# Plant Physiological Principles of Efficient Sand Amelioration

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High and reliable crop yields on sand or even shifting sand of low fertility can be obtained by crop production on a physiological basis. This means that overall cultural pratices should be adapted to special needs and requirements of the crops grown and to the character of the soil type. Consequently, in order to deepen the sphere of plant roots, the conditions of cultivation must be improved both in the surface soil and in the subsoil.

To this end we elaborated a method for the reclamation of sandy soils [2,3]. This method essentially consists in 1. deep loosening of the sand, and 2. placing one or more, at least 1 cm thick layers of manure or compost rich in colloids, into the soil (proceeding upward from underneath. at dephts between 38 and 75 cm.)

*This method of sand reclamation exerts a fundamental influence on the physiological processes of plant life by means of deep cultivation and by creating high nutrient concentration.* By deep cultivation the root mass becomes redistributed to the depth of the loosened layer [1]. As the moisture capacity of the inserted sheet differs from that of the sand medium high concentration of water and nutrients is brought about within a narrow space for intensive development of the physiologically active root system. In the subsoil which usually contains more moisture than the upper layers right from the outset the water and nutrient supply thus becomes continuous even when nutrients in the surface soil are no more available to plants, due to the lack of moisture in dry spells. The water stored in deeper layers of the soil is thus economically utilized; moreover, the microbial activity intensifies with increasing depth [5].

In order to support the above statements results of two trials are presented, obtained in years — 1954 and 1961, respectively — under entirely different meteorological conditions. The crop was a typical sand-plant, winter rye in the former and winter wheat, a "non-sand plant", in the latter experiment.

Both trials were conducted at the Sand Experiment Station of the Res. Inst. of Soil Sci. and Agric. Chemistry of the Hung. Academy of Sciences, at Őrszentmiklós. The soil was calcareous sand, low both in nutrients and organic matter (from 0.6 to 1.0 per cent). In 1950 and 1953, respectively, 70 tons per ha of farmyard manure were ploughed in, 25 cm deep. The same amounts of manure were placed as sheets, 60 cm deep in 1950 and 45 cm deep in 1953. The size of the plots was 200 sq. m with four replicates.

Monthly values of precipitation during the vegetation period are shown in Table 1. In the growing season 1953—54 there was a lack of moisture amounting to 135 mm as compared to the average of 10 years, which exerted considerable influence on plant growth and crop yields.

To elucidate the course of plant development the increase of dry matter in the rye variety „Lovászpatonai" is shown in Fig. 1. Full lines relate to the increase in dry matter of the above ground parts of the crop.

Samples taken at the flowering stage (25. 5. 1954.) were divided into stalks, leaves and ears, respectively. From this time on dotted lines in Fig. 1. indicate the dry weight of the aerial parts of the plants without ears. The area

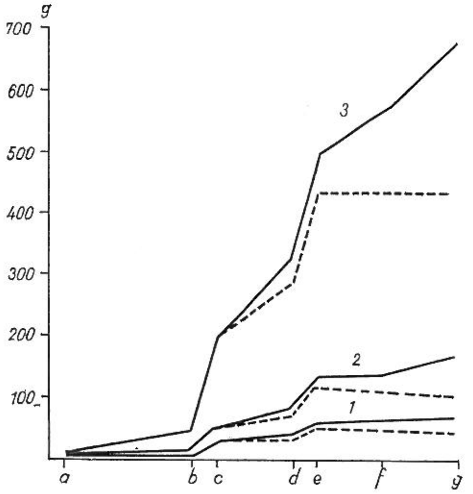


*Fig. 1.*

Increase in dry weight of the aerial parts of rye (per 100 plants). 1: Check. 2: Surface-manured. 3: Sand reclaimed with placed layers. a) Full tillering stage (30. 3. 1954.), b) In shooting (28. 4. 1954.). c) Before earing (7. 5. 1954.), d) Flowering stage (25. 5. 1954.), e) Beginning of seed set (2. 6. 1954.), f) Onset of waxy ripening (18. 6. 1954.), g) At harvest (8. 7. 1954.)

enclosed by the dotted and the full lines reflects the characteristic trend of ear formation.

