Response of drought - resistant and drought - susceptible maize cultivars to chlormequat application*

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COMPENDIO

Cultivares de maíz (Zea mays *L) resistentes y susceptibles a sequía se trataron con clormequat 5000 ppm sumergiendo la semilla durante 24 horas; luego se sembraron en bolsas de plástico con 1 kg de suelo en el invernadero. Al llegar a la 5a hoja se cerraron las bolsas de modo que el agua se perdiera solamente por transpiración. Se efectuaron dos experimentos teniéndose resultados similares. El clormequat determinó una reducción en la tasa de transpiración pero solamente en los cultivares susceptibles. La reducción de la transpiración no puede adscribirse a diferencias en el área de la hoja ni a la relación tallo/raíz. Tampoco hubo diferencias en la recuperación del "stress" por sequía ni en la capacidad de germinar en soluciones de alta molaridad. Por tanto las diferencias de comportamiento entre cultivares susceptibles y resistentes se suponen ser debidas a factores intracelulares en conexión con los materiales de la pared celular.*

Introduction

CHLORMEQUAT, also known as CCC, is a plant growth regulator; chemically is chloroethyl-trinetyl ammonium chloride. Its effects on cold and drought resistance and in general on the capacity to increase yields under adverse conditions have been studied for several years. In an experiment (5) it was demonstrated that the effect is a differential one, since it induces a greater water economy in drought-susceptible plants but not no in drought-resistant ones.

This paper is a further demonstration of such differential effect and also of other responses of drought resistant and susceptible cultivars to chlormequat application related to water economy.

General Material and Methods

This research was performed in the laboratories and greenhouse of the Instituto Tecnológico de Monterrey (México). Cultivars of maize *(Zea mays* L) were used; both drought-resistant: Sintético Precoz (SP) and Nuevo León Var. Sintética 1 (NL VS1), and drought-susceptible: Nuevo León Híbrido 3 (NL H3) and Nuevo León Híbrido 5 (NL H5). Values for field capacity and permanent wilting point of the soil used were investigated. There were 6 bags per treatment.

The following aspects of plant response to chlormequat were studied: rate of transpiration, plant height, foliar area, stem/root ratio, capacity of recovery from drought-stress, capacity of germination in solutions of high molarity and chlorophyll content per leaf weight.

Effects on Height and Transpiration Rate

Methodology

Two experiments were performed. Maize "seeds" were immersed in chlormequat 5000 ppm for 24 hrs: controls were immersed in water equal time. Then seeds were put in plastic bags with 1 kg. soil and grown in the greenhouse. When the 5th. leaf was beginning to develop the bags were watered to field capacity and closed so that water was lost only by transpiration. The bags were weighed every 5 days until the first plant reached the permanent wilting point. At that time they were measured and two days later the last weights were taken.

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Table 1.—Effect of chlormequat (CCC) on height and transpiration of maize (*Zea mays* L.) cultivars drought-susceptible and drought-resistant. First Experiment. Summer 1978. Data from 6 bags/treatment.

Response to drought	Cultivar and Treatment	Water (g) transpired at: 10 days	20 days	Height at 20 days
Resistant	SP CCC	67 ab	108 b	38 ab
	SP-Test	68 ab	102 b	40 ab
	NL VS1-CCC	69 ab	104 b	31 c
	NL VS1-Test	60 b	104 b	33 bc
Susceptible	NL H3-CCC	77 ab	117 ab	41 a
	NL H3-Test	82 ab	136 a	42 a

Treatments with the same letter had not significant difference after Duncan.

Both experiments were performed using the same methods but in the second one the soil was characterized in a presure chamber to know its water potential during the experiment.

Experimental Results

Results of the First Experiment are in Table 1. It can be seen that drought-resistant cultivars treated with chlormequat transpired as much, or even more than the controls. On the other hand, NL H3, susceptible to drought reduced transpiration in 15% when chlormequat was applied. Differences among treatments were masked because the plants had strong individual behaviour but, that not withstanding, differences between treated and non-treated NL H5 were clear.

The same response was found in the Second Experiment. In this case the experiment ended when the first plants used up the available water in the soil; these were NL H5 susceptible to drought. It was clear that NL H5 treated with chlormequat lost water more slowly than the control; statistically NL H5 with chlormequat lost as much water as SP which is a drought-resistant cultivar. The values of transpiration (Fig. 1A) were corroborated by values of soil water potential (Fig. 1B).

Effects on Leaf Area, Stem/Root Ratio and Drought-Stress

Methodology

Plants from the First Experiment were weighed. In plants from the Second Experiment the area of the 5th leaf was measured. In both experiments water was added to the soil 48 hrs after having reached the permanent wilting point and recovery from drought-stress condition observed during 8 days.

