ΕΔΑΦΟΛΟΓΙΑ.— **Recovery by plants and exchange resin of fertilizer potassium which is fixed by soils**, *by A. D. Simonis**, διὰ τοῦ Ἀκαδημαϊκοῦ κ. Ἰωάννου Παπαδάκη.

INTRODUCTION

Many aspects, often contradictory, have been expressed, concerning the consequences caused on the plants by potassium fixation in the soils [4, 11, 14]. One consequence is the reduced availability of potassium. Nevertheless, this has a transient only character and may be considered as a disadvantange of short duration [5, 18]. According to the recent concepts [10, 17, 18], the fixation of potassium by soils is a process of conservation protection of potassium by soil, that minimize losses by luxury consumption in the plants and by leaching in the soil and acts, in the long term, beneficially for the plants.

Many research workers [1, 10] avoid to use the term «fixation» due to the fact that this term leads by itself often to misunderstanding and confusion. First of all, the term «fixation» is a relative concept, since many factors (mainly wetting-drying, temperature and level of exchangeable potassium of soil) are acting, so that the dynamic equilibrium in the system: fixed K $K \rightleftarrows$ exchangeable K moves towards the direction of fixation or desorption of potassium (10, 11, 13). Only the plant determines if and to what extent the fixed potassium defined by laboratory methods, is of no importance in terms of nutrition of plants. We should stop talking about «fixed» potassium in soil and talk about its ease of exchange ability [1].

The fixation of fertilizer potassium added to the soil and its afterwards removal by chemical extraction or by plants has been studied by many researchers [7, 8, 12]. Recently, it was noticed, in potassium fixation experiments in Nortern Greece soils, that significant amounts of K, fixed previou-

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* Α. Δ. ΣΙΜΩΝΗ, **Πρόσληψη ἀπὸ τὰ φυτὰ καὶ ρητίνη ἐναλλαγῆς τοῦ καλίου τῶν λιπασμάτων ποὺ δεσμεύεται ἀπὸ τὰ ἐδάφη.**

sly by soils, were subsequently released to exchange resin [16].

The purpose of the present investigation was to examine, comparatively, the recovery of fixed fertilizer potassium of soils by plants and exchange resin.

MATERIALS AND METHODS

Fourteen surface (0-25 cm) soil samles were selected from diferent locations of Nortern Greece and were subjected to various analyses in the laboratory, according to the standard procedures [6]. Some pedological and physicochemical characteristics of these soils are given in Table 1.

Two series of experiments were carried out:

1. —laboratory experiments of potassium fixation-release of potassium fixed with exchange resin and
2. —greenhouse recovery experiments of fixed potassium of soils by oat plants.

In the potassium fixation-release experiments, quantities of 1050 g from each soil in ninefold repetition (3 K levels - 0, 16, 32 mg K /100 g soil - X 3 replications) were transferred in plastic containers and mixed thoughout with distilled water and K_2SO_4 solution. The soils were dried at 30° C for 20 days and subjected to four cycles of wetting and drying.

For the determination of fixed K released to exchange resin (Amperlite 1R-120), 5 g of resin and 50 cc of distilled water were added, after the fixation treatment, in 10g of soil. The soil-resin-water mixture was stirred, at intervals, for a period of two weeks. The resin was selected from the soil, wasted with distilled water, then transferred quantatively, in an adequate glass apparatus and after washing with 50 cc of N HCl solution, the K released from the resin, was determined by flame photometry.

For the determination of the recovery of fixed potassium of soils by plants, the soils were —after the fixation experiments— fertilized with adequate amounts of N and P and cultivated in the greenhouse, successively, 3 times with oat plants. The harvested plant material of every cut was dried at 80° C, weighted and ground. The dry matter of plant meterial was ashed at 550° C, the residue was dissolved in a solution of 20% HCl and K was determined by flame photometry.

