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DEPENDENCE OF AVAILABLE MAGNESIUM CONTENT ON SOME SOIL PROPERTIES IN THE LUBLIN DISTRICT

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INTRODUCTION

For over a decade have been observed signs of magnesium deficiency in plant cultures of regions with high agricultural standing and intensive mineral fertilization. The lower crop yields resulting from this phenomenon have drawn attention to the problem of easy plant-availability of magnesium [2, 6].

The investigation results on soil contents of this component show that chernozems and organic soils are richest in available magnesium, while alluvial soils, rendzinas and brown soils are poorer. Greatest magnesium deficiency appears in sandy podzolic soils [1, 3, 4, 5, 6].

A direct correlation between the amount of particles < 0.02 mm. and available magnesium content in soil was found [5, 6]. This regularity was confirmed by investigations on the distribution of the total magnesium reserve in particular soil fractions, which decreases with the increase in size of soil particles [4]. Moreover, it was observed that a decrease in acidity causes an increase in available magnesium content in soil [5, 6].

This dependence occurred particularly distinctly in soils with small amounts of particles < 0.02 mm. (lighter soils) and lower pH. Mg-fertilizer requirements of such soils can thus be determined with a fairly high accuracy from the mechanical composition and soil reaction [5, 6].

The purpose of our tests was:

— to determine the average content and fluctuations of the amount of available magnesium in Lublin district soils;

— quantitative determination of the influence of particles < 0.02 mm. ϕ, of soil reaction and of humus on this component. Our present investigations have yielded an answer to some, but not all, aspects of the problem.

OWN INVESTIGATIONS

In the years 1962—1963 soil samples were taken for analysis in 634 different sites of the Lublin district from test pits made for soil type determination. They represented the arable layer (0—30 cm.) of podzolic soils (212 samples), brown soils (234), chernozems (32), black soils (35), bog soils (55), alluvial soils (36) and rendzinas (30).

Available Mg content of the samples was determined by Schachtschabel's method, mechanical composition by the Bouyoucos method with Casagrande and Prószyński's modification, soil pH — electrometrically in 1 N KCl using a glass electrode, and humus content after Tiurin.

Table 1

Mean content of available magnesium, particles< 0.02 mm. Ø and humus in the arable layer and pH of soil types examined

Soils	Available magnesium mg./100 g. of soil				% of particles >0.02mm.Ø	pH	Humus %
	value range	variation coefficient	mean	confidence interval (P=0.99)			
Chernozems	5.10-16.80	38.0	9.81	± 1.82	35.9	6.67	1.44
Alluvial ("mada")	1.40-16.40	51.3	7.78	± 1.81	25.7	6.41	1.72
Bogs	1.80-20.00	65.5	6.97	± 1.64	19.5	5.96	2.12
Black	1.10-16.10	80.1	4.68	± 1.73	23.6	6.65	2.08
Brown	0.90-20.00	78.1	4.66	± 0.61	17.2	5.07	1.47
Podzolic	0.90-20.00	66.2	4.53	± 0.53	20.0	4.95	1.44
Rendzinas	1.00- 7.30	41.4	3.85	± 0.80	50.3	7.23	1.70

Magnesium content showed within the soil types (Tab. 1) fairly wide variance. The relatively highest range of values was observed in rendzinas, the widest one in podzolic, brown and bog soils. This is probably due to the effect of the mineral constituent in soils. The greater the difference between the parent rocks from which the soils are formed, the greater was the difference in range of Mg content. The greatest number of near-average contents was found in chernozems, alluvial soils and rendzinas, a smaller one in podzolic and bog soils, and the smallest in black soils and brown soils (compare variation coefficients).

Mean available Mg content in the arable layer was compared by Student's „t" and Cochran and Cox's „c" tests. The comparison showed that the soils examined can in this respect be divided into 3 groups differing significantly from each other:

1. chernozems (highest Mg),
2. alluvial and bog soils,
3. black, brown and podzolic soils (lowest Mg).

The differences between soils in these groups were within the limits of error.

The confidence intervals for mean magnesium amounts, calculated from the samples, determine with 99% probability the limits in which is contained the real mean for all soils of the given type in the Lublin district.

The dependence of available Mg content on the examined soil properties was determined by correlation coefficients, the significance of which was checked by „t" tests.

