Biostatistical And Physiological Analysis Of Leaf Area Index Of *Eleusine Coracana* Under Stress

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Abstract
Leaf area index is an important parameter which determines the yield of the crop. The crop responses variedly to physical stress at the regional scale due to the complexity, diversity of crop characteristics and farmers 'management practices along with the difficulties in quantifying those agronomic management practices at reasonable temporal and spatial scales. There was significant decrease in the values of LAI under extreme salt stress condition indicating total reduction in area due to salt stress. The increased level in LAI in *Eleusine coracana* crop plants may probably be due to induction of tolerance to presowing salt treatment. Rise in the level of LAI under 2 days water stress condition is quite significant indicating better adaptive conditions under moderate water stress in *Eleusine coracana*.

Key words:- Leaf area index, salt stress , presowing salt treatment , water stress , *Eleusine coracana*

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Introduction

Impact of different physical stresses on crop growth and productivity is one key concern with respect to crop production and food security under climate change. Crop responses varied to physical stress at the regional scale due to the complexity, diversity of crop characteristics and farmers 'management practices along with the difficulties in quantifying those agronomic management practices at reasonable temporal and spatial scales.

M. Battaglia *et.al.,* observed combined relationships between LAI in both *Eucalyptus nitens* and *Eucalyptus globulus* where marked differences in the effect of suboptimal growth temperatures on LAI were observed between species. André Graniera *et.al.,*,(2000), while working for a generic model of forest canopy conductance dependent on climate, soil water availability and leaf area index, revealed that when soil water was not limiting, water vapour (gc)was shown to increase linearly with LAI in the range 0 to 6 m2 m–2 and reach a plateau value. The study of the Leaf Area Index (LAI) variation along the crop cycle has paramount importance in the development of crop growth and their yield. The interaction between plants and environment determine the crop yield which is directly related to the solar radiation intercepted by the leaves for photosynthesis. Porter and Gawith, 1999; Zhao *et.al.,* 2007; Gupta *et.al.,* 2010 , reported more rapid senescence or even forced maturity due to exposure to extreme high temperature causes damage in the leaf photosynthetic apparatus of winter. While Yi Chen *et.al*.,2017 observed that higher average temperature and extreme high temperature lead to more rapid decrease of LAI in winter wheat. CAO Guang,2017 revealed that water logging stress in open bolls stage improves growth of the softwood, and increases cotton leaf area. Higher dry weight in root of pre treated seeds crop plants has been reported. Reduced LAI due to average salinity has been shown in *Eleusine coracana* (Chavan, 1980), and in *Nicotiana tobacum* (Gujar, 1983). However, rise in the level of LAI under 2 days water stress condition is quite significant indicating better adaptive conditions under moderate water stress in both the cultivars.

Material And Method

The seeds of *Eleusine coracana* were sown in different pots and were watered for one month. After a duration of 30 days plants were irrigated with different concentrations of NaCl such as 10, 30, 80 and 150 mM.

To study the ability of the crop to resist drought, the plants were deprived of water. This was achieved by watering the plants after intervals of 2, 4, 6 and 8 days.

Effect of salt stress was also studied by giving a presowing salt treatment to the seeds. These seeds were allowed to germinate and further grow for a period of 30 days. The seedlings were then irrigated with saline water of different conductivity.

All experiments had one set of plants which were irrigated with water and this served as control.

In the experiment, the LAI of *Eleusine coracana* was calculated through measuring the area of leaves. And the formula is shown as follows:

$$\mathbf{LAI} = \frac{\mathbf{A}}{\mathbf{A_0} \times \mathbf{N}}$$

Where ,

LAI is the leaf area index of *Eleusine coracana* planted in one measuring plot;

A_0 is the representative of leaf area of *Eleusine coracana* in one measurement plot;

N is the number of *Eleusine coracana* planted in one measuring plot;

A is the area of one measurement plot.

- The data were also statistically analysed using SPSS version 25 and the means were compared by Duncun's post hoc test ($p < 0.05$).

