ΕΔΑΦΟΛΟΓΙΑ.— **Potassium - Magnesium antagonism in tomato and cucumber grown in plastic greenhouses,** *by P. H. Koukoulakis, A. D. Simonis, S. Bladenopoulou**, διὰ τοῦ Ἀκαδημαϊκοῦ κ. *Ἰωάννου Παπαδάκη.*

INTRODUCTION

The effect of the antagonistic KxMg relationship on plant nutrition has been a research subject since 1922 when Gardner first observed Mg deficiency symptoms in tobacco (Foy and Barber, 1958). The relevant investigations that followed eversince, showed that among the factors responsible for the decrease of plant Mg content, K plays an important role. According to Welte and Werner (1963), K fertilization is considered as the most important reason for the Mg deficiency in crops. In fact both the K added and the excess exchangeable K of soil, may act antagonistically on Mg (Foy and Barber, 1958).

The antagonism of K on Mg has been observed in many crops (McColloch et al., 1957, Foy and Barber, 1958, Adams and Henderson, 1962, Loue, 1978). Obviously this relationship becomes economically important, when the Mg content decreases below the critical level (0.5-0.9%) (Smilde and Roorda van Eysinga, 1968), to the extent that the yields are negatively affected (Welte and Werner, 1963, Tisdale et al. 1985). In certain cases, the KxMg relationship has not only an effect on leaf Mg content, but also on animal health, due to «grass tetany» caused by the low Mg content of fodder crops. In this case, it is not sufficient to maintain a Mg leaf content higher than the critical

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values, but also it is necessary to be still higher, for the physiological growth and development of animals (Welte and Werner 1963, Loué 1978).

In spite of the importance of the KxMg relationship on plant growth, very few workers have quantitatively evaluated its affect on crop yields. Adams (1978) states that the marketable fruit yield of cucumber decreased by 20% due to Mg deficiency owing to the application of high K levels, while Loué (1978) showed that the antagonistic effect of KxMg on yields may be positive when Mg is applied in a single doze and in combination with various K levels to soils with low K, Mg and Ca content. On the other hand, the application of high levels of Mg decreases the yields at the low K levels, while the effect of Mg is very small at the higher K levels. Results from wheat experiments conducted on calcareous soils (pH=8) with a low exchangeable Mg level, showed strong positive interaction between K and Mg. Addition of 60 Mg/ha to sugar beets increased yield by 11 ton/ha, while K decreased the yields in the absence of Mg, but it increased them when applied in combination with Mg (Loué 1978). Loué emphasizes, that the decrease of Mg leaf content is basically due to the low level of soil available Mg, rather than to the application of K. When the soil Mg level is low, it must be improved by the addition of Mg to such an extent that the use of high K levels will be possible without the occurrence of antagonistic effect of K. The decrease of K fertilizer application with the view to avoiding the effect of the KxMg relationship on yields and on Mg leaf content, is by no means a solution to the problem.

In Greece, the antagonistic effect of K on Mg becomes more serious with the time owing to the cultivation of dynamic crops such as maize and protected vegetables. Furthermore, the problem becomes more acute due to the intensification of Agriculture. The necessary use of high K levels is expected to make more acute the already existing Mg deficiency symptoms in tomato and cucumber grown in plastic greenhouses and to further increase its negative effect on yield and possibly on quality.

The complete lack of relevant information about the KxMg antagonism under Greek conditions for the evaluation of its effect on crop yields and the need to forecast its future influence on Agriculture, made necessary this research work, the specific purpose of which is to study the effect of KxMg antagonism on the Mg nutrition and yield of tomato and cucumber crops grown in plastic greenhouses in the area of Thessaloniki.

MATERIALS AND METHODS

The experiments were conducted in the area of Langada and Vasilika prefecture of Thessaloniki during 1981-84. The effect of four K levels (0, 200, 400, and 600 kg K_2O/ha) on tomato *(Lycopersicon esculentum Mill, cv. Derinia, GC-204 and Jolly)* and five levels (0, 200, 400, 600 and 800 kg K_2O/ha) on cucumber *(Cucumis sativus L, cv. Bambina and hyb-1453)* was studied. A randomized block design (Snedecor and Cohran, 1969) in four replications (Kaltsikis, 1983) and plot size 4.5 ×3 m and 3 ×2 m for tomato and cucumber, respectively, was used. The physical and chemical characteristics of soils were: SCL, $CaCO_3$=0.20-2.6%, ECx10^3=0.80-2.0 mmhos/cm (25°C), Organic matter=1.50-6.50%, available soil P (Olsen)= 70-150ppm, excepting one case where P was 5 ppm, available soil K (Dirks) =2.20-8.50 mg K_2O/100g and pH=6.8-7.3.

