Improving of Alkali Soils with Small Doses of Reclamation Materials

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The reclamation of alkali soils was based on the application of substances which entered into ion exchange with the alkali soil. It is well known that the unfavourable physical, chemical and biological properties of alkali soils are mainly due to the fact that the amount of exchangeable sodium ions is rather considerable compared with other cations. The reclaiming agents contain calcium and effect the substitution of Na ions by Ca ions.

Methods of applying various substances, usually gypsum, acid metal salts or industrial wastes, respectively, have been adopted during the last decades or even earlier. Besides, in Hungary, several substances containing calcium carbonate have been used for alkali land reclamation to a great extent. The effectiveness of such materials is due to the fact that a group of Hungarian alkali soils has somewhat leached slightly acid surface horizons and thus the calcium carbonate is more or less effective. Another method which is in use in Hungary is the application of so-called „digo-earth", i.e. subsoil containing marl and some gypsum but only a low amount of salt is spread on the alkali surface and worked into the soil.

The above mentioned methods are right and efficient but they are rather expensive ones, thus only areas of limited extent could be improved this way. Moreover, the reclaiming material sometimes has to be shipped from afar (several hundred miles). The amounts of substance to be worked into the soil are of orders of several million kg, the costs of hauling and shipping are considerable in any case.

It has been pointed out in literature, relatively long ago, that the effect of calcium compounds applied in order to reclaim alkali soils cannot be fully attributed to simple ion exchange processes. In case of reclamation with Ca containing substances, even in low amounts, certain changes in the calcium metabolism of plants take place and contribute to increases in yield.

It was found on applying high amounts of calcium carbonate — 35, 40 or 50 tons, respectively, per hectare — that only a very low per cent of such doses became utilized, i.e. exerted some effect by way of ion exchange.

Based on those observations, experiments were conducted on alkali soils in Hungary with low amounts of reclaiming substances.

These experiments were layed out on soils that would have been reclaimed with large amounts (25, 30 or 40 tons/hectare) of the digo-earth mentioned or of calcium carbonate in the past.

Table 1. contains some data on the chemical properties of the soils of the experiments.

It can be seen that the total salt content of these soils is rather high especially in deeper horizons. The alkali character of the soils becomes even more evident on computing the proportion of exchangeable Na ions in the surface horizons to total exchangeable cations (m. e. per cent). The pH values too, indicate alkali soils, notwithstandig the fact that in the Great Plain of Hungary the upper horizons of the soils are often slightly acid.

Formerly the conventional reclamation method was performed on these soils by applying Ca in amounts equivalent to the exchangeable sodium per cent. In the present experiments from 10 to 15 per cent of the calculated and conventionally used amounts were applied only. The reclaiming substances were lime and gypsum, in some instances mixtures of both.

Table 1.

Some Chemical Properties of the Experimental Soils

(1) Site and depth of sample, cm		(2) Total salt %	(3) Exchangeable sodium ions, per cent total exchangeable cations	pH	(4) Humus per cent
Kunszentmárton	0— 20	0.088	14.2	6.8	3.4
	80—100	0.540	—	7.9	—
Nagysziget	0— 20	0.154	9.0	7.2	2.6
	80—100	1.195	—	8.0	—
Besenyszög	0— 20	1.113	18.6	6.7	3.1
	60— 80	2.333	—	8.2	—
Karcag	0— 20	0.125	10.9	7.0	2.4
	60— 80	2.196	—	8.5	—
Pankota I.	0— 15	0.170	9.16	7.3	4.7
	70— 80	0.460	—	8.3	—
Pankota II.	0— 20	0.250	16.9	7.0	3.8
	60— 80	0.800	—	7.8	—

In connection with the conventional method the application of manure has always been recommended and has been effected in most of the cases. In the present experiments manure was only occasionally applied or substituted sometimes by fertilizers with comparable nutrient content.

Some characteristic features of these experiments conducted for several years are presented in Table 2.