Sudden increase in dry weight of plants in the plots ameliorated by deep placed layers was noticed between shooting and earing (from 28. 4. to 7. 5.). This was the period when plants intensively utilized the layer substances. In these stages of growth plants in the check plots could hardly satisfy their needs for water, and those in the superficially manured plots to a small extent only. Though in the latter case large amounts of nutrients were available in the soil, with the drying up of the surface layer the continuous water supply of the roots extending near the surface was entirely cut off. *By contrast*, the curve representing the weight increase in the reclaimed plots runs to the end point almost without break, although the fresh weight did not increase any more after the beginning of seed set. In this case the root system utilized exactly the water reserves accumulated in the deeper layers, which were not available to the crops in plots which were supplied with nutrients only near the surface.

The effectivity of sand reclamation was unequivocally proved by daily growth rates, phenological data and by analytical results for plant organs and seeds. This is shown in Table 2.

It appears from Table 2. that rye grown in reclaimed sand exhibited larger and broader ears and higher numbers of seeds per ear. According to the morphological characters of the grain and baking quality grades of the flour the indices of grain and flour value similarly show the positive influence of sand reclamation.

According to histological analyses the formation of larger ear and grain yields was made possible by the increase of all types of tissue as well as by elongation. Total tissue diameter and particularly number and size of vascular bundles increased. Hereby the nutrient supply of vegetative and reproductive organs improved finally resulting in increased weight and better quality of yield. In the reclaimed plots the yield of rye was 5.25 times as high as in the check plots and 2.59 times as high as that obtained with 25 cm deep cultivation and manuring notwithstanding the deficit of precepitations amounting to 135 mm.

Thus, by deepening the root sphere sandy soils and even shifting sands can be adapted to the successful growing of various "non-sand crops".

This statement was confirmed by the results of a trial with the "intensive" winter wheat variety "F 481.", conducted in 1961. In one of the treatments the manure was flatly worked into the soil, while another treatment involved deep cultivation only. In a third treatment the same amounts of manure as in the first (70 tons per ha in each case) were placed as separate continuous layers, the depths being 62 cm in 1953, 46 cm in 1957 and 38 cm in 1960. (Plot size was 250 sq. m. with four replications).

In the growing season 1960—61 there was an excess of precipitation amounting to 110 mm as compared to the average of 10 years (Table 1.). The distribution of precipitation was rather irregular in 1961. From 13. 2. till 19. 4. no rain fell at all, then a wetter period followed. At the time when cereals ripened the weather was exceedingly hot. — Subsequently a dry spell ensued (7 mm rain in August, nothing in September). — In spite of the abnormal weather, especially of the severe drought in spring, the wheat grew well in the reclaimed

*Table 1.*

**Distribution of precipitation during the vegetation period**

| (1) Year | (2) Month | | | | | | | | | | | (3) Sum of precipitation | (4) Annual sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | IX. | X. | XI. | XII. | I. | II. | III. | IV. | V. | VI. | VII. | | |
| | month mm | | | | | | | | | | | mm | |
| Mean of 10 years | 41 | 33 | 53 | 54 | 39 | 35 | 32 | 46 | 52 | 59 | 48 | 492 | 542 |
| 1953. | 10 | 16 | 13 | 10 | | | | | | | | | 384 |
| 1954. | | | | | 34 | 20 | 34 | 51 | 44 | 38 | 87 | 357 | 547 |
| 1960. | 30 | 100 | 101 | 51 | | | | | | | | | 709 |
| 1961. | | | | | 31 | 28 | — | 65 | 87 | 48 | 61 | 602 | 509 |