Results and discussion

Effect of Increasing Salt Stress on Leaf Area Index (LAI)

Leaf area index is an important parameter which determines the yield of the crop. LAI is defined as a leaf area over a certain ground area (Sestak *et al.,* 1971). The rate of dry matter production in a standing plant depends on LAI as well as NAR (Voldgeng and Simson, 1976; Cock and Yoshida, 1973).

The *Eleusine coracana* was grown under increasing salt-stress and the LAI was determined in the crop of both varieties at intervals of 10 days and the results obtained are represented in figures 1. From the data it is evident that there is increase in the level of LAI up to 70 days and afterwards there is gradual decrease up to 90 days in both the cultivars under control condition. The value for LAI lies in between 0.86 to 1.51 in Dapoli-3 variety and 0.83 to 1.41 in HR-374 in plants grown under control condition. These results depict that there is increase in the values of LAI by 11.6 % and 12.1 % at 90 days over control in both the crops; the crop was irrigated with NaCl at a concentration of 8 mM. However the values for LAI declined in the crop plant, when irrigated with NaCl at concentrations of 30 and 80mM. These results also reveal that after 90 days, values of LAI decreased by 39.5 % in Dapoli-3 cultivars grown under extreme salt stress conditions .

A reduction in the LAI due to salinity is a known fact. The work of Hall (1972) indicates that in white pine, accumulation of Na^{++} and Cl^{-} reduce the length of the needle. Deleterious effects of salinity such as defoliation in grape, guava and olive plants have been reported. Chyung and Lapina (1974) have reported that under saline conditions, productivity of corn, sunflower and bean reduces due to delay in the formation and decrease in size of assimilatory surface of leaves. Meiri and Poljakoff Mayber (1970) observed 20 to 40 % reduction in bean plants when they were exposed to NaCl. Heikal (1976) observed reduction in leaf area in kidney bean due to salt stress.

Reduced LAI due to average salinity has been shown in *Eleusine coracana* (Chavan, 1980) in *Cajanus cajan* (Deshpande, 1981) and *Nicotiana tobacum* (Gujar, 1983). Kokate (1984) while studying salt tolerance and salt sensitive cultivars; of rice under salt stress reported that there is significant increase at 8 mM salt treatment in salt sensitive cultivars while at 10 mM salt stress, salt tolerance cultivars show increase in the level of LAI. He further reported that, at higher salt stress, there is 30 % to 50 % decrease in values of LAI in rice cultivars. Mal et al., (1992) while studying leaf area from leaf and total mass measurements in peanut showed closed relationship between leaf area and leaf dry weight. Salvi (1995), while studying physiology of *Dolichos biflorus* growing under saline condition, reported decrease in the LAI and NAR values under salt stress conditions. Venkatesan and his colleagues showed decrease in leaf area per plant under 600 mm NaCl treated *Ipomoea* plants (Venkatesan et al., 1997).

In the present investigation, the values of LAI in both the crop plants grown under 8mM NaCl salt stress condition that seems to be stimulatory. However, there was significant decrease in the values of LAI under extreme salt stress condition indicating total reduction in area due to salt stress.

Leaf Area Index (LAI) in salt presowing treated crop

Leaf area index (LAI) is the single important criteria over which by and large the yield is dependent. The leaf area index and net assimilation rate were studied in crop raised from salt presowing treated seeds. The salt treatment with increasing concentration was given to growing crop and the results obtained are represented in figures 2. It is evident from results that, the value for LAI goes on decreasing as crop ages. However, the level of decrease is by 40.69 % and 50 % in Dapoli 3 over control when drown under higher salinity i. e. 80mM and 150mM salt stress. However, the values for LAI remains at higher level in 8mM salt presowing seed treatment of Dapoli 3 by 8.13 % at 90 days. Controlled seeds of the cultivar showed comparatively higher level of LAI as compared to their salinity. Higher dry weight in root of pre treated seeds crop plants has been reported. There are number of examples where yield is positively correlated with LAI (Palit *et.al.*,1976). Heikal (1976) observed reduction in leaf area in kidney bean due to salt stress. Reduced LAI due to average salinity has been shown in *Eleusine coracana* (Chavan, 1980), and in *Nicotiana tobacum* (Gujar, 1983). Salvi (1996) observed increase in total leaf area and dry matter production in crop plants, when seeds were raised from water and 8mM pretreated seeds, during the study of the effect of presowing salt treatment in *Dolichos biflorus*, when grown under increasing salt concentrations.