It is evident that, in the cases mentioned, low amounts of reclaiming materials effected significant increases in yields of grain and row crops as well. The same is true with respect to fodder crops.

A part of the trials was conducted with parallel applications of the conventional high and low doses, respectively, of reclaiming substances. The results show that yield increases obtained with the low doses were not less,

frequently even larger than those obtained with high amounts of the reclaiming substances.

In some experiments the reclaiming materials, applied in low doses, had been granulated previously. This proved to be advantageous, especially with row crops, affording the incorporation of the amending material into the soil together with the seed. Thus more favourable circumstances arose around the germinating and growing plant, enhancing the development of it; the more developed plants endured the alkalinity of the soil better. In this manner by gradually invigorating the plants and improving the soil step by step, the roots of larger and better developed plants themselves may contribute materially to the reclamation of the soil.

Table 2.

Yield Increases Effected by Low Doses of Reclaiming Materials

(1) Site	(2) Crop	(3) Dose	(4) Yield increase per cent	L. S. D. 95 per cent
Kunszentmárton	Sugar beet	1060 kg/ha granulated	8.8	4.08
Nagysziget	Maize	554 kg/ha granulated	17,68	3.75
Besenyszög	Wheat	1060 kg/ha granulated	16.23	3.84
Karcag	Wheat	1060 kg/ha granulated	8.71	4.30
Pankota I.	Vetch and oats	1800 kg/ha powder	26.70	8.50
	Vetch and oats	27 00 kg/ha powder	21.20	8.50
Pankota II.	Maize	2080 kg/ha granulated	20-10	18.70
Pankota II.	Sugar beet	700 kg/ha granulated	11.80	5.20

As data show that, with respect to yields, nothing is gained through application of high versus low doses of reclaiming substances, the latter, on the contrary, often displaying more favourable effects, analyses were performed in order to ascertain the influence of high-dose and low-dose reclamation, respectively, on the chemical compositions of plants. Some of the results are given in the following tables, data referring to sugar beets in No. 3, and to vetches with oats in No. 4.

According to data in Table 3. the sugar content of beets is materially increased by the reclamation of the alkali soil, independently of the amount

of reclaiming material applied. The raw protein content and parallel to it also the nitrogen content of vetches as well as of oats was similarly increased by reclamation, again independently of the amount of reclaiming material doses.

Table 3.

Sugar Content of Beetroots on Reclaimed and Unreclaimed Soils, Respectively

(1) Variant	(2) Ash per cent	(3) Sugar content on the 70 per cent moisture basis
Control	1.47	14.57
1060 kg/ha granulated reclaiming material	1.93	18.71

These findings fully confirm the results of the preliminary trials mentioned above, proving that the action of reclaiming materials is by no means restricted to ion exchanges taking place on the surface of colloids but it is much more complicated and calcium compounds added to the soil even in low amounts exert considerable influence on processes in plant physiology.

It must be pointed out, however, that reclamation with low amounts of materials cannot be accomplished in all cases. For example, if the soil contains much soluble salt amounting to 0,5 per cent in the surface layer then neither

Table 4.

Chemical Analysis of Vetches and Oats Grown on Reclaimed and Unreclaimed Soils, Respectively, on the Basis of 14 per cent Moisture in Hay

(1) Variant	(2) N per cent	(3) Raw protein per cent
Control	0.98	6.12
1800 kg/ha reclaiming material	1.05	6.56
27 000 kg/ha reclaiming material	1.11	6.93
Vetches		
Control	2.00	12.50
1800 kg/ha reclaiming material	2.10	13.13
27 000 kg/ha reclaiming material	2.15	13.43

low nor high amounts of amendments may be effective without previous salt leaching.

Neither is it advisable to apply low doses of amendments to alkali soils of the solonetz type where sodium amounts to from 30 to 35 per cent of the total exchangeable cations and prevents plant production entirely.