*Table 2.*

**Morphological characters of rye ears, yield and flour quality data**

| (1) Treatment | (2) Ear dimensions | | (3) Number of grains | (4) Grain yield, q per ha | (5) 1000 grain weight g | (6) Number of grains in 100 g | (7) Laborograph | |
|---|---|---|---|---|---|---|---|---|
| | length cm | width mm | | | | | Score | Grade |
| *a)* Ploughed 25 cm deep | 4.00 | 7.00 | 11 | 4.78 | 20.10 | 4975 | 25.94 | $B_2$ |
| *b)* Surface manuring | 7.18 | 7.60 | 24 | 12.37 | 23.08 | 4333 | 25.98 | $B_2$ |
| *c)* Sand reclaimed by placed layers | 10.26 | 9.00 | 45 | 25.09 | 23.72 | 4216 | 30.21 | $B_1$ |

*Note:* Fertilizer applications were equal in all plots in all years.

sand. It displayed mesomorphic features; at the same time it made poor growth and retarded development in the other plots. Here the lower leaves turned yellow and dried about April 10th. The crop stand exhibited typical signs of insufficient moisture. More vigorous growth set on subsequently to rains. Nutritional disturbancies manifested themselves mainly by smaller ears, increased number of sterile spikelets and xeromorphic character of the plants.

To evaluate nutrient efficiency and crop yield, as well as water utilization efficiency, data are presented in Tables 3. and 4., respectively.

*Table 3.*

**Wheat crop yields and nutrient content of grain**

| (1) Treatment | (2) Grain | (3) Straw | (4) Grain: straw ratio | (5) Nutrient content of the grain g/sq. m. | | | |
|---|---|---|---|---|---|---|---|
| | yield q per ha | | | N | P | K | Ca |
| | | | | on the air-dry basis | | | |
| 1. Ploughed 25 cm deep ..... | 12.90 | 26.41 | 2.05 | 2.12 | 0.88 | 0.65 | 1.18 |
| 2. Deep turning ............ | 13.50 | 27.60 | 2.04 | 2.17 | 0.96 | 0.68 | 1.18 |
| 3. Shallow incorporation of manure ................ | 17.54 | 30.40 | 1.73 | 2.85 | 1.20 | 0,87 | 1.53 |
| 4. Sand reclaimed with placed layers .................. | 27.08 | 42.94 | 1.59 | 4.65 | 1.97 | 1.33 | 2.38 |
| L. S. D., 5 per cent ..... | 2.44 | 9.32 | | 0.34 | 0.22 | 0,14 | 0.28 |

*Note:* Fertilizer applications were equal in all plots in all years.

It is evident from Table 3. that there are no significant yield differences between treatments 1. and 2., viz. flat and deep cultivation. The same is true for the N, P, K and Ca content of the grain. According to experiences gained so far, deep cultivation secures high yields only in combination with increased amounts of fertilizers applied. In the case of normal sandy soils the deep cultivation alone has positive effects lasting but one year or two. Yield levels are correlated to enhanced root growth in consequence of deep cultivation, provided the development and functions of a physiologically active root system are warranted. Favourable and lasting changes in the physical properties of the soil are induced by altering conditions which hinder physiological processes, i. e. through the shattering of hard pans cemented by lime or iron compounds (e. g. Ortstein) present in the subsoil [4].

In the above wheat trial the straw to grain ratio was most favourable in the reclaimed plots. Compared to flat manuring there was an increase in grain yield amounting to 10 q per ha.

Figures for N, P, K and Ca content of air-dry grain/g per sq. m. corresponded to yield levels.

According to moisture determinations at harvesting time — 22. 6. 1961. — (Table 4.) the most efficient water utilization has been found in the reclai-

*Table 4.*

**Soil moisture at harvesting time**

| (1) Sampling depth, cm | (2) Treatments | | | |
|---|---|---|---|---|
| | 1. Ploughed 25 cm deep | 2. Deep turning | 3. Shallow incorporation of manure | 4. Sand reclaimed with placed layers |
| | Soil moisture, per cent by weight | | | |
| 0—10 | 3.6 | 3.7 | 3.4 | 2.1 |
| 10—20 | 5.5 | 5.7 | 5.7 | 3.5 |
| 20—30 | 5.9 | 6.3 | 5.9 | 3.3 |
| 30—40 | 6.2 | 6.8 | 5.6 | 2.9 |
| 40—50 | 6.3 | 6.7 | 5.8 | 3.2 |
| 50—60 | 6.0 | 6.5 | 6.2 | 3.4 |