Results in the present investigation showed trend for increasing leaf area and production of dry matter in crop plants, when grown under moderate salinity. The values for LAI remained in higher range in same crop raised from 8 mM salt presowing treatment and grown under moderate salt stress condition. This increased level in LAI in crop plants of the cultivars may probably be due to induction of tolerance due to salt presowing treatment.

Leaf Area Index (LAI) under water Stress

The Leaf Area Index (LAI) was studied in the cultivars, Dapoli 3 and the results obtained are represented in figures 3. It is evident from the results that, there was decrease in the level of LAI due to water stress condition in *Eleusine coracana*. LAI decreased with increasing stress. The decrease in the level at 8 days water stress condition was 40.7 % at 90 days in Dapoli 3.

In a study germplasm of cowpea (*Vigna unguiculata*) was screened for their ability to withstand water stress and it was observed that LAI reduced in all genotypes. LAI has been shown to decrease under drought in mulberry. Lot of work has been done at IRRI on water stress effect in rice and its leaf response. A study evaluated the adaptation of rice to drought prone environment. It pointed out that the drought causes overall reduction in the size of the leaves that ultimately reduced the value for LAI. Analysis carried out by CAO Guang et.al (2012) showed that LAI in the cotton bud period stage and flowering and ball-setting stage is restrained by water logging stress, which is opposite to LAI in the cotton ball opening stage they also observed that Leaf area index (LAI), or named as coefficient of leaf area, is referred to the ratio of gross leaf area and floor space, that is, LAI equals gross leaf divided by floor space. M. Battaglia et.al., observed that LAI declined linearly with water stress in two varieties of Eucalyptus. According to Sakhabutdinova *et al.*, (2003) , application of Salicylic acid was responsible for the alteration of phytohormones levels in wheat under varying water stress conditions. Shahbaz *et al.*, (2011) also found that foliar-applied glycinebetaine (GB) caused the adverse effects of drought stress by enhancing plant biomass and leaf area per plant in various genotypes of wheat crop compared to water stressed conditions. Hussain et al., (2008) observed that exogenous glycinebetaine (GB) and Salicylic acid (SA) application significantly improved various parameters of vegetative and reproductive growth under water stress in sunflower. Ali *et al.*, (2011) revealed that plant stress at 50 and 75 percent of field capacity caused reduction in leaf area, plant height, and biomass, however, these ill-effects were reversed by spraying of synthetic cytokinins, benzyl amino purine (BAP) and leaf extract of *Moringa oleifera* respectively in maize crop. Ali *et al.*, (2011) also reported that spray of Salicylic acid (SA) caused accumulation of *osmolytes* in chickpea (Cicer arietinum L.) crop. Yi Chen (2017) observed that the unclear mechanism and unavailable input data together could lead to biased estimation on key state variables of crop growth such as LAI, evaporation, or soil water. Granier A *et.al*.,(1996) and Cienciala E. *et.al*.,(1992), reported time lag between sapflow and canopy transpiration has been often reported, even when the vapour flux above a stand was directly measured . Jarvis P.G.(1976), had revealed that this phenomenon is due to water exchanges between tissues and the transpiration stream within the trees .

LAI is a dynamic indicator of the growth state of treatment crop. In some extend, crop production increases with LAI, when LAI rise to some limits, the production goes down on the contrary. That is because the covering of branches and leaves reduces light in the field and it also lower the photosynthetic efficiency. Results obtained from the present investigation showed that, there was decrease in level of LAI in the cultivars, Dapoli 3 under extreme water stress condition. However, rise in the level of LAI under 2 days water stress condition is quite significant indicating better adaptive conditions under moderate water stress in both the cultivars.