Such soils and similar ones should become improved as natural pastures; low amounts of reclaiming materials may be very effective. It is most advisable to apply $Ca(NO_3)_2$ because Ca in this form is quickly taken up by soil particles and, subsequently, soon reaches various plant organs. At the same time the other constituent of the compound, the nitrate, satisfies the need of plants for

nitrogen which is rather considerable on such soils. This method of reclamation may be combined with irrigation. In the course of several years a good pasture or even meadow may result, in some cases the soil becomes suited to ploughing.

The experiences collected in Hungary on the improvement of alkali soils with low amounts of reclaiming materials may be of value elsewhere, especially in countries with moderate climate, where soil conditions are similar.

Summary

The reclamation of alkali soils is customary throughout the world; usually gypsum, acid metal salts and industrial wastes, respectively, are applied. Besides, a current method in Hungary is the application of so-called „digo-earth", marly subsoils containing some gypsum and little salt are used for this purpose. The reclamation is frequently performed with calcium carbonate, if the surface horizon of the soil is slightly acid.

The mechanism of reclamation consists in the exchange of sodium ions bound to colloids in alkali soils for calcium ions, thus properties and fertility of the soil become improved. With regard to this, usually high amounts of reclaiming materials have been applied; in Hungary from 35 to 40 tons per hectare generally. This is, considering also the costs of hauling, shipping and working the material into the soil, rather expensive.

According to results of investigations, not only the ionic exchange but also other factors obtained with the method mentioned contribute to the improvement of the soil. Therefore the authors layed out several trials on alkali soils using but fractions — from 10 to 14 per cent — of the conventional doses of reclaiming materials. The majority of the experimental soils belonged to the solonetz type. The reclaiming material was sometimes applied in granulated form together with the seed, in other cases it was incorporated in the rows or spread on the surface of the soil.

The crops of the experiments were cereals as well as row or fodder crops. The low doses of reclaiming materials significantly increased yields, by from 8 to 25 per cent, in all cases. The effect of low and high amounts of reclaiming materials were compared in some cases and it was found that low doses were as or even more effective than high ones.

Plant analyses showed that reclamation with low doses considerably increased the sugar content of beetroots and the protein content of fodder crops.

Amélioration des sols à alcali par de petites doses de matériaux bonificateurs

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Résumé

L'amélioration des sols à alcali est bien répandu tout autour du monde et dans ce but l'on emploie surtout du plâtre, des sols métalliques à réaction acide et des déchets industriels. En Hongrie, en outre, s'est répandue une méthode d'amendement qui consiste dans l'emploi du soussol marneux, contenant de petites quantités de gypse. L'amendement des sols à alcali se fait extensivement avec du carbonate de calcium lorsque l'horizon supérieur du sol est légèrement acide.

Le mécanisme de l'amélioration est basé sur ce que les matériaux bonificateurs échangent les ions Na des colloides du sol à alcali contre des ions Ca, ainsi les propriétés du sol et sa fertilité s'améliorent. L'on emploie généralement de très grandes quantité de chaux, ainsi en Hongrie la quantité du matériaux bonificateurs atteint en moyenne 35 à 40 tonne par hectare, ce qui est fort couteux, y compris les frais de transport et des façons.

Comme selon les résultats de leurs recherches ce n'est pas seulement l'échange des ionsgni joue un rôle dans le processus d'amélioration, mais d'autres facteurs y contrientbu aussi, les auteurs ont fait des essais sur des sols à alcali avec de petites quantités du matériau bonificateur, s'élevant à 10—15% de la quantité usuelle. Les sols étaient du type solonetz. Dans certain cas ils ont employé le matériau bonificateur sous forme granulée,

la deposant avec la semence, en d'autres cas ils l'ont répandu en des lignes ou sur la surface du sol.