med plots. Surface manuring there was from 5.5 to 6.2 per cent by weight water in the layers in a depth between 30 to 60 cm, in contrast to from 2.9 to 3.4 per cent in corresponding depth of the reclaimed sand. This surplus of utilized water, too, contributed to the increase in yield. (The original minimum water capacity of the sand was about 10 per cent.) The moisture capacity of the inserted sheet substance, differing from that of the sand in itself locally increased the stored amounts of available water. Its nutrient reserves were, at the same time, important sources of nutrition for the plants during several years. The permanence of the layer is the consequence of its undisturbed state, as microbial decomposition and mineralization rate of the organic matter is reduced [3].

Besides the non-specific wheat also other crops, e. g. alfalfa and maize were successfully grown on shifting sand. In a trial conducted on a large scale (at Kutas, 1963), where the soil was clay-illuviated sand, the superficially manured maize suffered from severe drought and yielded only 19,5 q corn per ha. At the same time the yield amounted to 41,5 q per ha in the reclaimed plots.

It should be noted that the deep cultivation of sand and deep placement of nutrients — by deep ploughing if necessary — combined with careful putting into practice all proper cultural practices, is of importance for crop yields not only in dry but also in irrigation farming, because it greatly increases irrigation efficiency.

Under climatic conditions prevailing in Hungary, practical application of the sand reclamation method is spreading, to increase yields, not only in agriculture but in other branches of plant production, too, especially in viticulture and fruit growing.

The correctness of the underlying principle has been verified also by positive results obtained in other countries.

## Summary

It is justified by plant physiological principles to extend the root sphere downwards in sandy soils and shifting sands.

Taking into consideration these principles a method was elaborated in order to obtain lasting improvement of such soils, by creating deep root sphere. The essence of this method is that one or more layers consisting of manure or compost rich in colloids, are placed into the soil at depths from 38 to 75 cm proceeding upward from underneath; the thickness of each must be at least 1 cm.

The subsoil — sand — is originally rather dense (volume weight above 1.5) and thus hinders vertical root growth. This obstacle is removed by deep cultivation and subsoiling. Nutrients incorporated partly into the deeper layers effect intensive development of the physiologically active root system. This makes it possible to utilize water reserves present in these layers, which is usually unavailable with shallow cultivation.

Of our long-term experiments the results of two are presented; these had been conducted with rye and wheat, respectively, in years with rather differing weather conditions. In both cases the effects exerted on plant development and yield by the sand reclamation method were compared with those of shallow cultivation and manuring.

The same amounts of manure were applied to the plots cultivated 25 cm deep and to those reclaimed by deep-placed artificial layers. Notwithstanding the equal amounts of nutrients applied in both cases, considerable differences were observed in the rate of plant development, the increase in dry weight, the size and histological structure of the ears, the chemical composition of plant and grain, and in the quality of the flour. All these features and properties were more favourable with plants in the reclaimed plots. Both crops were of bright green colour even during dry spells whereas plants in plots cultivated and manured only 25 cm deep were seriously damaged, because water and nutrient supply from the surface layer that soon dried up, was completely cut off. The method of sand reclamation, on the contrary, resulted in high and reliable yields even in dry years.

With cultivation and manuring to a depth of 25 cm the yields of rye and wheat amounted to 12.37 and 17.54 q per ha, respectively. Corresponding data in the reclaimed plots were 25.09 and 27.08 q per ha, respectively.

Deep cultivation and deep placement of nutrients are thus important yield-increasing factors, not only in dry-farming but also under conditions of irrigation farming.

This method that became already known in other countries is spreading on a large scale in Hungary, in order to improve results not only in agriculture but in viticulture and fruit growing too.

## Literature

[1] DVORACSEK, M. & DVORACSEK, M. (Mrs.): Az altalajlazítás és hatásmechanizmusa homokon. Agrokémia és Talajtan. **10.** 67—84. 1961.

