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EFFECT OF (2-CHLOROETHYL) TRIMETHYLAMMONIUM CHLORIDE ON THE GROWTH AND MINERAL UPTAKE IN SAFFLOWER

(*CARTHAMUS TINCTORIUS* L.)

M. SAEED, S.M. SHERE AND K.S. MEMON

Division of Plant Physiology
Atomic Energy Agricultural Research Centre. Tandojam, Sind.

Abstract

When safflower was grown in the presence of CCC, a significant reduction in the plant height and weight was observed. Cycocel, however, does not appear to have any significant effect on the mineral content of the plants.

Introduction

A large body of information is available on the effect of (2-Chloroethyl) trimethyl ammonium chloride, commonly, known as cycocel or CCC, on the growth of plants. Workers (Tolbert, 1960; Stoddart, 1964; Emden & Cockshull, 1967; El Damaty et al, 1965 and Wunsche, 1969) have observed that CCC has a retarding effect on plant growth. It appears that the reduction in growth is primarily due to the action of CCC on stem elongation (Cathey, 1964) and is generally attributed to the inhibition in the biosynthesis of gibberellin (Guttridge, 1966; Zeevart, 1966). However, stimulatory effect of CCC on plant growth has also been reported for pea (Adedipe et al, 1968), gladiolus (Halevy & Shilo, 1970) and begonia (Heide, 1969). Strawberry on the other hand appears to be unaffected by CCC treatment (Guttridge, 1966).

The effect of CCC on the uptake and distribution of minerals in plants has been studied to a comparatively lesser extent. El Eouly et al (1970) have reported that in cotton seedlings the total ^{32}P uptake was inhibited in the presence of CCC. In addition to the reduction in total ^{32}P uptake a change in its distribution pattern was also observed. Under the influence of CCC ^{32}P was found to accumulate in stem while there was a reduction in its root content. Aded ipe (1969) has reported that in presence of 1 ppm CCC, the concentrations of N, P and Mg increased in pea plants while that of Ca and K remained unchanged. When the CCC level was increased to 100 ppm the K concentration fell while the results for other elements remained same as in 1 ppm treatment.

Because of the lack of enough informations available the present work was undertaken to study the effect of CCC on the growth as well as the mineral content and its distribution in safflower.

Materials and Methods

Safflower (*Carthamus tinctorius* L.) seeds were germinated in trays containing moist sand and under darkness at room temperature (25 ± 2 °C). After 4 days the seedlings were taken out of darkness into light and after another 6 days these were removed from sand, roots washed with distilled water and transferred to plastic jars containing 4L of Hoagland solution alongwith varying concentrations of CCC (0, 100, 200, and 400 mg of CCC (a. i.)/L). The jars were covered with black cloth bags to protect the solution and plant roots from light.

The pots were kept in growth room in a completely randomised fashion under a photoperiod of 12 hours of light and 12 hours of darkness. The light was provided to the plants through an overhead panel fitted with thirtysix, 80 watt Osram fluorescent tubes and six, 60 watt incandescent bulbs. The panel could be raised by pulley arrangements as the plant grew in height, and its level was maintained a few inches above the plant tip.

Loss of water from the pots, by transpiration, was made up by addition of distilled water and the growth medium was renewed every 15 days. At the end of 30 days the plants were harvested and their height, number of leaves per plant and the fresh weights of top and root were determined.

The tops and roots were washed with distilled water and dried in an oven at 80 °C for 5 days. After the determination of dry weight the plant material was ground in a Wiley mill for mineral analysis. The ground material was digested in nitric—per chloric acid mixture (Johnson & Ulrich, 1959) and the solution was analysed for K, Na, Mg, Ca, total P and total N. Potassium and sodium were determined through flame photometer and Ca and Mg by titration with versene (Jackson, 1962). Total P was determined colorimetrically (Jackson, 1962) and total N by the micro-Kjeldahl method.