The data were statistically analysed using SPSS version 25 and the means were compared by Duncun’s post hoc test ($p < 0.05$).

Table: Leaf Area Index of *Eleusine coracana* grown under stress

Treatment	**Concentration**	**50 Days**	**60 days**	**70 days**	**80 Days**	**90 Days**
	Control	1.527±0.015	1.327±0.021	1.133±0.015	0.937±0.015	0.873±0.015
	8mM	1.933±0.006	1.450±0.030	1.230±0.020	1.120±0.010	0.977±0.015
	30mM	1.343±0.021	1.223±0.015	1.033±0.025	0.830±0.020	0.747±0.021
	80mM	1.210±0.020	1.053±0.038	0.970±0.010	0.773±0.015	0.677±0.015
Salt Stress	150mM	0.193±0.015	0.820±0.036	0.827±0.021	0.663±0.031	0.533±0.015
	Control	1.567±0.021	1.377±0.015	1.217±0.012	0.980±0.017	0.923±0.02
	8mM	1.590±0.010	1.480±0.01	1.323±0.021	0.983±0.06	0.923±0.021
	30mM	1.113±0.015	1.030±0.020	0.980±0.010	0.823±0.023	0.623±0.023
Pre sowing salt stress.	80mM	1.047±0.032	0.947±0.015	0.847±0.035	0.740±0.017	0.527±0.029
	150mM	1.040±0.026	0.810±0.010	0.790±0.020	0.633±0.030	0.447±0.015
	Control	1.517±0.012	1.330±0.017	1.140±0.017	0.953±0.023	0.870±0.017
	2 Day	1.830±0.035	1.540±0.017	1.350±0.035	1.230±0.035	1.113±0.006
	4 Day	1.333±0.040	1.227±0.029	1.033±0.040	0.860±0.035	0.723±0.023
	6 Day	1.140±0.052	1.030±0.035,	0.867±0.023	0.753±0.012	0.670±0.017
Water stress	8 Day	0.947±0.029	0.740±0.017	0.670±0.017	0.607±0.012	0.527±0.029

Each value is the mean and SD of three replicate measurements.

Three-way ANOVA showing variation leaf Area index between, stress, concentration/ days of stress

Source	**df**	**F**	**P value**
Stress	2	87.842	.000
Days	4	4106.574	.000
Concentration	4	5490.943	.000
Stress * Days	8	29.170	.000
Stress * Concentration	8	117.733	.000
Days * Concentration	16	143.360	.000
Stress * Days * Concentration	32	81.751	.000

Inference: Leaf area index is significantly influenced by different stress levels, on different periods of exposure

Plants of *E. coracana* treated with 8 mM NaCl showed 1s3 % increase in leaf area index in saline stress as compared to control plants than in pre salt treated crops (10.2%)while crop at 2 days drought stress also shows 12% increase in LAI .Then in all given stresses, the LAI goes in decreasing as salinity increases in salt treated and salt pre treated plants also in case of water stress, with increase in duration of drought ,LAI decreases.

Conclusion

The physical stress affects to carry out some changes in their Leaf Area Index(LAI). The change in LAI shows that the physical stress must be making changes in physiology of crop plant as the photosynthetic area is reduced. The ANOVA test applied to the same data confirm that Leaf area index is significantly influenced by different stress levels, on different periods of exposure.