[2] EGERSZEGI, S.: Creation and permanent maintenance of a deep fertile layer in loose sandy soil. Acta Agr. Acad. Sci. Hung. **7.** 333—364. 1958.

[3] EGERSZEGI, S.: Economical and lasting utilization of organic fertilizers in sand soils. Acta Agric. Acad. Sci. Hung. **9.** 319—340. 1959.

[4] EGERSZEGI, S.: Die tiefe Bodenbearbeitung in Ungarn. Netherl. J. Agric. Sci. **11.** 110—119. 1963.

[5] MÜLLER, G. & RAUHE, K.: Zur Tiefkultur auf leichten Böden im besondern Hinblick auf die Bodenbiologie. II. Bodenbiologischer Teil. Z. Acker- und Pflbau. **109.** 309—332. 1959.

# Principaux points de vues de physiologie végétale de l'amélioration des sols sablonneux

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**Resumé**

Sur les sables l'accroissement de la profondeur de l'espace disponible à la plante est indiquée par des considérations de physiologie végétale.

En tenant compte des principes de la physiologie végétale nous avons élaboré un procédé pour l'établissement d'un profond espace vital sur des sols sablonneux et pour leur amélioration durable. Son principe c'est que par un labour profond nous établissons entre 38 à 75 cm dans le profil sableux en procédant de bas en haut, une ou plusieurs couches de fumier organique ou de compost riche en colloïdes.

Les racines pénétrent difficilement dans le sous-sol originairement très dense (poids spécifique 1,5 et au-dessus). Le labour et l'ameublissement profond facilitent leur pénétration. Les principes nutritifs placés aussi en profondeur ont pour conséquence le développement vigoureux d'un ensemble de racines physiologiquement actives. Par suite de cela la plante utilise la provision d'eau naturelle, qui généralement reste inusitée dans le sous-sol à cause de l'insuffisance du labour peu profond.

Nous présentons ici des expériences faites avec du seigle et du blé dans deux années de différentes conditions météorologiques, prises parmi nos expériences de plusieurs années.

Dans ces expériences nous avons comparé l'effet produit sur le développement de la plante et la formation du rendement par le labour et de la fumure peu profonds d'une part, et par l'amélioration de sol sablonneux, d'autre part.

Nous avons employé la même quantité de fumier organique dans le cas du labour de 25 cm et de l'amélioration stratifiée de sol sablonneux. Avec la même teneur en principes nutritifs il s'est produit un changement essentiel sur le sable amélioré, concernant l'allure du développement de la plante, l'accroissement de son poids sec, la composition chimique de la plante et du grain, ainsi que la qualité de la farine. Le seigle et le blé sont restés d'un vert frais dans la période sèche, la plante n'a pas présenté des signes de manque d'eau. En même temps les plantes ont subi de forts dommages a cause de la sécheresse sur le sol labouré et fumé à 25 cm de profondeur seulement. Dans ce cas la continuité de l'approvisionnement de la plante en eau et en principes nutritifs a été interrompu, parce que les principes nutritifs existant dans la couche supérieure du sol désséché n'ont pas pu se faire valoir. Par contre notre procédé d'amélioration des sables a assuré, par la création d'un espace vital profond le succès et la sécurité de la production, même en une année aride.

Dans le cas du labour de 25 cm et de la fumure peu profonde le seigle a donné 12,37 q/ha de grains et le blé 17,54 q. Sur le sable amélioré le rendement en grains a été 25,09 q/ha pour le seigle et 27,08 q/ha pour le blé.

Le labour profond et le placement des principes nutritifs aussi en profondeur est un facteur de croissance important non seulement dans l'agriculture sèche, mais aussi dans l'agriculture irriguée.

L'application dans les exploitations de notre procédé pour l'amélioration des sables, connu aussi à l'étranger, est en voie d'extension en Hongrie, outre la culture des plantes cultivées en terre labourée, aussi en vue d'assurer le succès de la viticulture et de la culture fruitière.