Determinations of exchangeable potassium were made by the ammonium acetate technique in the initial soil samples, as well as, in the soils a-

TABLE 1

General characteristics of soils studied

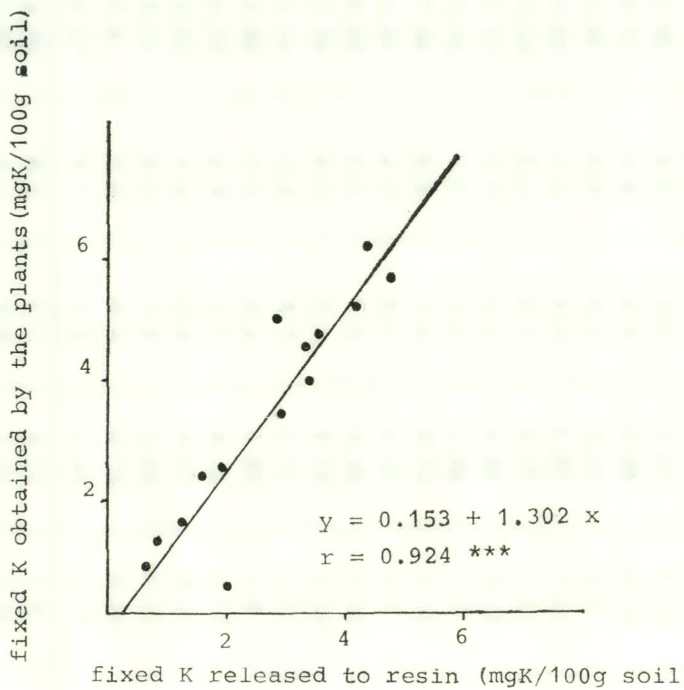
No Soil	Parent material*	Great Soil Group	Clay %	Silt %	pH	$CaCO_3$ %	Organic matter %	C.E.C me/100g soil	Percent K saturation %	Total K mg/100g soil
1	sch. micaceous	Acid Brown Forest Soil	18.8	45.6	4.72	-	3.07	19.90	4.42	1245.0
2	dep. mic. sch.	Red Mediterranean Soil	17.2	24.8	5.45	-	1.79	15.33	2.48	1950.5
3	dep. mic. sch.	Red Maditerranean Soil	10.8	27.6	5.05	-	4.81	13.05	2.07	2008.6
4	gneiss	Acid Brown Forest Soil	5.2	15.2	4.78	-	1.05	12.21	2.29	1294.8
5	alluvium	Alluvial Soil	29.2	17.2	5.95	-	0.50	36.37	0.47	1228.4
6	gneiss	Acid Brown Forest Soil	6.8	23.6	4.18	-	1.07	12.70	3.86	539.4
7	marl	Rendzina	36.8	27.6	7.03	3.2	1.52	34.98	2.89	1045.8
8	dep. mic. sch.	Red Mediterranean Soil	17.2	17.2	4.85	-	6.13	35.10	0.68	1626.8
9	dep. mic. sch.	Red Mediterranean Soil	8.8	17.6	4.45	-	3.38	12.08	2.15	1278.2
10	dep. mic. sch.	Acid Brawn Forest Soil	17.2	40.8	4.18	-	1.01	35.10	2.14	1817.5
11	dep. cal. mat	Red Mediterranean Soil	24.8	24.8	6.45	-	1.79	19.83	4.03	1016.7
13	greenstone	Acid Brown Forest Soil	11.2	39.2	4.95	-	6.87	22.83	3.15	1303.1
13	dep. cal. mat.	Red Mediterranean Soil	24.2	33.6	5.05	-	1.47	19.33	2.22	1261.6
14	alluvium	Alluvial Soil	27.1	46.5	7.53	3.0	2.80	20.95	1.75	1510.6

*dep. mic. sch.=deposits from mica schists, dep. cal. mat.=deposirs from calcareous materials sch. micaceous=schists micaceous.

TABLE 2

Quantities of K fixed by soils at two levels of K application and quantities of fixed K of soils obtained by three successive crops of oat and released to resin.