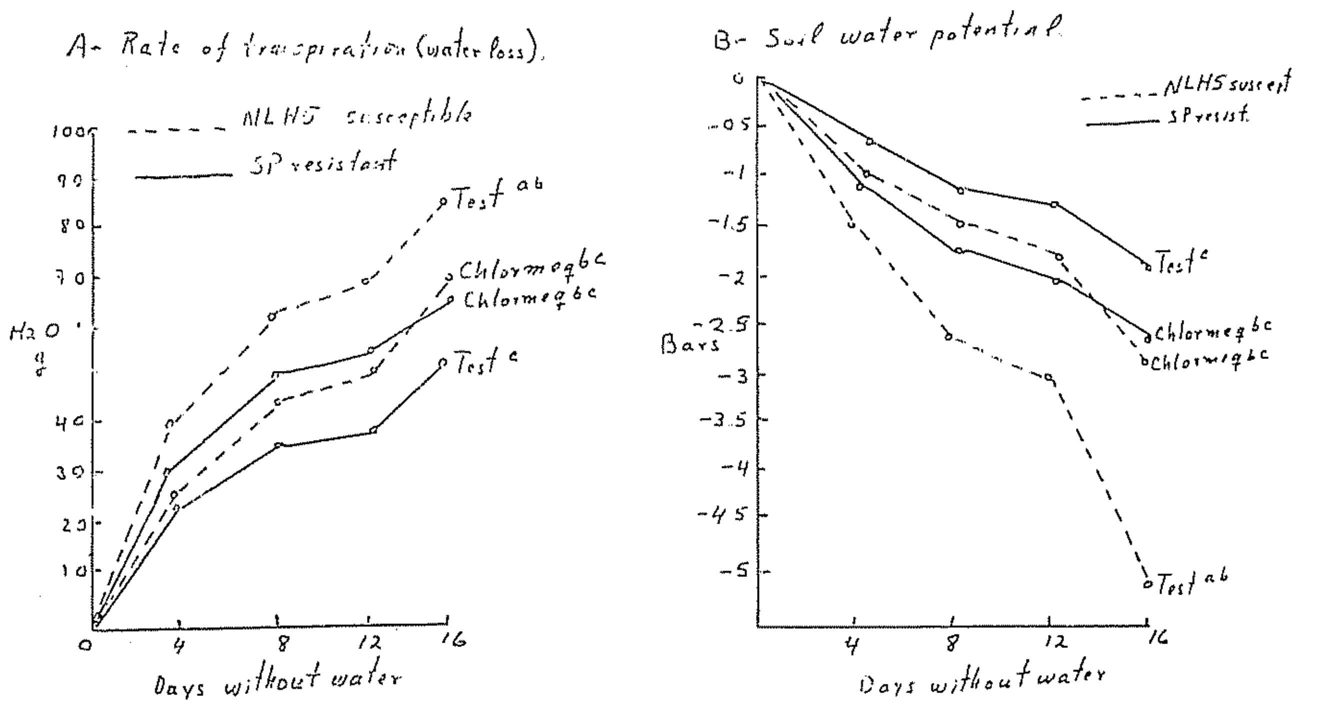

Fig. 1.—*Effect of chlormequat on water economy of two cultivars of maize* (Zea mays).

Table 2.—Effect of chlormequat (CCC) on leaf area, root/stem ratio and recovery from drought-stress condition of maize *(Zea mays)* cultivars drought-susceptible and drought-resistant. Second Experiment. Spring 1979. Data from 6 bags/treatment.

Response to drought	Cultivar and Treatment	Foliar area 5th leaf (cm)	Root/stem Ratio (g)	Recovery from Stress	
				1st Exp	2nd Exp.
Resistant	SP-CCC	57.6	0.4	Yes	No
	SP-Test	76.5	0.6	No	Yes
Susceptible	NL H3-CCC	—	0.5	No	—
	NL H3-Test	—	0.5	No	—
	NL H5-CCC	44.1	—	—	Yes
	NL H5-Test	66.0	—	—	Yes

Experiments Results.

Table 2 shows that chlormequat reduced leaf area in all cultivars about 20 per cent. On the other hand no effect was apparent on root/stem ratio. Results on the capacity of recovery from drought-stress condition are very inconsistent.

Effect on Germination in Solutions of High Molarity

Methodology

Experiments on the capacity of germination in solutions of hight molarity were performed by placing seeds in Petri dishes with 20 cc of sacarose solutions: 0, 0.2, 0.4, 0.6 and 0.8 M.

Dishes were sealed with plastic tape to prevent water loss and therefore change in molarity, and were kept in an incubator at 25°C. The criterium for germination was that the radicle measured 5 mm.