*Figure 1.* Augmentation du poids sec de la partie au-dessus du sol du seigle (100 plantes). 1. Contrôle. 2. Fumé avec du fumier de ferme placé proche de la surface. 3. Sable amélioré par couches a) en plain tallement, b) lors de la montée, c) avant l'épiage, d) à la floraison, e) au commencement de la formation du grain, f) au commencement de la cérification, g) à la moisson.

*Tableau 1.* Répartition des précipitations tombées pendant la période végétative. (1) Année. (2) Précipitations mensuelles mm. (3) Précipitations totales mm. (4) Total de l'année. Moyenne de 10 ans de la plus haute ligne.

*Tableau 2.* Données concernant l'aspect des épis, la qualité de la farine de seigle et le rendement. (1) Traitement. (2) Longueur de l'épis (cm) et sa largeur (mm). (3) Nombre des grains. (4) Rendement en grains q/ha. (5) Poids de mille grains. (6) Nombre des grains

dans 100 g. (7) Index du laborographe et évaluation. a) Labour de 25 cm. b) Fumure à proximité de la surface. c) Sable amélioré par couches.

*Tableau 3.* Rendement du blé et teneur en matières nutritives du grain. (1) Traitements: 1. labour de 25 cm, 2. labour à la charrue défonceuse, 3. fumure à proximité de la surface, 4. sable amélioré par couches. (2) Rendement des grains q/ha. (3) Rendement de la paille q/ha (4) Proportion grains: pailles. (5) Teneur en matières nutritives des grains g/m$^2$, valeurs rapportées à la matière séchée à l'air.

*Tableau 4.* Humidité du sol à la moisson (22 juin 1961). (1) Profondeur. (2) Traitements (voire 3-e tableau 1—4).

## Die pflanzenphysiologischen Gesichtspunkte der erfolgreichen Sandmelioration

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### Zusammenfassung

Pflanzenphysiologische Gesichtspunkte lassen es wünschenswert erscheinen, den Wurzelnährraum in Sand- und Flugsandböden nach der Tiefe zu erweitern.

Auf diesen pflanzenphysiologischen Grundlagen wurde ein Verfahren zur Vertiefung und dauernden Verbesserung des Wurzelnährraumes in Sandboden ausgearbeitet. Das Wesen der Methode ist das Unterbringen einer Schicht, oder mehrerer Schichten von Stallmist oder kolloidreichem Kompost im Sandprofil, in Tiefen von 38 bis 75 cm, von unten nach oben fortschreitend, falls mehrere Schichten gelegt werden. Jede Schicht soll zumindest 1 cm dick sein.

Im ursprünglich sehr dicht gelagerten Untergrund (Raumgewicht höher als 1,5) ist das Vordringen der Wurzeln abwärts stark behindert. Gefördert wird dasselbe durch Tiefkultur, namentlich durch tiefe Lockerung. Die auch in tieferen Schichten untergebrachten Nährstoffe ermöglichen die kräftige Entwicklung des physiologisch aktiven Wurzelsystems, sowie die Verwertung der Wasservorräte in den tieferen Schichten, die, infolge der Mängel der Flachkultur sonst ungenutzt im Untergrund verbleiben.

Von unseren mehrjährigen Versuchen sollen hier zwei besprochen werden. Dieselben wurden in Jahren von recht unterschiedlicher Witterung mit Roggen, bzw. Weizen ausgeführt.

Es wurde die Pflanzenentwicklung und der Ertrag bei flacher Bodenbearbeitung und Düngung mit den entsprechenden Ergebnissen bei Sandmelioration verglichen.