A correlation between Mg amount and percentage of particles < 0.002 mm. was noted in podzolic, brown and bog soils (Tab. 2). The increase of particles < 0.02 mm. was associated with an increase in Mg content and vice versa; if this soil fraction was smaller, the available Mg was lower too. The same regularity was found by W o n d r a u s c h in podzolic soils [6]. No such linear dependence was observed in chernozems and rendzinas. It is characteristic that chernozem showed the highest, while rendzina the lowest mean Mg content. It seems therefore that in both cases other soil properties played a more important role and that the mechanical composition of the soil did not differentiate the Mg amount to the same extent as in soils with only average content of this component.

A correlation of available Mg with reaction was proved only in podzolic and brown soils. It was of positive character. The more acid the soil (lower pH), the less magnesium it contained. The existence of such regularity is supported also by other investigation results [5, 6]. No relation between pH and magnesium was found in the remaining soils. This fact can be interpreted by a relatively high experimental error (which cannot be avoided in experiments of that kind), by the small number of samples, or by lack of correlation between these features. This aspect may be elucidated in further investigations.

Rising percentage of humus content in rendzinas caused an increase of available Mg content (significant correlation coefficient). An analogous dependence existed most probably in alluvial soils; here, however, the coefficients had fairly high value and their significance could be proved only by longer series of test data. Their very low coefficient values appearing in podzolic and brown soils (represented by numerous samples) pointed on the other hand to a complete lack of connection between humus and available Mg. In respect to bog and black soils separate investigations are required.

In all cases in which a relation between the fraction < 0.02 mm. and Mg was proved, a significant relation between regression coefficient of available Mg and fraction per cent was observed. The coefficients had

Table 2

Available magnesium content in arable layer (0-30 cm.) of different soil types, mg./100 g. of soil

Factor	Soils													
	podzolic		brown		chernozems		black		bogs		alluvial		rendzinas	
	n*	Mg	n	Mg	n	Mg	n	Mg	n	Mg	n	Mg	n	Mg
% of particles<0.02mm Ø														
<10	21	2.94	57	2.29	-	-	9	2.97	5	5.02	3	2.47	-	-
10-20	100	3.78	118	3.58	-	-	11	3.97	32	5.06	14	6.61	1	3.10
20-30	68	5.34	33	7.14	3	5.03	7	5.11	12	8.82	8	8.08	5	3.94
30-40	20	6.91	22	11.14	23	10.97	1	4.60	3	11.47	4	7.67	4	3.95
40-50	3	6.73	2	12.00	6	7.75	3	10.23	2	18.05	4	11.22	5	4.50
>50	-	-	2	18.75	-	-	4	5.58	1	20.00	3	13.27	15	3.62
Correlation coefficient	+ 0.450		+ 0.817		- 0.025		+ 0.411		+ 0.736		+ 0.640		- 0.194	
Regression coefficient	+ 0.166		+ 0.301		- 0.020		+ 0.047		+ 0.321		+ 0.160		- 0.016	
Significance level of coefficients	0.99		0.99		-		0.95		0.99		0.99		-	
pH														
≤ 4.5	69	3.33	88	2.57	1	7.20	3	2.80	8	7.24	-	-	-	-
4.5-5.5	108	4.84	85	5.09	1	16.80	2	3.80	14	5.76	4	6.10	1	5.30
5.6-6.5	25	5.90	44	7.20	10	11.04	4	7.68	12	5.33	15	9.33	3	3.37
6.6-7.2	7	7.06	12	6.68	11	8.14	16	4.14	20	8.86	12	8.87	6	4.40
≥7.3	3	3.93	5	6.88	9	9.99	10	5.09	1	4.50	5	1.82	20	3.68
Correlation coefficient	+ 0.280		+ 0.447		- 0.210		+ 0.030		- 0.023		- 0.158		- 0.117	
Regression coefficient	+ 1.162		+ 1.953		- 0.995		+ 0.036		- 0.097		- 0.823		- 0.340	
Significance level of coefficients	0.99		0.99		-		-		-		-		-	
% of humus														
≤ 1.00	43	4.94	45	5.19	13	8.68	13	3.43	8	9.05	8	7.11	9	2.79
1.01-2.00	144	4.36	159	4.34	12	10.16	8	3.65	28	5.55	15	7.18	9	3.73
2.01-3.00	20	5.25	24	5.55	5	11.72	8	6.21	9	7.96	11	8.39	9	4.57
≥3.01	5	3.24	6	5.78	2	10.25	6	6.73	10	8.42	2	11.50	3	5.20
Correlation coefficient	- 0.050		+ 0.015		+ 0.246		+ 0.040		+ 0.144		+ 0.290		+ 0.480	
Regression coefficient	- 0.047		+ 0.091		+ 0.968		+ 0.007		+ 0.503		+ 1.172		+ 0.809	
Significance level of coefficients	-		-		-		-		-		-		0.99	

