South African Avocado Growers' Association Yearbook 1987. 10:47-48.
Proceedings of the First World Avocado Congress

Nitrate nutrition as a tool to reduce chloride toxicity in avocado

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SYNOPSIS
Three levels of nitrate (2, 8 and 16 mMol) and four levels of chloride (2, 4, 8 and 16 mMol), in a complete factorial experiment, were given for two months to two avocado rootstocks, Mexican (salt-sensitive) and West Indian (salt-tolerant). An increase in the concentrations of nitrate in the irrigation solution reduced the Cl^- content in the leaves and enhanced the ability of the avocado plant to use increasing concentrations of saline water. Good growth was obtained at 16 mMol Cl^- in the presence of equimolar $N0_3$ concentration. The results of this study suggest that by raising the nitrate content in the irrigation water, the tolerance of avocado plants to salinity is increased.

INTRODUCTION

The avocado tree is one of the cultivated fruit trees most sensitive to salinity (6). Chloride concentrations in the irrigation water considered as tolerable for most crops, are detrimental to avocado. Accumulation of chloride in the leaves induces leaf necrosis, which develops from the leaf tip to its base. It results in reduced photosynthetic surface of the tree, earlier leaf shedding and decreased yield.

Secondary damage induced by salinity also occurs in the avocado. Trees grown under saline conditions are more sensitive to frost, mineral deficiencies, water stress, etc. Such trees suffer more from sunburn, because of their reduced foliage. The damage to the trees is also expressed in reduced root growth and hence, reduced water uptake from the soil.

In many species, competition occurs between chloride and nitrate uptake. Chloride uptake may be reduced by increased nitrate uptake (8). Sixty years ago, Haas mentioned that low nitrate concentration in the soil was followed by uptake of higher chloride quantities than those taken up when the nitrate concentration was high (4). In several experiments with avocado, increased nitrate nutrition resulted in decreased chloride toxicity (3,5,6). A field trial conducted in Israel showed reduced chloride content in the leaves and reduced leaf burn as a result of increased N fertilisation (2).

An experiment was conducted in Western Galilee, Israel, to investigate the relationship between chloride and nitrate and their effects on two avocado rootstocks. The results are still preliminary, but due to their high practical importance, it was decided to report on them before the end of the experiment and the drawing of final conclusions.

MATERIALS AND METHODS

Two rootstocks, West Indian (relatively salt-resistant) and Mexican (salt-sensitive), were seeded in the autumn of 1985. The seedlings were irrigated with tap water for six months, at which time they were transferred to 10 L containers filled with sand. During the following two months the seedlings were irrigated with nutrient solutions containing four levels of chloride (2,4,8,16 meq / L = 70,140,280,560 mg Cl^- / L) and three levels of nitrate (2,8,16 meq / L = 28,112,224 mg N-$N0_3$ / L), for a total of 12 treatments. Each treatment included eight seedlings of each rootstock, with one plant serving as a replication.

The nutrient solutions were prepared to maintain a constant ratio among the cations K^+:Ca^{2+}:Mg^{2+} (6:10:2 respectively). All solutions were included, also chloride and nitrate salts of K, Ca and Mg, also KH_2PO_4 (0,6 meq / L), $MgSO_4$ (0,2 meq / L), $CaSO_4$ (1,0 meq / L) and Coratin-mixed fertiliser of micro-elements (50 mg / L). Chloride levels covered the whole range of saline water used for avocado irrigation from 2 meq / L Cl^-, which is considered very good water, to 16 meq / L Cl^-, which contains more than the highest level recommended for avocado irrigation. The N-NO_3 levels also cover the full range of nitrogen applied to avocado plantations.

RESULTS

The data presented here were obtained after two months of irrigation with the nutrient solutions. Increased N-NO_3 concentrations had a significant effect in reducing damage under the highest Cl^- concentration in the nutrient solution (16 meq /L). It was proved with the two rootstocks, but the Cl^- toxicity was more pronounced in the case of the Mexican rootstock.

Chloride levels in the leaves were generally higher in the Mexican leaves than in the West Indian leaves. The increased Cl^- concentration in the solution induced a higher Cl^- content in the leaves, but usually this rise was reduced by increased N-NO_3 concentrations in the nutrient solution (Table 1).

The chloride concentration in the roots of the Mexican rootstock was lower than that in the roots of the West Indian (Table 2). With the increased Cl^- concentration in the nutrient solution, the Cl^- level in the roots also increased; the increase was more moderate in the West Indian than in the Mexican seedlings. Generally, Cl^- concentration in the roots was reduced with the increased N-NO_3 levels in the solution; the reduction was more pronounced in the Mexican rootstock.

TABLE 1 Effect of chloride and nitrate concentrations in the nutrient solution on chloride content (% dw) in the leaves of two avocado rootstocks

ROOTSTOCK	$N\text{-}NO_3$ cntr (meq / L)	CHLORIDE CONCENTRATION(meq/1)				
		2	4	8	16	Average
MEXICAN	2	0.68	1.08	0.88	1.97	1.15 x
	8	0.56	0.41	0.70	1.51	0.80 y
	16	0.53	0.53	0.78	1.11	0.74 y
	Average	0.59 c	0.68 c	0.79 b	1.54 a	0.90
WEST INDIAN	2	0.48	1.11	0.76	1.89	1.06 x
	8	0.33	0.61	0.82	1.42	0.80 y
	16	0.33	0.37	0.78	1.02	0.63 y
	Average	0.38 c	0.70 b	0.79 b	1.45 a	0.83

Averages followed by a common letter do not differ significantly at P=0.05.

TABLE 2 Effect of chloride and nitrate concentrations in the nutrient solution on chloride content (% dw) in the roots of two avocado rootstocks.

ROOTSTOCK	$N\text{-}N0_3$ cntr (meq / L)	CHLORIDE CONCENTRATION (meq / L)				
		2	4	8	16	Average
MEXICAN	2	1.00	1.05	0.80	1.58	1.11 x
	8	0.81	0.83	0.93	0.90	0.87 y
	16	0.83	0.58	0.71	0.76	0.72 y
	Average	0.88 b	0.82 b	0.82 b	1.08 a	0.90
WEST INDIAN	2	1.00	1.22	1.24	1.33	1.19 x
	8	1.03	1.07	1.30	1.57	1.24 x
	16	0.93	0.92	0.94	1.09	0.97 y
	Average	0.99 c	1.07 bc	1.16 b	1.33 a	1.13

Averages followed by a common letter do not differ significantly at P = 0.05.

DISCUSSION

The effect of nitrate on reduced chloride uptake was more pronounced in the Mexican than the West Indian rootstock. An eightfold increase in the Cl^- concentration in the nutrient solution induced a 1,2 to 1,5-fold increase in the Cl^- concentration in the West Indian roots vs a 1,6-fold rise in the Mexican roots. This was observed in the low $N\text{-}N0_3$-treated seedlings, while in the high $N\text{-}NO_3$ treatment, despite an eightfold increase in the chloride concentration in the nutrient solution, Cl^- did not increase at all in the Mexican roots.

The reduced Cl^- uptake resulting from the nitrate application, as well as the reduced damage due to salinity in the avocado seedlings, were also found in other species such as cotton, snap beans (1,11), tomato (9,10) and barley (7).

The preliminary observations reported on are of significance in reducing salinity damage to avocado plantations. Constant application of nitrates to saline irrigation water might reduce Cl^- damage to avocado trees, especially those grafted on the salt-sensitive Mexican rootstocks.

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