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SHORT COMMUNICATION

AZOSPIRILLUM APPLICATION ON RECOVERY OF DROUGHT STRESSED RAGI (*ELEUSINE CORACANA* GAERTN)

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Influence of *Azospirillum* inoculation on recovery of drought stressed *Eleusine coracana* was studied. Drought stress caused a sharp decline in total nitrogen content, soluble proteins, proline content and *in vivo* nitrate reductase ac.ivity in leaves. On rewatering, the recovery from stress was much faster in *Azospirillum* inoculated plants as compared to the uninoculated ones. It appears that *Azospirillum* inoculation alleviates the stress effect in ragi.

Drought stress caused an increase in nitrate and total nitrogen content (Mattas and Pauli, 1965) and total soluble protiens (Stutte and Todd, 1968). Accumulation of proline has also been found in water stressed plants (Savitskaya, 1967). Nitrate

Table I. Effect of drought stress on total nitrogen, soluble proteins, proline

Parameters	Uninoculated control plants					Uninoculated stressed	
	Plant age (days)					Plant age	
	38	45	52	55	60	38	45
Total nitrogen (mg/g dry leaf)	38.25 ±0.27	29.00 ±0.26	27.00 ±0.25	28.00 ±0.3	29.00 ±0.2	22.80 ±0.28	27.50 ±0.3
Soluble proteins (mg/g fr. leaf)	3.25 ±0.25	3.50 ±0.27	7.50 ±0.3	6.01 ±0.25	10.50 ±0.5	4.00 ±0.3	2.50 ±0.2
Proline (mg/g fr. leaf)	1.50 ±0.25	2.50 ±0.4	10.00 ±0.75	2.50 ±0.4	2.50 ±0.5	1.50 ±0.25	6.25 ±0.3
In vivo nitrate reductase activity (μ moles NO_2^- formed/h/g fr. leaf)	0.88 ±0.03	0.63 ±0.02	0.06 ±0.01	0.53 ±0.05	1.04 ±0.02	1.03 ±0.05	0.81 ±0.03

± Standard deviation.

reductase is considered as the rate limiting enzyme in nitrogen assimilation. Water stress is known to decrease the activity of nitrate reductase in plants (Bardzik *et al.*, 1971). Application of nitrogen has been reported to reduce the adverse effect of drought on dry matter and grain yield of pearl millet (Lahiri, 1980). *Azospirillum*, a Gram negative bacterium associates with C_3 and C_4 grasses and fixes atmospheric nitrogen. Inoculation with Azospirillum increased the yield and total nitrogen content in cereal crops (Kapulnik *et al.*, 1981). The present study reports the influence of *Azospirillum* inoculation on recovery of drought stressed *Eleusine coracana*.

Eleusine coracana (Co-11) seeds were treated with *Azospirillum lipoferum* (commercial inoculum obtained from Agricultural College and Research Institute, Madurai) and sown in earthen pots (10" diameter and 12" height) filled with red soil. Five days after sowing, the seedlings were thinned to 10 plant per pot. Tap water was used to water the plants. All the experimental plants were maintained in a green house under conditions of broad day light. Drought stress was given by withhold ing water supply for a specific period of plant growth (*viz.* 45th day to 52nd day).

Dry weight was determined by drying the plant materials in an oven at 90°C till the weight became constant. Total nitrogen content (Umbreit *et al.*, 1972), proline content (Bates *et al.*, 1973) and soluble proteins (Lowry *et al.*, 1951) were measured colorimetrically. For *in vivo* nitrate reductase assay 1 mm leaf sections

and *in vivo* nitrate reductase activity in leaves of *E. coracana*

drought plants			*Azospirillum* inoculated drought stressed plants				
(days)			Plant age (days)				
52	55	60	38	45	52	55	60
25.00 ±0.25	27.00 ±0.28	29.00 ±0.3	27.00 ±0.27	28.50 ±0.29	26.00 ±0.31	30.00 ±0.4	32.00 ±0.35
12.00 ±0.6	10.00 ±0.7	12.50 ±0.75	2.50 ±0.2	12.00 ±0.5	4.00 ±0.3	11.00 ±0.5	13.50 ±0.65
65.00 ±0.5	5.00 ±0.28	5.00 ±0.28	10.00 ±0.7	1.50 ±0.3	40.00 ±0.75	1.50 ±0.3	1.50 ±0.3
0.13 ±0.05	0.75 ±0.05	0.98 ±0.05	1.15 ±0.06	0.70 ±0.04	0.10 ±0.03	1.13 ±0.05	1.43 ±0.06