* Number of samples

positive value and formed the measure of changes in Mg amount with changing percentage of fractions < 0.02 mm. A 1% increase or decrease of particles < 0.02 mm. in the soil was followed by a change (in the same direction) in available Mg content by as many mg.) 100 g. of soil as the coefficient amounted to. The coefficients, of course, refer only to the population from which the sample was taken, i.e. to soils of the Lublin district.

In soils belonging to the type with significant regression coefficient, the available Mg content can be calculated from the per cent of particles < 0.02 mm. according to the equation of normal regression:

$$Y = \bar{y} + b_{yx}(x - \bar{x}),$$

in which

Y is the available Mg amount searched for (in mg) 100 g of soil);

$\bar{y}$ — the mean available Mg content in the given soil type (arithmetic mean calculated from the sample);

b_{yx} — regression coefficient;

$\bar{x}$ — mean % of particles < 0.02 mm. in soil of the examined type (comp. Table 1);

x — % particles < 0.02 mm. in the given sample.

The mean Mg content, figuring in the equation, was calculated from a sample and is thus encumbered with an error. Therefore, the calculation of limits of the expected available Mg content is more certain. The lower limit can be calculated by subtracting the mean confidence interval value (Tab. 1) from the estimated Mg content (Y), and the upper limit — by addition of this value. The probability, that the result obtained by chemical analysis may find itself in the determined limits, corresponds to the significance level on which the regression coefficient was proved.

The procedure described above gives approximate results which evidently cannot replace exact laboratory tests. It can though be used to estimate the Mg content for practical purposes (e.g. to determine fertilization requirements). We may add that the most accurate estimations of Mg amount were obtained for podzolic and brown soils as they were represented by a large number of samples. Moreover, it is possible to calculate Mg content in those soils in another way, namely by substitution in the normal equation of proper pH values and regression coefficients for x and $\bar{x}$. Parallel calculations in relation to various features allow to estimate the Mg amount more exactly and certainly, since this method is to the same degree as the coefficient encumbered with an error risk, resulting from soil variability and deviation of particular soils from the regularity existing for the given type.

CONCLUSIONS

1. The arable layer of chernozems contained on an average more available Mg than other soils of the Lublin district. Poorest in this constituent were rendzinas, black, podzolic and brown soils.

2. Positive correlation between the per cent of particles < 0.02 mm. and the amount of available Mg was observed in podzolic, brown, black, bog and alluvial soils.

3. Podzolic and brown soils contained the less magnesium the higher their acidity (lower pH). No correlation with Mg content was found in other soil types.

4. Increase of humus percentage leads to a significant increase of Mg content in rendzinas. No such linear correlation was proved in other soils.

5. Evaluation for practical purposes of orientative values of Mg content in the arable layer of podzolic and brown soils of the Lublin district from the percentage of particles < 0.02 mm. and the soil pH is possible by means of the equation of normal regression.

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DIE ABHÄNGIGKEIT DES GEHALTES AN PFLANZENAUFNEHMBAREM MAGNESIUM VON EINIGEN BODENEIGENSCHAFTEN IN DER WOJEWODSCHAFT LUBLIN

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Zusammenfassung

Es wurden insgesamt 634 Proben aus der Ackerkrume (0—30 cm) verschiedener Standarte der Lubliner Wojewodschaft auf Gehalt an pflanzenaufnehmbarem Magnesium, mechanische Zusammensetzung, pH (Bodenreaktion) und Humusgehalt untersucht.

Der zahlenmässige Anteil von Proben verschiedener Bodentypen betrug: podsolierte Böden — 212, Braunerde — 234, Tschernosemböden — 32, dunkle humose Böden — 35, Sumpfböden — 55, Madaböden — 36, Rendzinaböden — 30.