Results and Discussion

The results presented in Table 1 show that the presence of CCC in the culture solution caused a highly significant reduction in the plant growth as indicated by lower values of plant weight and height. This reduction in the plant growth was evident when the CCC concentration in the culture solution was 100 mg/L and a further increase in the CCC level upto 400 mg/L showed no significant change. Under the influence of CCC the plants became stocky and compact with thick succulant and rough textured leaves. The leaf colour was also much darker than in the control and at the age of about 20 days the upper leaves tended to curl upward.

There was a substantial reduction in both the top and root weights of the plants in the presence of CCC. However, it was observed that unlike the top, the reduction in dry weight of root was statistically not significant, though the decline in its fresh weight was highly significant. This anomaly could be explained by the fact that by analysis it was found that the moisture level in the root was significantly affected by CCC treatment.

From the data given in Table 2, it is evident that there exists a high positive correlation between the root growth and other plant growth characteristics. This shows that the primary effect of CCC, at least when applied through root, could be the inhibition of root growth which in turn affects the over all plant growth.

These observations of plant growth response in safflower to the presence of CCC were very much similar to what other workers have reported in the case of several other plant species (El Damaty et al, 1965; Stoddart, 1964; Tolbert, 1960 Emden & Ccockshull, 1967; Wunsche, 1969; Zeevaart, 1964). However, the actual mechanism by which CCC affects plant growth is still not known. Tolbert (1960) has put forward a hypothesis that CCC could be a competitive inhibitor of choline esterase because of its structural similarity to choline. Even if this explanation is correct, this cannot explain the effect of CCC in higher plants, because of the lack of any evidence about the presence of this enzyme in such plants. Choline is also known to be involved in lipid metabolism and methylation reactions. Alteration of any of these processes due to presence of structurally similar CCC, can result in altered cell development which in turn could lead to changes in the plant growth.

It has also been suggested that the reduction in plant growth could be due to the inhibition of gibberellin biosynthesis in the presence of CCC (Guttridge, 1966; Zeevaart, 1966). Reid & Crozier (1970), however, have observed that CCC instead of inhibiting, can in some cases stimulate gibberellin production. They have reported as much as 150 fold increase in the gibberellin content of pea due to the CCC treatment.

These observations thus support the contention of Cathey (1964) that the effect of CCC depends on the nature of plant species and it is very unlikely that this compound can affect all plants in an identical manner.

From the data presented in Table 3, it appears that the presence of CCC has little affect on the uptake and distribution of minerals in safflower. In view of the reduced growth, the total amount of various minerals in CCC treated plants was less than in control, but their percentage remained unaffected. In case of cotton, El Fouly et al (1970) have reported that the uptake of ^{32}P was inhibited in the presence of CCC. Adedipe (1969) has also reported a change in the concentration of various elements in pea due to treatment with CCC. He has also reported that plants treated with 100 ppm

CCC had a reduced growth and consequently the total amount of the above mentioned elements in these plants was less than the control, though in some cases an increase in their concentration was observed. The only exception to this was the total phosphorus content which increased despite the lower weight of the plants.

It is, therefore, concluded that under the present experimental conditions, no significant effect of CCC could be observed on the concentration of N, P, K, Na, Ca and Mg.

Table 1. Effect of CCC, applied through roots, on Safflower plant characters.

Parameter	Control	CCC mg/L (a.i.) 100	200	400
Height of the plant (cm)	21.250	14.120**	12.750**	13.620**
Number of leaves/plant.	19.250	16.500*	15.270*	16.250*
Fresh weight of top (g)	36.420	22.000**	15.800**	15.070**
Dry weight of top (g)	2.750	1.750**	1.310**	1.370**
Fresh weight of root (g)	11.570	7.070**	5.400**	5.350**
Dry weight of root (g)	0.550	0.386	0.334	0.325

* Difference significant from control at 5% level

** Difference significant from control at 1% level

a.i. Active ingredient.

Table 2. Coefficients of correlation between Safflower plant growth and root growth response to treatment with CCC.

Plant response	Fresh wt of tops (g)	No. of leaves /plant.	Dry weight of tops (g)	Height (cms)
Fresh weight of roots (g)	+0.977**	+0.815**	—	+0.878**
Dry weight of roots (g)	—	—	+0.909**	

** Significant at 1% level.

Table 3. Effect of CCC on the mineral content of safflower.