Fertilization: 400 kg N/ha were applied uniformly to all plots (1/3 as $(NH_4)_2SO_4$ basal dressing and 2/3 as side dressing (NH_4NO_3) in four dosages). Also, 1/2 of K as (K_2SO_4) basal dressing and 1/2 side dressing in 2 doses, and 300 kg P_2O_5/ha was applied basically to only one experiment as 0-20-0.

Leaf sampling: The tomato leaf samples were taken according to Smilde and Roorda van Eysinga (1968) and cucumber leaves according to Roorda van Eysinga and Smilde (1969). The leaves from each tretment were separated into three categories: blades (B), petioles (P) and whole leaves (B+P). They were washed with de-ionized water and dried in the oven at 88°±1 C. They then were ground and stored in plastic bags for chemical analysis.

Chemical analyses: 1g of dry matter was ashed at 550° C. The ash was disolved in 6N HCl and diluted with distilled water to 250ml. K was determined flamephotometrically and Ca and Mg volumetrically with 0.01 N EDTA (Jackson, 1960). The available soil P was extracted with 0.5 M $NaHCO_3$ (pH 8.5) (Olsen et al, 1954), and the soil K determined with the method of Dirks Scheffer (1933), while the organic matter with the Walkley-Black method (Modification by Axaris, 1971).

RESULTS

The cucumber and tomato yields obtaiued dnring 1981-1984 are shown in Table 1. In Fig. 1 the relationship between the K levels applied and the yields obtained as well as the leaf Mg content, is given. The antagonistic K effect on cucumber Mg content of leaves is given in Fig. 2, while the negative relationship between K and Ca leaf content for cucumber and tomato is depicted in Fig. 3.

DISCUSSION AND CONCLUSIONS

The application of K in various levels to tomato and cucumber, during 1981-84, did not increase, significantly, the marketable fruit yields. On the contrary, in certain cases K affected negatively the tomato yields (Exp. PLTK 1981 and 1984) and cucumber (PLAK 1983) (Tab. 1). This decrease in the case of tomato varied from 11.56-13.87%, while in cucumber it was about 8.0%, as compared to zero treatment.

Table 1

Effect of K on tomato and cucumber fruit yields (ton/ha)

Treatments kg/ha	PLTK-81	PLTK-82	PLTK-83	PLTK-84	PLAK-81	PLAK-82	PLAK-83	PLAK-84
0	177	131	120	150	128	84	187	181
200	154	125	132	153	141	96	175	192
400	161	131	130	141	131	87	174	192
600	153	145	145	133	140	82	172	202
800	-	-	-	-	148	89	183	210

As it is shown in Fig 1, application of K decreased fruit yields, and Mg content in tomato leaves up to 1.83% DM. This level was however higher than the critical value of 0.90% suggested by Smilde and Roorda van Eysinga (1968) below which deficiency symptoms may possibly appear. The maintance of the Mg content of leaves at a relatively satisfactory level, was due to the fact that the soils were sufficiently supplied with exchangeable Mg as shown by the Ca/Mg ratio which was smaller than 7 (Tisdale et al., 1985).

According to Welte and Werner (1963) the increased K use in plants grown on soils poor in Mg, causes the appearance of Mg deficiency symptoms. On the contrary, the application of high K levels to soils rich in Mg, increases both the Mg uptake by plants as well as the yields. That is why to soils poor in Mg, it is necessary that Mg be added along with the K fertilization (Welte and Werner, 1963, Loué, 1978).

Applied K not only acted antagonistically on tomato Mg leaf content (Fig. 1) but on cucumber as well (Fig. 2). Correlation between K and Mg leaf content showed a strong negative relationship in both tomato (Fig. 3), and cucumber. Similar correlation was found between Ca and K leaf content in cucumber.

The antagonistic effect of K on leaf Mg content explains to a great extent not only the non significant effect of the added K levels on fruit yields but also its negative effect on yields (Tab. 1).

The intensive fertilization with K is necessary in the case of protected vegetables due to the fact that they are K-loving crops. This necessitates the presence of the soil available Mg in high levels for overcoming the antagonistic effect of K on Mg and thereby avoiding the KxMg negative effect on yield (Welte and Werner, 1963, Loué, 1978).