Soil samples	K added mgK / 100 g soil	Fixed K		Fixed K taken up by plants mgK / 100g soil	Fixed K released to resin mgK / 100g soil	Fixed K taken up by plants % of fixed K	Fixed K released to resin %of fixed K
		mgK / 100 g soil	% ot added				
1	16	9.1	56 9	2.4	1.7	26.4	18.7
	32	18.3	57.2	9.4	6.7	51.4	36.6
2	16	7.0	43.8	2.6	2.1	37.1	30.0
	32	9.0	28.1	3.4	2.9	37.8	32.3
3	16	9.0	56.4	4.0	3.5	44.4	38.9
	32	14.0	43.8	7.2	6.5	51.4	46.4
4	16	9.1	56.9	0.7	2.1	7.7	23.9
	32	12.5	39.1	1.9	3.2	15.2	25.6
5	16	12.5	78.1	5.7	4.8	45.6	38.4
	32	19.3	60.3	8.2	6.5	42.5	33.7
6	16	11.6	72.5	3.5	2.9	30.2	25.0
	32	21.2	66.3	8.0	6.4	37.9	30.2
7	16	3.6	22.5	1.3	0.9	36.1	25.0
	32	12.7	39.7	5.4	4.5	42.5	30.2
8	16	12.1	75.6	5.2	4.3	43.0	35.5
	32	21.9	68.4	5.4	5.0	24.7	22.8
9	16	7.7	48.1	5.1	2.9	40.3	37.7
	32	20.4	63.8	9.1	8.8	44.7	37.3
10	16	3.6	22.5	1.6	1.4	44.4	38.9
	32	11.2	35.0	3.7	3.2	33.0	28.6
11	16	10.2	63.8	4.7	3.6	46.1	35.3
	32	18.3	57.2	7.9	8.5	43.2	46.5
12	16	9.5	59.4	4.6	3.5	48.4	36.8
	32	13.3	41.6	7.1	6.4	53.4	48.1
13	16	11.8	73.8	6.2	4.5	52.5	38.1
	32	19.3	60.3	8.3	7.0	43.0	36.3
14	16	10.8	67.5	0.9	0.7	8.3	6.3
	32	17.4	54.4	2.5	1.6	14.4	9.2
Mean value	16	9.1	57.0	3.3	2.8	36.4	30.6
	32	16.3	51.1	6.3	5.5	38.2	33.5



Fif. 1. Relationship between the quantities of fixed potassium obtained by plants and rsin at the 16 mgK/100 g soil level of K application.

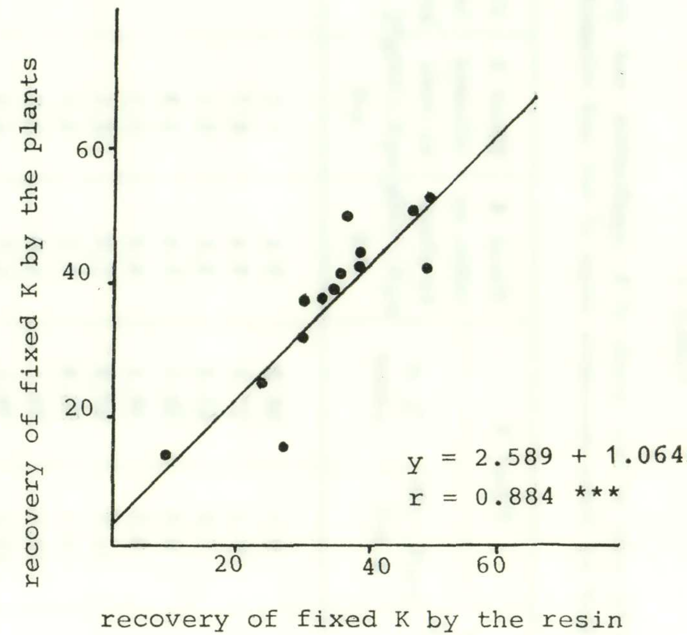


Fig. 2. Relationship between the recovery of fixed potassium of soils by plants and resin at the 32 mgK/100 hg soil level of K application.

fter the processes of the fixation, treatment of soils with exchange resin and cultivation of soils with oat plants.

RESULTS

The quantities of K fixed by soils at the 16 and 32 mgK/100 g soil levels of K application and the quantities of fixed K of soils, taken up by three successive crops of oat and released to resin, are given in Table 2.

The quantities of K fixed by soils at 16 and 32 mgK/100 g soil levels of K application were determined from the relationship:

fixed K=initial exchangeable K of soils+added K - exchangeable K of soil after the fixation.

The quantities of fixed K taken up by the plants and released to resin, were determined, for each soil, from the relationships:

1.— Obtained exchangeable K= initial exchangeable K (after the fixation) - final exchangeable K (after the cropping or treatment with resin)

2.— Obtained non exchangeable K= total K uptake - obtained exchangeable K.

3.— Obtained fixed K= obtained non exchangeable K from K-treated samples (native+fixed K) - obtained non exchangeable K from the control (unfertilized) samples (native K)

Figures 1 and 2 show the relations between the quantities of fixed K obtained by oat plants and released to resin, at the 16 and 32 mg K/100 g soil levels of K application.