Bei der 25 cm tief greifenden Flachkultur, wie auch bei der schichtenweisen Sandmelioration gelangten die gleichen Dosen von organischem Dünger zur Anwendung. Bei gleichen Nährstoffgehalt des Bodens zeigten sich beträchtliche Unterschiede zugunsten der Melioration im Entwicklungsgang der Pflanzen, in der Gewichtszunahme an Trockenmasse, in den Dimensionen und in der histologischen Struktur der Ähren, in der chemischen Zusammensetzung der Pflanzen und der Körner, sowie in der Mehlqualität. Sowohl die Roggen-als auch die Weizenpflanzen bleiben auch während Dürreperioden saftig grün, ohne Anzeichen von Wassermangel. In den Parzellen mit Flachkultur (25 cm) und nur oberflächennah eingebrachter Düngung stellten sich demgegenüber starke Dürreschäden ein. Hier erlitt die Wasser- und Nährstoffversorgung eine Unterbrechung, da die Nährstoffe in der ausgetrockneten Oberflächenschicht den Pflanzen unzugänglich geworden sind. Das Meliorationsverfahren hatte durch die Erschließung tiefen Wurzelnährraumes auch im Dürrejahr hohe und sichere Erträge gewährleistet.

Bei Flachkultur bis zu 25 cm und oberflächennaher Düngung beliefen sich die Körnererträge auf 12,37 dz Roggen und 17,54 dz Weizen je ha. Auf dem verbesserten Sand wurden 25,09 dz Roggen, bzw. 27,08 dz Weizen je ha geerntet.

Tiefkultur und tiefes Einlagern der Nährstoffe sind wichtige ertragssteigernde Faktoren, nicht nur in der Trockenkultur, sondern auch bei künstlicher Bewässerung.

Die betriebsmässige Anwendung des in Rede stehenden, und auch im Ausland bekannt gewordenen Sandmeliorationsverfahrens gewinnt in Ungarn immer mehr an Verbreitung. Nicht nur im Ackerbau, sondern auch im Wein- und Obstbau wurden damit gute Erfolge erzielt.

*Tabelle 1.* Verteilung des Niederschlages während der Vegetationsperiode. (1) Jahr. (2) Monatliche Niederschlagsmenge mm. (3) Niederschlagsumme, mm. (4) Jahressumme mm. Die oberste Reihe stellt den zehnjährigen Durchschnitt dar.

*Tabelle 2.* Angaben betreffs des Äussereu der Ähre, der Beschaffenheit des Roggenmehls und des Ertrages. (1) Behandlung. (2) Ährenlänge (cm) und Breite (mm). (3) Körnerzahl. (4) Körnerertrag dz/ha. (5) Tausendkorngewicht. (6) Körnerzahl je 100 g. (7) Labograph Wertzahl und Bewertung. a) 25 cm Anbau. b) Organische Düngung in der Nähe der Oberfläche. c) Schichtweise meliorierter Sand.

*Tabelle 3.* Ernteertrag des Weizens und Nährstoffgehalt des Korns. (1) Behandlungen: (1) 25 cm Anbau. (2) Tiefes Wenden. (3) Stallmistdüngung in der Nähe der Oberfläche. (4) Schichtweise meliorierter Sand. (2) Körnerertrag dz/ha. (3) Nährstoffgehalt des Korns g/m² auf lufttrockenes Material bezogene Werte.

*Tabelle 4.* Feuchtigkeitsgehalt des Bodens bei der Ernte (22. Juni 1961). (1) Tiefe der Probenahme. (2) Behandlungen (1—4. s. Tab. 3.).

*Abb. 1.* Trockensubstanz-Zunahme des oberirdischen Teils des Roggens (je 100 Pflanzen). 1. Kontrolle. 2. In der Nähe der Oberfläche mit Stallmist behandelt. 3. Schichtenweise meliorierter Sand. a) In voller Bestockung, b) im Schossen, c) vor dem Ährenschieben, d) in Blüte, e) zu Beginn des Samenansatzes, f) zu Beginn der Wachsreife, g) bei der Ernte.

# Физиологические основы эффективной мелиорации песков

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**Резюме**

На песчаных почвах, сыпучих песках увеличение глубины площади питания расчний диктуется физиологическими требованиями самих растений. Принимая во внимания физиологические особенности растений, для увеличения в глубину площади питаеия и стойкой мелиорации песков, мы разработали новый метод. Сущность его заключается в том, что при глубокой обработке 38—75 см в почву с низу в верх вносятся огтанические удобрения или богатые коллоидами компосты в несколько слоев. Минимальная ношность этих слоев должна быть не менее одного см.