Die statistische Analyse der Untersuchungsergebnisse hat es ermöglicht, die Mittelwerte des Gehaltes an pflanzenaufnehmbarem Mg in verschiedenen Bodentypen miteinander zu vergleichen und die Abhängigkeit des Mg-Gehaltes von gewissen Bodeneigenschaften zu ermitteln, was wie folgt zusammengefasst werden kann:

Bei Tschernosemböden enthält die Ackerkrume im Durchschnitt mehr pflanzenaufnehmbares Magnesium als dies bei den anderen Böden der Wojewodschaft Lublin der Fall ist. Die Mada- und Sumpfböden sind wesentlich ärmer an diesem Element; bei den Rendzina-, podsolierten und dunklen Humosenböden sowie bei Braunerde tritt die Mg-Verarmung noch deutlicher in Erscheinung.

In der podsolierten Böden, Braunerde, dunklen humosen Böden, wie auch in Mada- und Sumpfböden konnte eine positive Korrelation festgestellt werden zwischen dem prozentuallen Anteil von abschwemmbaren Teilen (Korngrösse $< 0{,}02$ mm ϕ) und dem pflanzenaufnehmbaren Mg-Vorrat. Je mehr abschlämmbare Teile in diesen Böden vorhanden sind, desto höher ist ihr Mg-Gehalt.

Mit steigender Versauerung (niedriges pH) der podsolierten Böden und der Braunerde sinkt ihr Gehalt an pflanzenaufnehmbarem Magnesium. Bei den anderen Bodentypen wurde dagegen keine Korrelation zwischen Mg-Gehalt und Bodenreaktion (Säurezustand) festgestellt.

Wachsender Humusgehalt in Rendzinaböden ist mit einer merkbaren Zunahme der Mg-Menge verbunden. In anderen Böden wurde keine lineare Wechselbeziehung zwischen den erwähnten Eigenschaften beobachtet.

Es besteht demnach die Möglichkeit, auf Grund des Prozentsatzes der abschlämmbarer Fraktion und des pH, den pflanzenaufnehmbaren Mg-Gehalt der Ackerkrume bei podsolierten Böden und bei der Braunerde mit Hilfe der Regressionsgleichung mit für praktische Zwecke hinreichender Genauigkeit zu bestimmen.

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DÉPENDANCE DE LA TENEUR EN MAGNÉSIUM ASSIMILABLE DE CERTAINES PROPRIÉTÉS DES SOLS DE LA RÉGION DE LUBLIN

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Résumé

Dans 634 échantillons de la couche cultivable (0—30 cm) des sols de divers endroits du palabinat de Lublin on détermine la teneur magnésium, la composition mécanique, le pH et la teneur en humus. Ces échantillons représentaient: les sols

podzoliques (212), les sols bruns (234), les tschernozioms (32), les terres noires (35), les sols de marais (55), les sols alluviaux (36), et les rendzines (30).

L'analyse statistique des résultats a permis une comparaison de la teneur moyenne en magnésium assimilable des sols (tabl. 1) et une définition quantitative des rélations entre ce composant et les propriétés examinées du sol (tabl. 2), ce qui a conduit aux conclusions suivantes:

Dans la couche cultivable des tschernozioms il y avait, en moyenne, plus de magnésium assimilable que dans les autres sols de la région de Lublin. En effet, les sols alluviaux et les sols de marais étaient plus pauvres en ce composant; les rendzines, les terres noires, les sols podzoliques et bruns en contenaient le moins.

Dans les sols podzoliques, sols bruns, terres noires, sols de marais et alluviaux il y avait une corrélation positive entre le pourcentage de particules $< 0{,}02$ mm ϕ et la quantité de magnésium assimilable. Plus il y avait de particules mentionnées dans les sols, plus leur teneur en magnésium était grande.

Plus les sols podzoliques et bruns étaient acidifiés, moins ils contenaient de magnésium assimilable (pH plus bas). Toutefois dans les autres types de sols on n'a pas constaté de corrélation entre la teneur en magnésium et la réaction.

L'augmentation du pourcentage d'humus relevait en effet la teneur en magnésium des rendzines. Quant aux autres sols on n'a pas prouvé de dépendance linéaire entre ces caractéristiques.

Il y a une possibilité de déterminer pour les buts pratiques, à la base du pourcent-age de particules $< 0{,}02$ mm ϕ et du pH, selon la regression linéaire, la teneur approximative en magnésium de la couche cultivable des sols podzoliques et bruns de la région de Lublin.