Ils ont fait ces essais avec plusieurs espèces de plantes des graminées, des plantes sarclées et des plantes fourragères, et par l'emploi de petites quantités du matériau bonificateur ils ont obtenu un accroissement significatif du rendement de 8 à 25%. Dans un grand nombre de cas ils ont fait des comparaisons entre les effets des petites et des grandes quantités employées et ils ont trouvé que la petite dose égale et même surpasse l'effet de la grande dose.

L'analyse chimique des plantes a montré que sous l'effet de l'amendement avec de petites doses du matériau bonificateur la teneur en sucre des betteraves sucrières a été appréciablement plus haute, comme chez les plantes fourragères la teneur en protéines.

Tableau 1. Certaines propriétés chimiques des sols de l'expérience. (1) Situation et profondeur des sols cm. (2) Salinité totale %. (3) Ions-Na échangeables, en pour cent de la totalité des cations échangeables. (4) Humus %.

Tableau 2. Effet sur l'augmentation des rendements des matières employées pour l'amendement en petites quantités. (1) Endroit. (2) Culture. (3) Traitement. (4) Augmentation du rendement %.

Tableau 3. Contenue en sucre des betterave cultivées sur du sol amendé et non amendé. (1) Traitement. (2) Cendres %. (3) Teneur en sucre % à 70 d'humidité.

Tableau 4. Analyse chimique de l'avoine et de la vesce cultivées sur du sol amendé et non amendé, rapportée à du foin à 14% d'humidité. (1) Traitement. (2) Protéines boutes %.

Die Verbesserung der Alkaliböden mit geringen Gaben von Meliorationsmitteln

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Zusammenfassung

Die Methoden zur Verbesserung von Alkaliböden sind überall verbreitet. Meist gelangen Gips, saure Metallsalze oder mancherlei Industrieabfälle zur Anwendung. In Ungarn ist auch das Aufbringen von sog. »Digo-Erde« üblich, das ist mergeliger Boden aus Untergrundschichten, der etwas Gips und wenig Salze enthält. Auch mit kohlensaurem Kalk werden Alkaliböden verbessert, falls der oberste Horizont derselben schwach sauer reagiert.

Das Wesen der Melioration ist der Austausch der an die Kolloide von Alkaliböden gebundenen Natriumionen gegen Kalziumionen aus dem Meliorationsmittel. Eigenschaften und Fruchtbarkeit der betreffenden Böden werden hierdurch verbessert. Dem entsprechend werden recht hohe Gaben der Meliorationssubstanz angewandt; in Ungarn allgemein 35 bis 40 t je ha. Die Kosten des Verfahrens sind — die für Fracht und Einbringen in den Boden mitinbegriffen — recht hoch.

Nach einigen Forschungsergebnissen spielen bei der obigen Verbesserung von Alkaliböden nicht nur Vorgänge des Ionenaustausches, sondern auch andere Faktoren mit. Unter Rücksicht hierauf wurden von den Verfassern Versuche mit nur 10 bis 15% der üblichen Gaben von Meliorationsmitteln angelegt. Die Versuchsböden gehörten überwiegend dem Solonetztyp an. Das Verbesserungsmittel wurde in einigen Fällen gekörnt und zusammen mit dem Saatgut in den Boden gebracht, sonst in die Reihen gegeben oder auf die Oberfläche des Alkalibodens gestreut.

Die Versuchsgewächse waren verschiedener Art, Getreide, Hackfrüchte oder Futterpflanzen. Kleine Gaben der Meliorationsmittel zeitigten jedesmal gesicherte Mehrerträge von 8 bis 25%. Mehrmals wurde die Wirksamkeit geringer Gaben mit jener von hohen verglichen, und es zeigte sich, daß die Ergebnisse mit den ersteren ebenso hoch oder noch höher waren als jene mit den letzteren.

Aus den Analysenzahlen der Pflanzen ging hervor, daß bei Anwendung kleiner Gaben von Meliorationsmitteln sowohl der Zuckergehalt von Zuckerrüben als auch der Eiweißgehalt von Futterpflanzen erhöht wurde.

