1):209-224.
6. Kwajaffa AM, Isa P, Olusola AA. Effects of soil moisture content and soil fertility amendments on growth and yield of Okra plant (*Abelmoschus esculentum* (L) Moench) in Southern Guinea Savanna Agro-Ecological Zone of Nigeria. Scientific Research Journal. 2015;3(2):267-273.
7. Maity U, Bera AK. Effect of exogenous application of brassinolide and salicylic acid on certain physiological and biochemical aspects of green gram [*Vigna radiata* (L.) Wilczek]. Indian Journal of Agricultural Research. 2009;43(3):194.
8. Rady MM, Mohamed GF, Abdalla AM, Ahmed YH. Integrated application of salicylic acid and Moringa oleifera leaf extract alleviates the salt-induced adverse effects in common bean plants. Journal of Agricultural Technology. 2015;11(7):1595-1614.
9. Rana MS, Hoque TS, Abedin MA. Improving growth and yield performance of cauliflower through foliar application of moringa leaf extract as a bio-stimulant. Acta Scientifica Malaysia. 2019;3(2):07-11.
10. Thomas H, Howarth CJ. Five ways stay green. Journal Experimental Botany. 2000;51:329-237.
11. Makkar HP, Siddhuraju P, Becker K. Plant secondary metabolites. Totowa, NJ, USA: Humana Press; c2007.
12. Cakmak I. Enrichment of cereal grains with zinc: agronomic or genetic biofortification?. Plant and soil. 2008;302:1-7.