Fig:- 1 Leaf Area Index of *Eleusine coracana* under salt stress

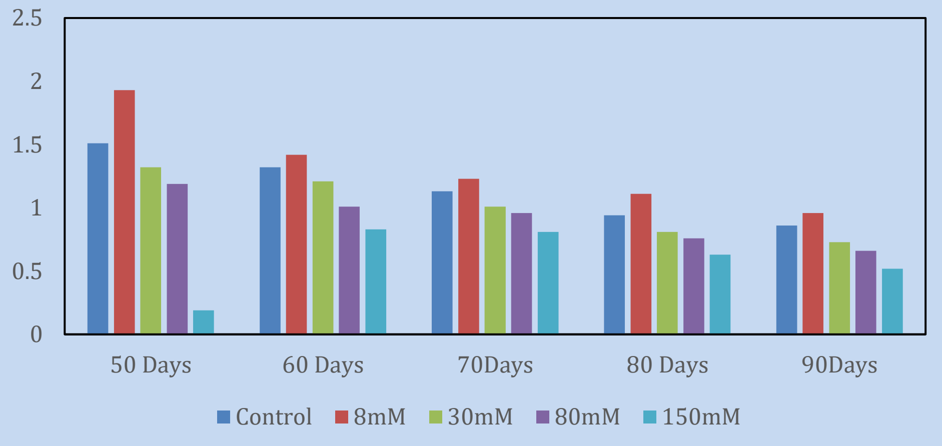


Fig:-2 Leaf Area Index of *Eleusine coracana* under pre sowing salt stress

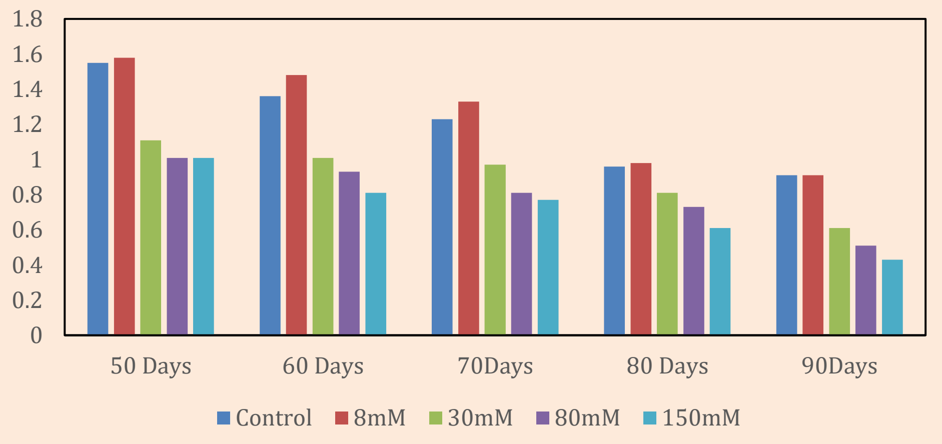
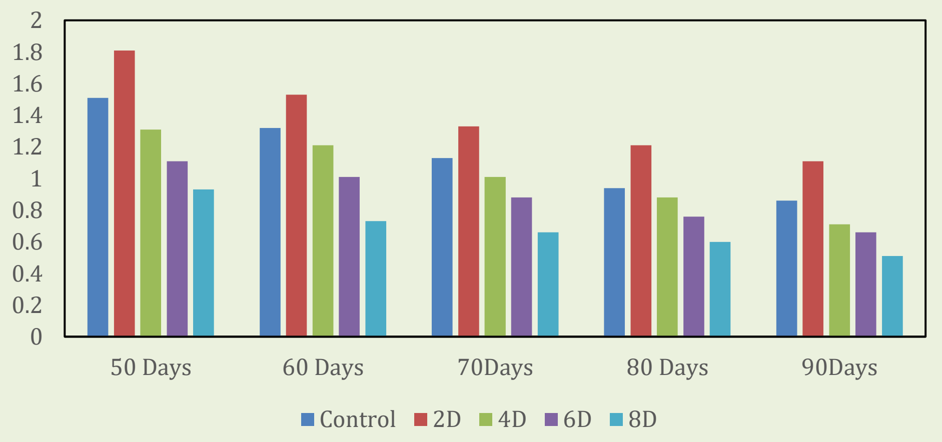


Fig:- 3 Leaf Area Index of *Eleusine coracana* under water stress



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