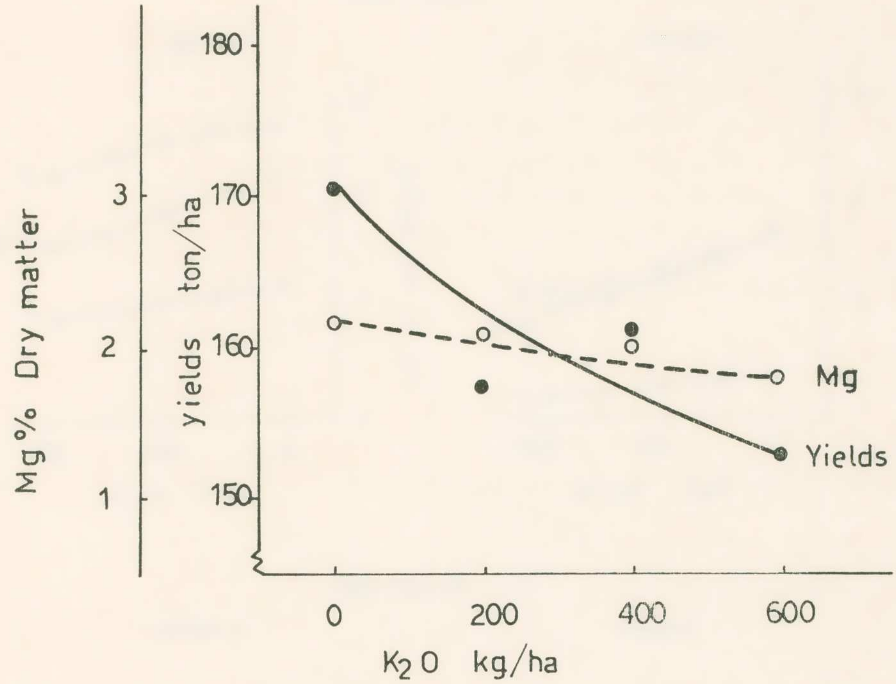
From the above discussion it is concluded that both K and the KxMg relationship act as controlling agents on Mg and K nutrition of tomato and cucumber. This is also supported by the fact that the ratio K/Mg of leaf could be used as an index of plant supply with K, owing to the close correlation found between the above ratio and the K leaf content of plants (Welte and Werner, 1963, Koukoulakis, 1986).

Summarizing the results of this work, the following may be stated:

—K affected antagonistically the Mg leaf content in both tomato and cucumber and decreased the marketable fruit yields. The negative effect of KxMg ranged quantitatively from a lack of response to applied K, up to the yield decrease by 11.56-13.87% and 8%, for tomato and cucumber, respectively.

—The decrease of the Mg level in leaves due to the K antagonistic effect, makes K and KxMg, controlling agents of the Mg nutrition of tomato and cucumber.

—The application of K in high levels, which are necessary for cucumber and tomato, not only for high yields, but also for the improvement of their quality, must be done in combination with Mg in case the soil is inadequately supplied with Mg. The maintainance in soil of a relatively high level of available Mg is necessary to counteract the negative effect of the KxMg on yields and quality of both tomato and cucumber.