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ZALEŻNOŚĆ ZAWARTOŚCI PRZYSWAJALNEGO MAGNEZU OD NIEKTÓRYCH WŁASNOŚCI GLEB LUBELSZCZYZNY

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Streszczenie

W 634 próbkach warstwy uprawnej (0—30 cm) gleb z różnych punktów woj. lubelskiego oznaczono zawartość przyswajalnego magnezu, skład mechaniczny, pH i zawartość próchnicy. Próbki te reprezentowały gleby bielicowe (212), brunatne (234), czarnoziemy (32), czarne ziemie (35), gleby bagienne (55), mady (36) i rędziny (30).

Statystyczna analiza wyników pozwoliła porównać przeciętną zawartość przyswajalnego magnezu w glebach (tab. 1) oraz ilościowo określić zależności istniejące pomiędzy tym składnikiem a badanymi własnościami gleby (tab. 2), doprowadzając do następujących wniosków:

Warstwa uprawna czarnoziemów zawierała przeciętnie więcej przyswajalnego magnezu niż inne gleby Lubelszczyzny. Istotnie uboższe w ten składnik były mady i gleby bagienne, a najuboższe rędziny, czarne ziemie oraz gleby bielicowe i brunatne.

W glebach bielicowych, brunatnych, czarnych ziemiach, glebach bagiennych i madach zachodziła dodatnia korelacja pomiędzy procentem frakcji spławialnej (cząstki $< 0{,}02$ mm ϕ) a ilością przyswajalnego magnezu. Im więcej było w tych glebach cząstek spławialnych, tym wyższą wykazywały one zawartość magnezu.

Gleby bielicowe i brunatne zawierały tym mniej przyswajalnego magnezu, im były bardziej zakwaszone (niższe pH). Nie stwierdzono natomiast korelacji zawartości magnezu z odczynem w pozostałych typach gleb.

Wzrost procentu próchnicy istotnie podnosił zawartość magnezu w rędzinach. W innych glebach nie udowodniono liniowej zależności pomiędzy tymi cechami.

Istnieje możliwość wyliczania do celów praktycznych, na podstawie procentu frakcji spławialnej i pH, wg równania prostej regresji, orientacyjnej zawartości przyswajalnego magnezu w warstwie uprawnej bielicowych i brunatnych gleb Lubelszczyzny.

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СОДЕРЖАНИЕ УСВОЯЕМОГО МАГНИЯ В ЗАВИСИМОСТИ ОТ НЕКОТОРЫХ СВОЙСТВ ПОЧВ ЛЮБЛИНСКОГО ВОЕВОДСТВА

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Резюме

В 634 образцах пахотного слоя (0—30 см) почв из различных пунктов люблинского воеводства определено содержание усвояемого магния, механический состав, pH и содержание перегноя (гумуса). Эти образцы являлись репрезентантами почв подзолистых (212), буроземных (234), черноземных (32), черных (темноцветных) (35), болотных (55), мад (36) и рендзин (30).

Статистическая обработка результатов исследований дала возможность сравнить среднее содержание усвояемого магния в почвах (табл. 1) и количественно определить существующие зависимости между содержанием магния а исследованными свойствами почвы (табл. 2).

Полученные результаты позволяют сделать следующие выводы: пахотный слой черноземов содержал в среднем больше усвояемого магния чем другие почвы люблинского воеводства. Существенно более бедны магнием оказались мады и болотные почвы; самыми бедными — рендзины, черные почвы, а также подзолистые и буроземные почвы.

В подзолистых, буроземных, черных, болотных почвах и мадах процентное содержание мелкозема (частиц $< 0{,}02$ мм) положительно коррелировало с количеством усвояемого магния. Чем больше было количество мелкозема в этих почвах, тем выше и содержание магния.

С увеличением кислотности в подзолистых и буроземных почвах уменьшалось содержание усвояемого магния. Такой зависимости не обнаружено в остальных типах почв.

Повышение процента перегноя существенно повышало содержание магния в рендзинах. В остальных типах почв нет линейной зависимости между содержанием перегноя и магния.

На основании процентного содержания мелкозема и значении pH есть возможность для практических указаний вычислить по уравнению линейной регрессии ориентировочное, приблизительное содержание усвояемого магния в пахотном слое подзолистых и буроземных почв Люблинского воеводства.