

EFFECT OF ABSCISIC ACID AND KINETIN ON GROWTH AND PROLINE ACCUMULATION IN CACAO SEEDLINGS UNDER WATER STRESS*

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SUMMARY

The effect of exogenous ABA and kinetin applications on leaf expansion rate and proline contents was studied. The leaf growth was retarded during stress by ABA but recovery was faster after rewatering. Leaf turgidity was also maintained by ABA and proline accumulation was lesser as compared to control showing lack of relation between RWC and proline content. Kinetin effect on these indicators was similar to those of control.

INTRODUCTION

The accumulation of abscisic acid (ABA) and proline in plants subjected to water stress is reported earlier (Singh *et al.*, 1973). Due to increased ABA levels under drought, various physiological and morphological changes like stomatal closure and inhibition of vegetative growth occur which is important for survival under drought condition (Quarrie and Jones, 1977). The external application of ABA induced accumulation of proline which was similar to those caused by PEG or NaCl (Huber, 1974, 1979; Rajagopal and Anderson, 1978). The present paper describes the role of ABA and cytokinins on proline accumulation and leaf growth of cacao seedlings grown under water stress condition.

MATERIALS AND METHODS

Seedlings of cacao *Theobroma cacao* L. var. Forestro were raised in polybags filled with garden soil and FYM in 1 : 1 ratio. Three months old seedlings were drenched with kinetin and ABA at 10 mg/l concentration 15 days before inducing stress and repeated four times at three days intervals. Water stress was induced by withholding irrigations for seven days. Observations were taken prior to stress treatment, at the end of stress (stress) and 5 days after rewatering (recovery). Leaf growth rate was measured as linear elongation per day. Leaf discs having a size of 1 cm were floated on distilled water for 6 h and relative water content (RWC) was determined by the method of Weatherly (1950).

Proline was estimated by the method as described by Bates *et al.* (1973). Each treatment had two replicates with six plants each. Leaves sampled from each replicate were pooled for determinations. Overall means and standard errors were

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calculated to compare the treatments. The dry matter partitioning and leaf expansion rate were analysed using 'F-test'. RWC and proline were compared based on standard error only.

RESULTS AND DISCUSSION

There was a marked inhibition of leaf expansion rate in cacao seedlings during stress period. However, when statistically analysed there was no significant difference between the treatments, possibly because the variations among the expanding leaves were large (Table I). However, the leaf growth was better in ABA treated seedlings when the plants were relieved of stress. Thus, ABA appears to provide an adaptive role for survival during drought and better recovery after rewatering. The pattern of dry matter partitioning due to these treatments is presented in Table II. Although there was a general decrease due to ABA and an increase by kinetin in dry matter contents of leaf and root, the data were not significant.

TABLE I. Effect of ABA and kinetin on leaf expansion rate and RWC

Treatment	Expansion rate (cm/day)			RWC (%)		
	Pre-stress	Stress	Recovery	Pre-stress	Stress	Recovery
Control	1.76*± 0.41	0.58± 0.29	1.86± 0.23	85.7	59.5	91.3
ABA	1.62± 0.20	0.33± 0.11	2.43± 0.51	88.2	81.1	88.5
Kinetin	1.56± 0.20	0.59± 0.27	1.67± 0.24	90.7	63.9	87.2
ABA + Kinetin	1.48± 0.20	0.29± 0.08	1.88± 0.17	84.0	74.9	88.1
SE	NS	NS	NS	1.19	3.47	1.02

*Mean ± SE

NS = Not Significant

TABLE II. Dry matter partitioning after final harvest

Treatment	Dry matter yield (mg/plant)		
	Leaf	Stem	Root
Control	725 ± 120*	645 ± 230	198 ± 87
ABA	722 ± 248	557 ± 260	183 ± 68
Kinetin	820 ± 236	518 ± 210	240 ± 80
ABA + Kinetin	706 ± 316 NS	440 ± 100 NS	171 ± 55 NS

*Mean ± SE

NS = Not Significant

TABLE III. Effect on proline content

Treatment	Proline ($\mu\text{g/g}$ fresh weight)		
	Pre-stress	Stress	Recovery
Control	75.0	648.0	147.0
ABA	54.0	318.0	109.5
Kinetin	63.0	564.0	123.0
ABA + Kinetin	66.0	576.0	100.5
SE	2.9	48.8	6.8

The proline content in leaves increased dramatically due to drought (Table III). Proline content was less in ABA treated plants as compared to other treatments and it came down after recovery from the water stress. Our results are contrary to what is reported earlier for other crops. Abscisic acid treatment caused increased accumulation of proline (Huber, 1979; Rajagopal and Andersen, 1978) similar to those caused by water stress (Singh *et al.*, 1973) or salt stress (Huber, 1974, 1979). In cacao seedlings, it has been observed that the accumulation of proline was to a lesser degree whenever the turgidity of leaves was maintained under water stress by application of hormones like ABA (Table III) or cycocel (Balasimha and Subramanian—unpublished). Thus, it appears that endogenous ABA and proline levels are inversely related to leaf turgidity. The ABA treatment retained leaf turgidity as shown by high RWC and resulted in lower proline accumulation.

Leaf turgor is an important factor controlling ABA levels in water stressed leaves (Pierce and Raschke, 1980). The higher RWC of leaf was associated with lower proline content. It seems reasonable to assume that as the metabolic rates are high because of leaf turgidity due to ABA, proline might have been utilised efficiently. There is rapid growth after recovery from stress, and ABA thus facilitated osmotic adjustment and adaptability to stress environments. It has been reported that there is a direct correlation of proline with growth during the leaf rolling in barley plants (Rajagopal and Madsen, 1981) and similar results have been obtained in the present study.

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