1. Fig. Effect of K on marketable tomato fruit yields and leaf content (Blade+petiole) in Mg. (Exp. PLTK 1981).

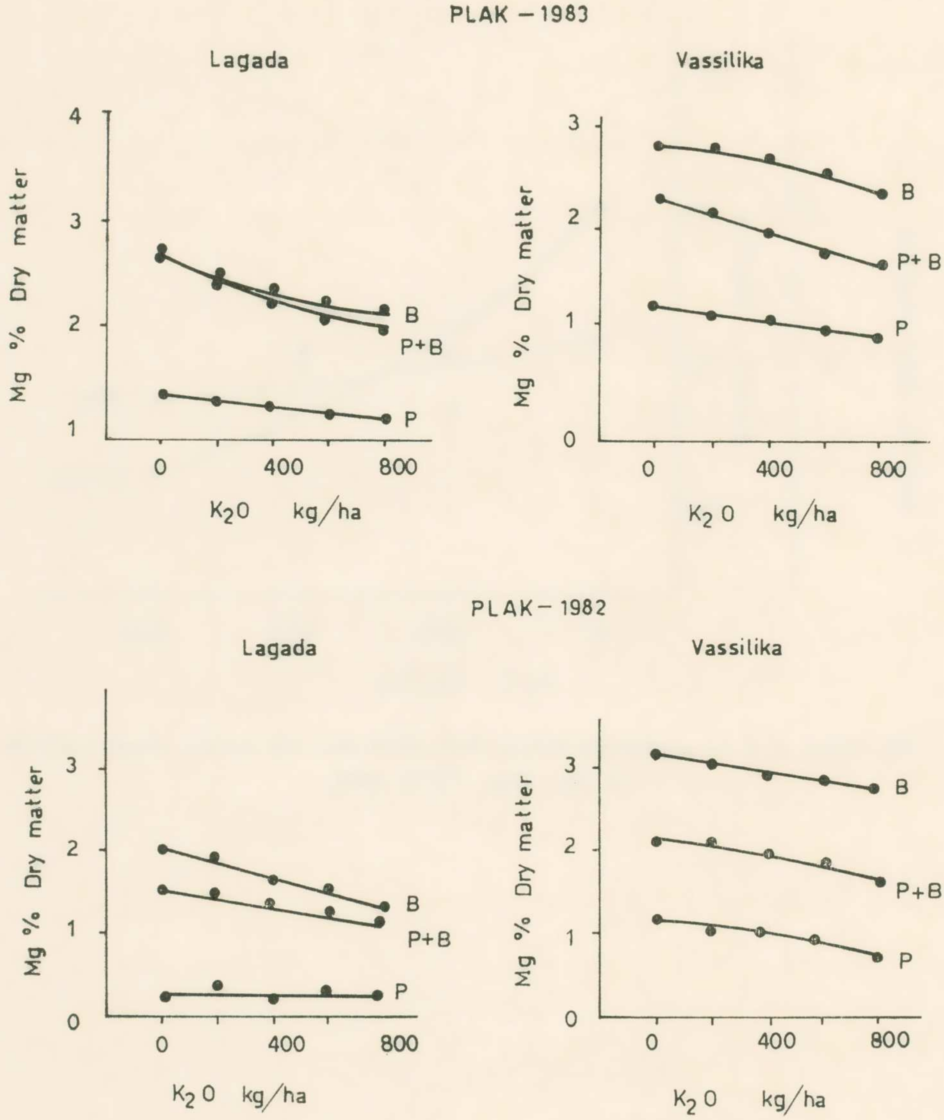


Fig. 2. Effect of potassium treatments on cucumber leaf (Blade=B, Petiole=P, whole leaf=B+P) dry matter Mg content.