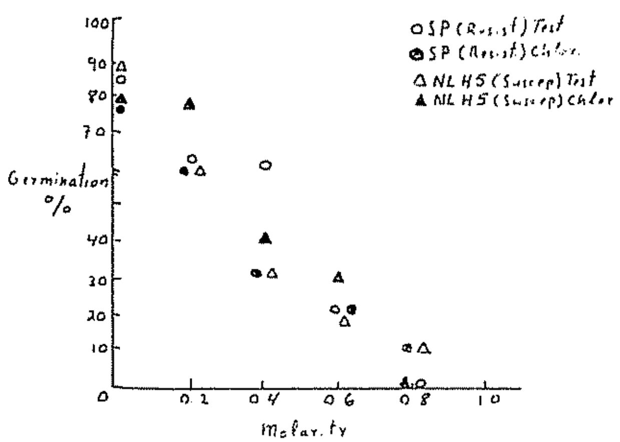

Fig. 2.—*Effect of chlormequat on germination of maize* (Zea mays) *cultivars in solutions of different molarities.*

Experimental Results

Results are presented graphically in Figure 2. The effect of the solution osmotic potential is clear, and it is inversely related to germination. There were no differences due to chlormequat; those found in the 0.4 M solution were not consistent with the other values.

Effects on Chlorophyll Content

From plants in the 5th leaf stage 10 g of leaves were taken. The pigments were extracted with acetone 80 per cent, until total extraction by a vacuum-pump and then acetone was added to make up 300 cc. The extraction and investigation of the chlorophyll content was performed after the method in Ross (6). Fig. 3

Discussion

The effects of chlormequat can be different in the several cultivars of a given species. In the case here presented it was confirmed that, as shown in a previous paper (5), the transpiration rate of drought-susceptible plants is lowered by the regulator whereas the drought-resistant plants remain unaffected.

The cause of the lower transpiration can not be ascribed to the reduction in leaf area since this effect was found in both types of cultivars. It has been reported that chlormequat determines a higher value of leaf water potential in some cultivars (3, 4, 7) but it is doubtful that it applies in the case here reported because, even though this value was not investigated, there was evidence that chlormequat did not increase the germination percentage of seeds placed in solutions of high molarity, which would be expected if the water potential of embryo cells would had been increased.

It was found too that the effects of chlormequat on the capacity of recovery from drought stress condition are quite erratic and that the effect on the stem/root ratio is non-existent or negligible. As suggested

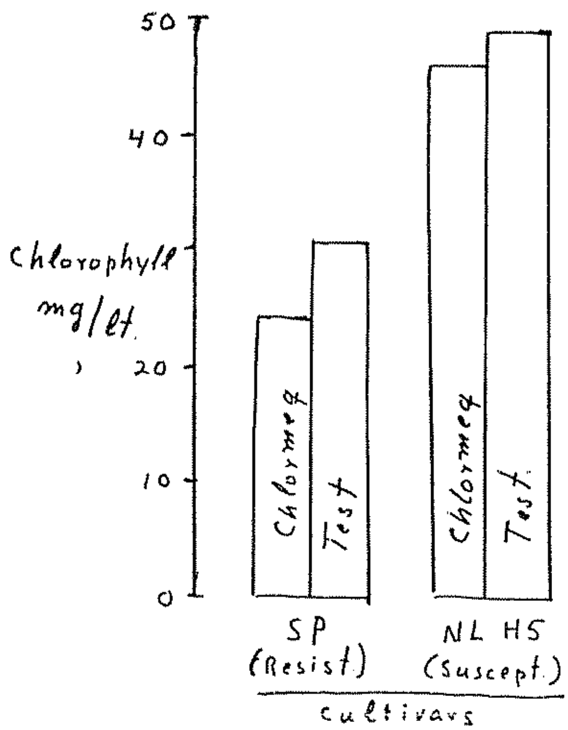

Fig. 3.—*Effect of chlormequat on chlorophyll concentration of maiz* (Zea mays) *cultivars in 5th-leaf stage*

by Ginzo *et al.* (2) the transpiration could be lowered due to some change in the cell walls, possibly by interacting with gibberellic acid on the calcium metabolism after the mode of action proposed by Castro and Malavolta (1).

Contrary to expectation chlormequat diminished chlorophyll content per gram of leaf. However this effect is in accordance with the report of Zakaryan and Vibarbyan (8) who state that the regulator inhibits chlorophyll synthesis during the growing period and retard degradation in later stages, since in the experiments here reported chlorphyll content was evaluated in plants in the 5th leaf stage.

Summary

Maize *(Zea mays* L) cultivars, both drought-resistant and drought-susceptible were treated with chlormequat 5000 ppm by immersing seed in the solution during 24 hrs. and then were grown in bags with 1 kg. soil in the greenhouse. At 5th leaf-stage the bags were closed so that water was lost by transpiration only. Chlormequat determined a reduction in the transpiration rate but only in drought-susceptible cultivars. Reduction in transpiration can not be adscribed neither to differences in leaf-area nor in stem/root ratio. Also, no differences were observed in recovering from water-stress ncr in the capacity to germinate in high-molarity solutions. Differences in behaviour between drought-susceptible and drought-resistant cultivars are probably due to intracellular factors

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