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Effect of cycocel on seedlings of cacao (*Theobroma cacao* L.).

Resumen. Se estudió el efecto del cicocel (cloruro de 2-cloroetil trimetil-amonio) sobre plántulas de cacao sometidas a deficiencia de agua. El reactivo mantuvo la turgencia de las hojas. En las plántulas bajo condición de sequía la acumulación de prolina fue menor que en el testigo mientras que la actividad de la reductasa del nitrato fue mayor. Se discute el efecto del cicocel en plántulas de cacao bajo condiciones de sequía y en período de recuperación.

Cycocel (2-chlorethyl trimethylammonium chloride), a powerful growth retardant is reported to have beneficial effects on plants under stress environments (2,4). Cacao plants are sensitive to water stress and periods of drought from December to April in coastal India lowering the yield. Hence, a study has undertaken to study the effects of foliar application of cycocel on cacao seedlings under stress conditions with reference to growth and some metabolic parameters sensitive to water stress.

Material and methods

Seedlings were raised in polyethylene bags containing 1:1 mixture of garden soil and farm yard manure. The experiments were conducted in 3-month old seedlings. Cycocel (1000 ppm) was sprayed 4 times at 3 day intervals before stress treatment started. Water stress was induced by with-holding irrigations for 7 days. Measurements of leaf expansion was taken in 2-3 young leaves from 10 plants in each treatment. For biochemical analysis each treatment was divided into 2 replicates of 6 plants each. Fully expanded mature leaves were sampled from each plant and pooled in each replicate. Proline was extracted and estimated by the method of Bates *et al* (1). The Nitrate reductase (NR) activity was assayed by *in vivo* procedure (5). The relative water content (RWC) was determined by the method described by Weatherely (10). The experiment was repeated twice and statistically analysed wherever necessary.

Results and discussion

The results of the effect of cycocel treatment are presented in Table 1. The leaf expansion rate, though lower than in control before stress, was markedly improved under stress and recovery periods in cycocel treated plants. Increased growth by cycocel under drought has been reported (4). The RWC was maintained at higher levels in cycocel treated plants under stress conditions. Since turgidity was maintained, leaf growth was also relatively unaffected.

The proline content increased nearly 10-fold under stress in control, while cycocel (1000 ppm) treated plants had only 3-fold increase, and this declined sharply during recovery. Since the first discovery of accumulation of proline in leaves (6), it has been reported in several annual crops, but very scanty information is available in plantation crops (3, 7). In cereals, the tendency to accumulate more proline was accompanied by better adaptation to drought tolerance (9). It appears from the present results that the level of proline accumulated indicated degree of stress. As the turgidity of leaves was maintained under stress due to cycocel treatment, the proline

Table 1. Effect of cycocel on cacao seedlings.

Treatment	Pre-stress	Stress	Recovery
	Relative water content (%)		
Control	87.9	48.9	87.8
Cycocel	87.0	84.4	92.7
SD	0.61	19.42	2.83
	Leaf expansion rate (cm/day)		
Control	1.49	0.87	1.03
Cycocel	1.09	1.88	1.65
CD	0.38	0.35	0.50
	Proline content (μg/g fresh wt)		
Control	54.0	908.0	123.0
Cycocel	78.0	210.0	80.0
SD	10.8	355.9	22.1
	NR activity (μM NO_2^-/g fresh wt/h)		
Control	7.5	5.6	4.9
Cycocel	8.0	7.8	6.8
SD	0.7	1.3	0.9

content also did not show any marked increase. It is reasonable to assume that as the growth was comparatively better in cycocel treated plants, the proline might be utilized more efficiently in the protein synthesis required for such developmental process. Such correlations with regard to proline, growth and leaf rolling have been reported recently (8).

The NR activity in cacao was inhibited due to stress. The cycocel treated plants showed higher NR activity on fresh weight basis compared to control during stress period. The retention of NR activity can be explained by assuming that the metabolic activities of leaf are maintained at a higher rate under cycocel effect due to the maintenance of higher RWC which enabled efficient electron supply for nitrate reduction. Growth amelioration and better metabolic activity under stress with foliar cycocel application thus indicates that the chemical can be employed as a spray on cacao plants during periods of drought.