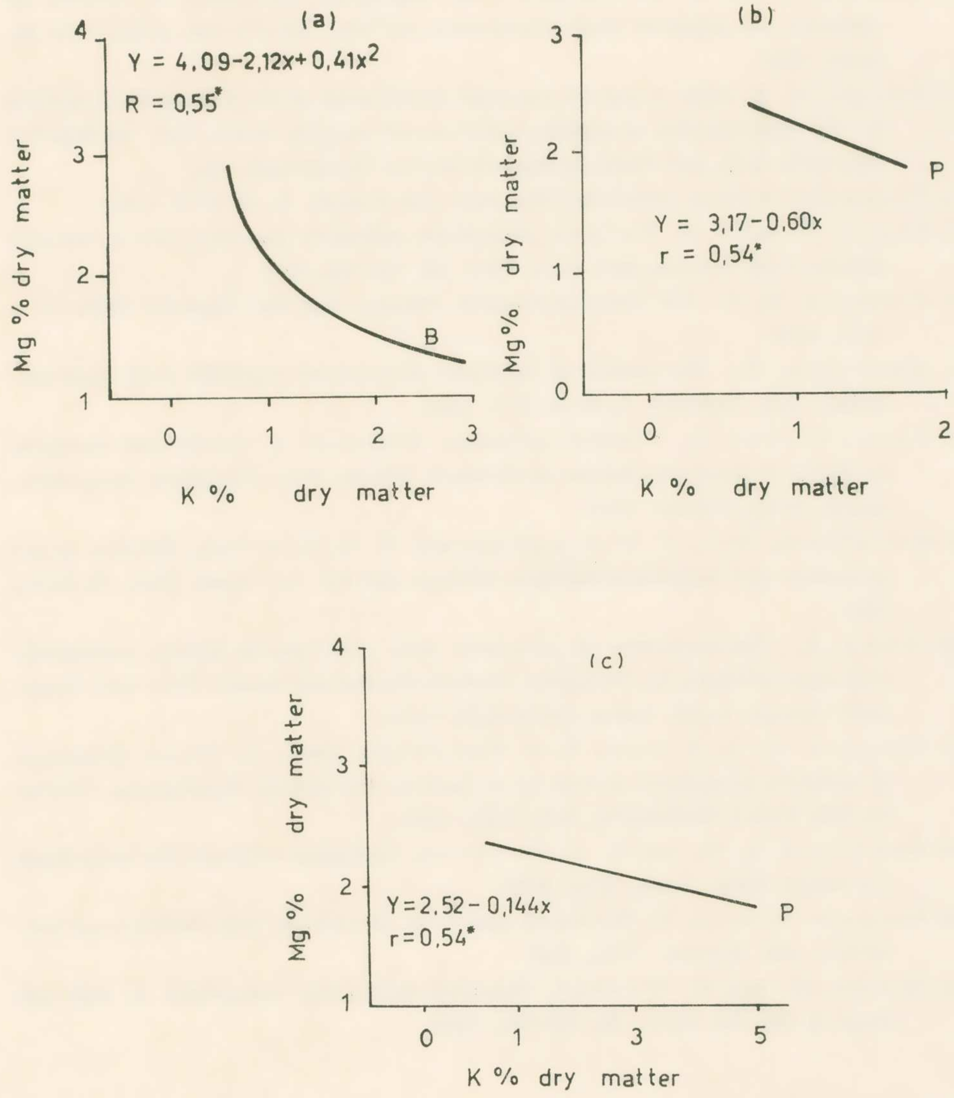


Fig. 3. Relationship between tomato leaf dry matter K and Mg content (blade B, and petiole P) (a=Exper. PLTK-1982, b=Exper, PLTK-1983 and c=PLTK-1982).

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ΠΕΡΙΛΗΨΗ

Ἀνταγωνισμὸς καλλίου - μαγνησίου στὴν ὑπὸ κάλυψη τομάτας καὶ ἀγγουριᾶς.

Σὲ πειράματα λίπανσης τῆς τομάτας (*Lycopersicon esculentum Mill, cv. Derinia GC-208* καὶ *Jolly*) καὶ ἀγγουριᾶς (*Cucumis sativus, L cv. Bambina* καὶ *Hyb-1453*). ποὺ πραγματοποιήθηκαν σὲ θερμοκήπια μὲ πλαστικὴ κάλυψη στὶς περιοχὲς Λαγκαδᾶ καὶ Βασιλικῶν τοῦ Νομοῦ Θεσσαλονίκης ἀπὸ τὸ 1981-84, ἐφαρμόστηκαν τέσσερα ἐπίπεδα K στὴν τομάτα (0, 20 40 καὶ 60 kg K_2O/στρ). καὶ ἕνα ἐπιπλέον (80 kg K_2O/στρ.) στὴν ἀγγουριά, σὲ πειραματικὴ διάταξη τῶν τυχαιοποιημένων ὁμάδων μὲ διαστάσεις τεμαχίων 3×2m καὶ 4,5×3m, ἀντίστοιχα, γιὰ τὴ μελέτη τῆς ἀνταγωνιστικῆς ἐπίδρασης τοῦ καλίου στὶς ἀποδόσεις καὶ στὴ θρέψη τῶν πιὸ πάνω καλλιεργειῶν μὲ Mg.

Βρέθηκε ὅτι τὸ K ἔδρασε ἀνταγωνιστικὰ στὴν περιεκτικότητα τοῦ Mg στὰ φύλλα τῆς τομάτας καὶ τῆς ἀγγουριᾶς καὶ μείωσε τὶς ἀποδόσεις ἀπὸ 11,6-13,9% στὴν τομάτα καὶ 8% στὴν ἀγγουριά. Ἡ σχέση K×Mg, λόγω τῆς ἀνταγωνιστικῆς δράσης της στὸ Mg τῶν φύλλων, δρᾶ σὰν ἐνεργὸς ρυθμιστικὸς παράγοντας στὴ θρέψη τῶν καλλιεργειῶν αὐτῶν μὲ Mg, ἰδιαίτερα στὰ χαμηλὰ ἐπίπεδα τοῦ διαθέσιμου Mg. Ἡ προσθήκη ὑψηλῶν δόσεων K θὰ πρέπει νὰ συνοδεύεται, στὶς περιπτώσεις χαμηλῶν ἐπιπέδων διαθέσιμου Mg στὸ ἔδαφος, μὲ παράλληλη προσθήκη Mg, ἐνῶ ἡ ἀποφυγὴ ὑψηλῶν δόσεων K γιὰ τὴν ἀντιμετώπιση τῶν δυσμενῶν ἐπιπτώσεων τῆς ἀνταγωνιστικῆς δράσης τοῦ K στὸ Mg, δὲν ἀποτελεῖ λύση τοῦ προβλήματος.