were introduced into test tubes containing 5 ml of assay mixture. The assay mixture was prepared by mixing 0.5 ml of n-propanol, 1.0 ml of 5% Triton X-100, 40.0 ml of buffered KNO_3 solution (0.68 g of KH_2PO_4 and 0.505 g of KNO_3 were dissolved in 34 ml of water and the pH was adjusted 7.5 with 2 N KOH; it was made upto 40.0 ml with distil'ed water) and 8.5 ml of distilled water. The assay was carried

Table II. Summary of "Two way ANOVA"

Source	df	SS	MS	F-ratio	Remarks
(a) *Total nitrogen*					
Treatment	14	504.10	36.01	24.00	**
(i) Age	4	85.91	21.48	14.32	**
(ii) Stress	2	116.22	58.11	38.78	**
(iii) Age × Stress	8	301.96	37.75	25.19	**
(iv) Error	30	44.96	1.50		
Total	44	549.06			
(b) *Soluble proteins*					
Treatment	14	715.19	51.08	4.92	*
(i) Age	4	405.53	101.38	9.76	*
(ii) Stress	2	51.29	25.64	2.47	@
(iii) Age × Stress	8	258.37	32.30	3.11	@
(iv) Error	30	311.53	10.38		
Total	44	1036.72			
(c) *Proline*					
Treatment	14	13608.85	972.06	920.98	**
(i) Age	4	8834.17	3434.46	3166.18	**
(ii) Stress	2	1225.49	612.74	564.88	**
(iii) Age × Stress	8	3549.19	443.65	408.99	**
(iv) Error	30	32.54	1.08		
Total	44	13641.39			
(d) *in vivo* nitrate reductase					
Treatment	14	6.88	0.491	8.72	*
(i) Age	4	5.97	1.49	26.50	**
(ii) Stress	2	0.57	0.29	5.07	*
(iii) Age × Stress	8	0.34	0.04	0.76	@
(iv) Error	30	1.69	0.056		
Total	44	8.58			

** indicates highly significant.
* indicates significant.
@ indicates not significant.

out at 30°C for 1 or 2 h in dark and the nitrite released into the medium was estimated by naphthylethylene diamine/sulphanilamide couple.

The results presented in table I showed changes in total nitrogen content, soluble proteins, proline content and *in vivo* nitrate reductase activity in leaves of ragi upon drought stress.

The results of "Two way ANOVA" tests (Table-II) showed that the age of the plant and the stress had significant influence over the various parameters such as total nitrogen content, soluble proteins, proline content and *in vivo* nitrate reductase activity. The interaction between the age of the plant and the stress was found to be significant for total nitrogen and proline, but not for soluble proteins and *in vivo* nitrate reductase activity.

The decrease in total nitrogen content of ragi during stress is similar to the finding obtained for *Sorghum* (Rego *et al.*, 1986), However, *Azospirillum* inoculation induced quick recovery as compared to the uninoculated plants. The accumulation of proline during drought stress is in accordance with results reported in barley (Savitskaya (1967). As has been shown (Barnett and Naylor, 1966), proline accumulation under stress could act as storage compound for carbon and nitrogen. This view is substantiated by the occurrence of high quantities of soluble proteins during the period of recovery from water stress.

The decrease in nitrate reductase activity during drought stress and subsequent recovery after rewatering is in accordance with the results of Bardzik *et al.* (1971). This increased activity during recovery period appears to be the result of greater mobilization of storage compound as energy source.

In conclusion, it may be suggested that *Azospirillum* inoculation can be exploited to alleviate the stress effects in millets like ragi.

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