Summary

The effect of cycocel (2-chlorethyl trimethylammonium chloride) on water stressed cacao seedlings was studied. The chemical maintained the leaf turgidity. Proline accumulation was lesser as compared to controls and there was higher retention of nitrate reductase activity in leaves of plants under drought. The role of cycocel in cacao seedlings under stress and recovery is discussed.

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Comparison of indices of plant water status in two (*Celosia argentea* L. and *Amaranthus dubius* Mart. ex Thell) tropical leaf vegetables.

Resumen. Se estudió la relación entre los índices de contenido de humedad foliar conocida como contenido de humedad relativa (RWC), potencial osmótico, potencial de humedad foliar y la resistencia a la difusión de vapor de agua en la hoja (LDR). Las comparaciones entre índices se hicieron entre *A. dubius* y *C. argentea* creciendo la humedad de campo (lujuria) y humedad restringida (inadecuada).

Las relaciones fueron diferentes entre hojas jóvenes (superiores) y maduras (inferiores) y entre las dos hortalizas creciendo a diferentes contenido de humedad.

El potencial de humedad foliar en las hojas jóvenes es menor que en las maduras de *A. dubius,* proceso inverso cuando la planta crece con poca agua. Las hojas de *C. argentea* presentan un comportamiento similar, cuando crecen a capacidad de campo, incrementando significativamente en las hojas jóvenes bajo humedad restringida. Por cada unidad de descenso en el RWC en ambas especies, *A. dubius* sufrió una pérdida mayor en el potencial de humedad foliar que *C. argentea*

Para un valor dado de RWC, el LDR en plantas creciendo a humedad de campo mostró ligeros aumentos en *A. dubius* y ninguno en *C. argentea* tanto en hojas jóvenes como maduras. El LDR fue mayor en las hojas jóvenes de ambas especies sometidas a déficit de humedad.

Several researchers (5, 6, 7, 8, 12, 13), have studied the effect of plant water status on physiological processes. Four indices of water status are often used: leaf relative water content (RWC), sap osmotic potential (π), leaf tissue water potential (Ψ), and leaf water vapour diffusion resistance (LDR).

Shepherd (6, 7, 8), reported that the relationships between the indices and transpiration are not simple. However, it is worthwhile trying to elucidate the relationships because of their relevance to study of water movement in plants, plant growth analysis and modelling, and resistance to drought.

This paper compares the response of two tropical leaf vegetables. *Amaranthus dubius* and *Celosia argentea,* grown under conditions of field capacity and at limited water supply. The comparisons of relationships between the indices are made within and between the plant species.

Material and methods

Seeds of *A. dubius* and *C. argentea* were sown in sandy clay loam soil (20.6% clay) at the University of Ife Agricultural Farm, Ile-Ife.

The indices of plant water status considered are:

– leaf relative water content (RWC), which is the moisture content as a percentage of the fully saturated moisture content, was estimated according to Barrs (1);

– sap osmotic potential and leaf tissue water potential were determined using a simple termocouple psychrometer as described by Shepherd (8); and

– leaf water vapour diffusion resistance (LDR) was measured between 0900-1600 hours on young (upper) and old (lower) leaves attached to the parent plant, using an aspirated diffusion prometer as described by Byrne *et al* (2).

The first three indices were determined at 0900 and 1200 hours each day; and at two other times on three days per week on detached leaves. Each determination was carried out on young (upper) and old (lower) leaves, excluding damaged and senescent ones.

The experimental period for both species extended from the first week to the tenth week after germination, when the plants were harvested.

The two species were supplied with water at two levels. The treatments were imposed on two replicates of each species. One replicate of each species was watered so that the soil was approximately kept at field capacity, which will be referred to as 'luxury' plants. The other replicate was supplied water at one week intervals, resulting in frequent wilting, which will be referred to as 'inadequate' plants.