В исходном состоянии почва очень плотна (объемный вес 1,5) и корни с трудом проникают в неё. Глубокая обработка и рыхление способствуют проникновению корней в глубокие горизонты почвы. Глубокое внесение питательных веществ приводит к усиленному развитию физиологически активной корневой системы. В результате этого используется растениями и естественный запас воды в подпочве, который при обычной обработке не используется.

Из многолетних опытов приводятся данные двух опытов с рожью и пшеницей, заложенных в различных климатических условиях. В опытах мы сравнивали влияние на развитие и урожай растений, поверхностой обработки с обычным внесением удобрений и послойной мелиорации песка.

И при обработке на 25 см, и при послойной мелиорации применялись одинаковые дозы органического вещества. При одинаковом содержании питательных веществ на мелиорированном песке в ходе развития растений, в накоплении сухого вещества, в размерах колосьев, в структуре клеточных тканей, в химическом составе растений и семян, а так же в качестве муки наблюдались существенные различия по сравнению с контролем. Как рожь, так и пшеница в засушливый период оставались зеленными и растения не страдали от недостатка влаги. В этих же условиях при обычной обработке на 25 см, при поверхностном внесении удобрений, растения страдали от засухи. В этом случае растения не могли непрерывно обеспечиваться водой и питательными веществами т. к. в высушенном поверхностном слое питательные вещества были недоступны для растений. Новый метод мелиорации песков, задачей которого является образование глубокого питательного пространства, обеспечивает успешное выращивание сельскохозяйственных культур и в засушливый период времени.

При поверхностной обработке на 25 см и обычном внесении удобрений рожь дала 12,37 ц/га, а пшеница 17,54 ц/га, в то время как на мелиорированных песчаных почвах

урожай ржи был 25,09 ц/га, а пшеницы 27,08 ц/га. Глубокая обработка и глубокое послойное внесение питательных веществ является важным фактором повышения урожая как в богарных, так и в орошаемых условиях.

Этот метод, широко распостраненный в Венгрии не только в полеводстве, но при выращивании садов и виноградников, пользуется большим успехом и в других странах.

*Табл. 1.* Выпадение осадков за вегетационный период. (1) Год. (2) Среднемесячное количество осадков в мм. (3) Сумма осадков в мм. (4) Среднее за год, в мм. Верхняя строчка-среднее за 10 лет.

*Табл. 2.* Внешний вид колоса, качество ржаной муки и данные относящиеся к урожаю. (1) Варианты. (2) Длина колоса в см. и ширина его в мм. (3) Число зерен. (4) Урожая зерна в ц/га. (5) Вес 1000 зерен. (6) Число зерен в 100 граммах. (7) Показания лаборографа. a) при вспашке на 25 см. b) поверхностная заделка удобрений, c) послойно мелиорированный песок.

*Табл. 3.* Урожай пшеницы и содержание питательных веществ в зерне. (1) Варианты: 1. Обработка на 25 см. 2. Глубокая обработка. 3. Поверхностное внесение навоза. 4. Послойно мелиорированный песок. (2) Урожая зерна в ц/га. (3) Урожай соломы в ц/га. (4) Соотношение зерно: солома. (5) Содержание питательных веществ в зерне в г/м$^2$ в пересчете на абсолютно сухое вещество.

*Табл. 4.* Влажность почвы в момент уборки урожая. (22 июня 1961 года). (1) Глубина взятия образца. (2) Варианты, с 1 по 4 см. в табл. 3.

*Рис. 1.* Накопление сухого вещества в надземной части растения ржи. (100 растений). (1) Контроль. (2) При поверхностном внесении навоза. (3) При послойной мелиорации песка. a) В стадии полного кущения. b) При выходе в трубку. c) Перед колошением. d) В стадии цветения, e) В стадии образования завязи. f) В стадии восковой спелости. g) Во время уборки урожая.