	Control	CCC mg/L (a.i.)		
		100	200	400
TOPS		(Per cent dry wt.)		
Nitrogen	5.28	4.70	5.18	5.20
Phosphorus	0.66	0.73	0.68	0.72
Potassium	6.25	6.53	6.00	6.13
Sodium	0.17	0.14	0.18	0.18
Calcium	2.42	2.95	2.69	2.33
Magnesium	0.59	0.53	0.60	0.54
ROOTS				
Nitrogen	3.90	3.80	4.22	3.88
Phosphorus	1.33	1.43	1.23	1.31
Potassium	8.38	7.50	7.66	7.75
Sodium	0.29	0.23	0.25	0.17
Calcium	1.85	1.95	1.67	1.45
Magnesium	0.33	0.45	0.47	0.57

References

Ade dipe, N.O. 1969. Growth, mineral uptake and phosphorus metabolism of *Pisum sativum* L. as influenced by air and soil temperatures, phosphorus nutrition and growth retarding chemicals. Ph.D. Thesis. The University of British Columbia.

Adedipe, N.O., D.P. Ormrod and A.R. Maurer. 1968. Response of pea plants to soil and foliar application of cycocel (2-chloroethyl) trimethylammonium chloride. Canad. J. Plant Sci., **48:** 323—325.

Cathey, H.M. 1964. Physiology of growth retarding chemicals. Ann. Rev. Plant Physiol., **15:** 271—302.

El Damaty, A.H., H. Kuhn and H. Linser. 1965. Water relations of wheat plants under the influence of (2-chloroethyl) trimethylammonium chloride (CCC). Physiol. Plant., **18:** 650—657.

El Fouly, M.M., A.A. Ismail and F.E. Abdalla. 1970. Uptake, distribution and translocation of P^{32} absorbed through roots of cotton seedlings as affected by CCC treatment. Physiol. Plant., **23:** 686—690.

Emden van, H. F. and K. E. Cockshull. 1967. The effect of soil applications of (2-chloroethyl) trimethylammonium chloride on leaf area and dry matter production by the brussels sprout. J. Exptl. Bot., **18:** 705—715.

Guttridge, C.G. 1966. The interaction of (2-chloreothyl) trimethylammonium chloride and gibberellic acid in strawberry. Physiol. Plant., **19:** 397—402.

Halevy, A.H. and Ruth Shilo. 1970. Promotion of growth and flowering and increase in content of endogenous gibberellins in gladiolus plants treated with the growth retardant CCC. Physiol. Plant., **23:** 820—827.

Heide, O.M. 1969. Interaction of growth retardants and temperature in growth, flowering, regeneration, and auxin activity of begonia x cheimantha Everett. Physiol. Plant., **22:** 1001—1012.

Jackson, M.L. 1962. Soil chemical analysis. Constable & Company, Ltd. London, p 151—154.

Johnson, C.M. and A. Ulrich. 1959. Analytical methods for use in plant analysis. Calif. Agr. Expt. Sta. Bull. No. 266.

Reid, D.M. and A. Crozier. 1970. CCC-induced increase of gibberellin levels in pea seedlings. Planta (Berl.), **94:** 95—106.

Stoddart, J.L. 1964. An assessment of (2-chloroethyl) trimethylammonium chloride as a potential aid to grass-seed production. J. Brit. Grassland Soc, **19:** 373—375.

Tolbert, N.E. 1960. (2-chloroethyl) trimethylammonium chloride and related compounds as plant growth substances. I. Chemical structure and bioassay. J. Biol. Chem., **235:** 475—479.

Wunsche, U. 1969. Growth retarding and stimulating effects of CCC on *Antirrhinum majus* L. Planta (Berl.), **85:** 108—110.

Zeevaart Jan, A.D. 1966. Reduction of gibberellin contents of pharbitis seeds by CCC and after-effects in the progeny. Plant Physiol., **41:** 856—862.