Tabelle 1. Einige chemische Merkmale der Böden. (1) Ort und Tiefe der Böden cm. (2) Gesamt-Salzgehalt %. (3) Austauschbare Na -Ionen in Prozenten der gesamten austauschbaren Kationen. (4) Humus %.

Tabelle 2. Die ertragsteigernde Wirkung der in kleinen Mengen verabreichten Meliorationsstoffe. (1) Ort. (2) Kultur. (3) Behandlung. (4) Ertragsteigerung %.

Tabelle 3. Zuckergehalt der auf verbesserten und unverbesserten Boden angebauten Zuckerrüben. (1) Behandlung. (2) Asche %. (3) Zuckergehalt bei 70% Feuchtigkeit, %.

Tabelle 4. Chemische Analyse von Hafer und Wicke auf meliorіertem und nichtmeliorіertem Boden auf Heu von 14%igem Wassergehalt umgerechnet. (1) Behandlung. (2) Rohprotein %.

Мелиорация засоленных почв Венгрии малыми дозами мелиорирующих веществ

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Резюме

Мелиорация засоленных почв широко распространена во всем мире; в качестве мелиорирующих веществ применяются гипс, кислые металлические соли и отходы промышленности. В Венгрии кроме этого широко распространен метод «дигозаш», который заключается в перемешивании верхних горизонтов почв с подпочвой содержащей мергель и небольшое количество гипса. Используется для мелиорации засоленных почв и углекислый кальций в тех случаях, когда верхние горизонты почвы имеют слабо кислую реакцию.

Механизм мелиорации заключается в обмене ионов натрия поглощающего комплекса почвы на ионы кальция мелиорирующего вещества и таким образом свойства и плодородие почвы улучшается. Для мелиорации почв используют большие дозы мелиорирующих веществ, так в Венгрии внесение в среднем 35—40 тонн на га мелиорирующих веществ, включая транспортировку и работы по заделке мелиорирующих веществ, очень дорого стоящее мероприятие.

Результаты исследований показали, что при мелиорации засоленных почв вышеуказанными методами происходит не только обмен ионов, но играют роль и другие факторы. Были заложены опыты по мелиорации засоленных почв малыми дозами мелиорирующих веществ, которые составляют 10—15% от конвенционального количества вносимых мелиорирующих веществ. Почвы в опытах относились к типу солонцов. Мелиорирующий материал в одном случае вносился в гранулированном виде вместе с семенами, в другом случае в рядки или поверхностно.

Опыты проводились с различными растениями: зерновыми, пропашными и кормовыми растениями и во всех случаях применение малых доз мелиорирующих веществ дало достоверную прибавку урожая равную 8—25%. Сравнивая эффект полученный от применения малых и обычных доз мелиорирующих веществ, пришли к выводу, что эффективность от малых доз достигает или даже в некоторых случаях превышает эффективность от обычных доз.

Данные химических анализов растений показали, что в сахарной свекле под влияниемвнесения малых доз мелиорирующих веществ значительно увеличивается содержание сахара, а в кормовых растениях содержание белка.

Табл. 1. Химические свойства почв, на которых закладывались опыты. (1) Место и глубина в см. (2) Сумма солей в %. (3) Содержание обменного натрия в % от суммы обменных катионов. (4) Гумус в %.

Табл. 2. Влияние малых доз мелиорирующих веществ на урожай растений. (1) Место. (2) Культура. (3) Варианты. (4) Повышение урожая в %.

Табл. 3. Содержание сахара в сахарной свекле с контрольных и мелиорированных делянок. (1) Вариант. (2) Зола в %. (3) Содержание сахара в сахарной свекле при 70% влажности.

Табл. 4. Данные химического анализа вико-овсяной смеси при влажности 14%, на мелиорированных делянках и контроле. (1) Вариант. (2) Сырой белок в %.