DISCUSSION - CONCLUSIONS

The K fixation values in the studied soils, ranged from 3.6 to 12.5 and 9,0 to 21.9 mgK/100g soil, respectively, at the 16 and 32 mgK/100 g soil levels of K application, while the quantities of fixed K wich were obtained by plants, ranged from 0.7 to 6.2 and from 1.9 to 9.4 mgK/100 g soil, respectively (Table 2). On a percentage basis, the quantities of K obtained by the plants, ranged from 7.7 to 52.5% of the fixed K, with a mean value of 36.4%, and from 14.4 to 53.4%, with a mean value of 38.2%, respectively, for the 16 and 32 mgK/100 h soil levels of K application (Table 2).

The quantities of fixed K released to exchange resin, ranged from 0.7

to 4.8 and from 1.6 to 8.8 mg K/100 g soil, at the 16 and 32 mgK/100 g soil levels of K application, respectively. The percent amount of fixed K released to exchange resin, ranged from 6.3 to 38.5% with a mean value of 30.6% and from 9.2 to 48.1%, with a mean value of 33.5%, respectively (Table 2).

The K uptake by the plants and the resin, from the fixed-non exchangeable K, from the soils of the great soil groups, was in the order: Red Mediterranean Soils>Acid Brown Forest Soils>Alluvial Soils>Rendzina. The Alluvial Soils fixed 66% of the added K (mean value of the two levels of K application) and subsequently released 23% to plants and 18.5% to resin, of the fixed-K 56%, while the Red Mediterranean soils fixed 56% of the added K and releaded 44% and 37% of the fixed K, respectively, to plants and to resin Table 1, 2).

The ability of the oat plants to obtain fixed- non exchangeable K from the soils, did not differ considerably, from the respective ability of the exchange resin (Table 2), and the correlation relating, fixed K, obtained by the oat plants to «fixed K» released to resin, was, statistically, significant (P 0.001) (Fig, 1, 2).

The K obtained by plants and exchange resin from the soils, was derived from three sources-froms of K: exchangeable K (+K of soil solution), fixed-non exchangeable K and native-non exchangeable K. A conciderable proportion of the K-uptake, was derived from forms of K which were non-exchageable at the time of seeding the oat plants. The fixed K contributed, greatly, to the total K-uptake by the plants and accounted for about 26% of the uptake. This result supports the view (1) that the fixed K is in equilibrium with the available-labile forms of K:
fixed K$\rightleftarrows$labile K and is used, as a suplying reserve of the exchangeable K (1, 2, 5).

The fixed-non exchangeable K, is characterized in the literature as «relatively loosely held non exchangeable K» [2] or «intermediate» form of K [3] it would be possible to use these terms, instead of the term «fixation, for the fixed but potentially useful K which may be released from soil for use by crops, thus correcting the ambiguity which is inherent in the latter term [10]. With the technique of Matthews and Beckett [9, 14, 15] potassium is released, only, from the «intermediate» form of K [3].

ΠΕΡΙΛΗΨΗ

Πρόσληψη ἀπὸ τὰ φυτὰ καὶ ρητίνη ἐναλλαγῆς τοῦ καλίου τῶν λιπασμάτων ποὺ δεσμεύεται ἀπὸ τὰ ἐδάφη

Χρησιμοποιήθηκαν 14 ἀντιπροσωπευτικὰ δείγματα ἐδάφους καὶ ἔγιναν πειράματα δέσμευσης καλίου —ἀπελευθέρωσης δεσμευμένου καλίου μὲ ρητίνη ἐναλλαγῆς στὸ ἐργαστήριο καὶ πειράματα πρόσληψης δεσμευμένου καλίου μὲ φυτὰ βρώμης στὸ θερμοκήπιο.

Γιὰ τὸ σύνολο τῶν ἐδαφῶν ποὺ μελετήθηκαν 37% τοῦ δεσμευμένου καλίου προσλήφθηκε ἀπὸ τρεῖς διαδοχικὲς καλλιέργειες βρώμης καὶ 32% ἀπελευθερώθηκε μὲ ρητίνη ἐναλλαγῆς σὲ μιὰ περίοδο δυὸ ἑβδομάδων. Οἱ ποσότητες τοῦ δεσμευμένου καλίου ποὺ προσλήφθηκαν ἀπὸ τὰ φυτὰ συσχετίζονταν στατιστικὰ σημαντικὰ ($P<0{,}001$) μὲ τὶς ἀντίστοιχες ποσότητες ποὺ ἀπελευθερώθηκαν μὲ τὴ ρητίνη.

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