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AGROPHYSICS IN MODERN AGRICULTURE

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Agriculture is a basic source of food for people and feed for animals. Its main purpose is to supply enough healthy products at minimum chemical and physical damage to the environment.

The progress in agricultural production is a consequence of the development of agricultural sciences. These natural sciences, being interdisciplinary, need various "pure" disciplines (chemistry, physics, biology) in order to investigate agricultural materials, such as soils, cultivated plants and plant materials.

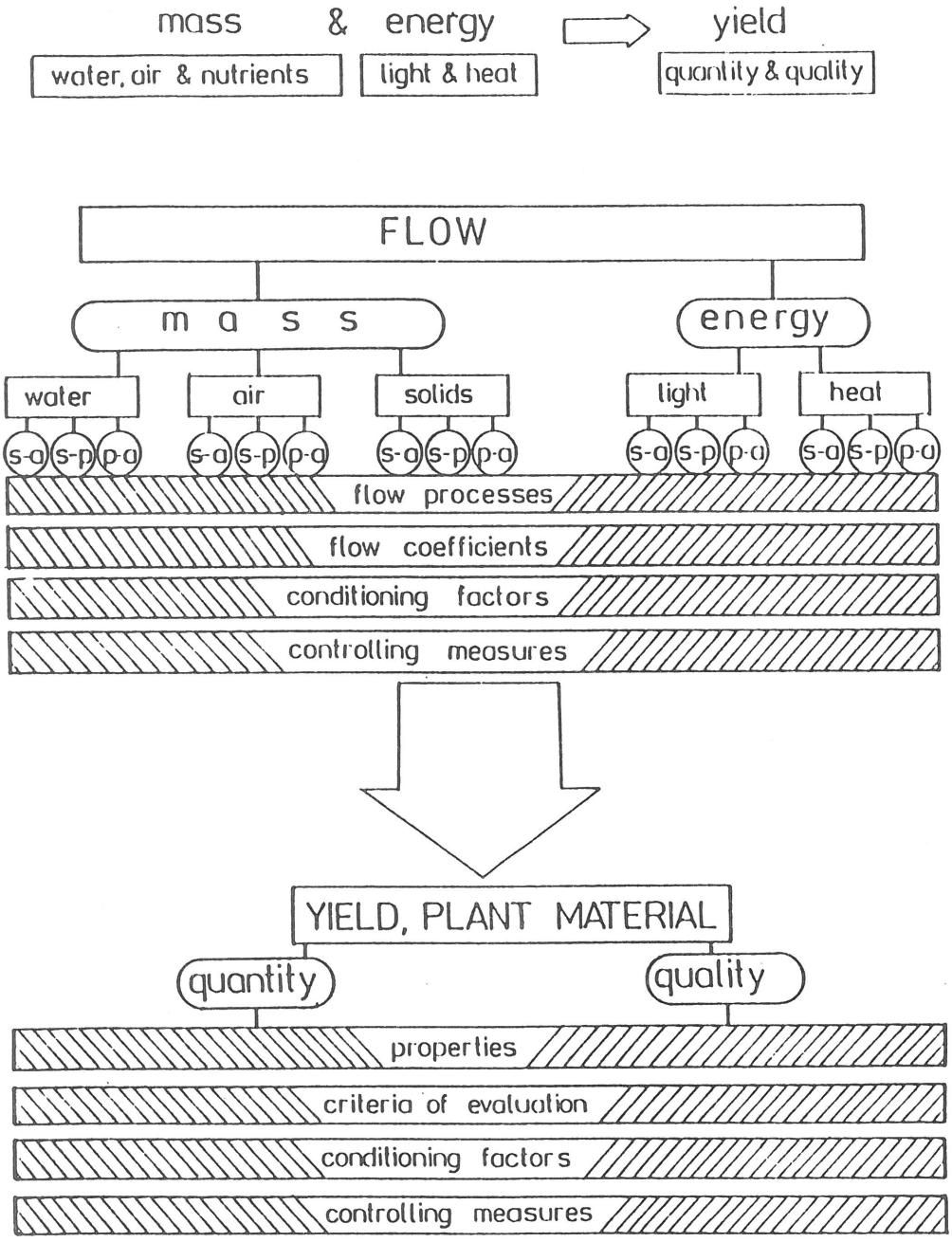
Agricultural materials are very complex in their composition and structure. The application of methods from "pure" sciences to examine those materials and the processes connected with them entails overcoming great difficulties.

The increase in plant production during the last decades took place mainly as a result of the chemicalization of agriculture and achievements in plant breeding. In the scientific investigations carried out so far, the greatest attention has been paid to the chemical properties connected with the fertility of the soil, fertilization, and plant protection, and recently also with the threat to the natural environment.

The rapid progress in the chemicalization of agriculture has undoubtedly contributed to the considerable increase in agricultural production, but the limit of the profitability resulting from an increase in the amount of the chemicals applied has almost been reached. The danger of the aggravating effect of excessive amounts of chemicals on the quality of consumption products and on the environment has also appeared.

Recently there has also been considerable progress in the mechanization of agriculture reflected by an increase in the number of machines which, through their traffic upon the soil and its cultivation, cause changes in the physical status of the soil, often in the direction of properties unfavourable to the growth and development of plants.

Knowledge concerning the physical properties of plants, plant materials and products is not yet satisfactory. We can be proud of great achievement in increasing crop yields. This increase, however, is not fully utilized due to a lack of knowledge of plant quality features, and particularly of their physical properties. Protection against losses of the mass of agricultural materials produced is, then, one of the most important problems in our economy. In the situation of food shortage there are losses of plant products reaching 20 percent and more. They appear during harvesting, when a great deal of grain is scattered to the soil. Also physical



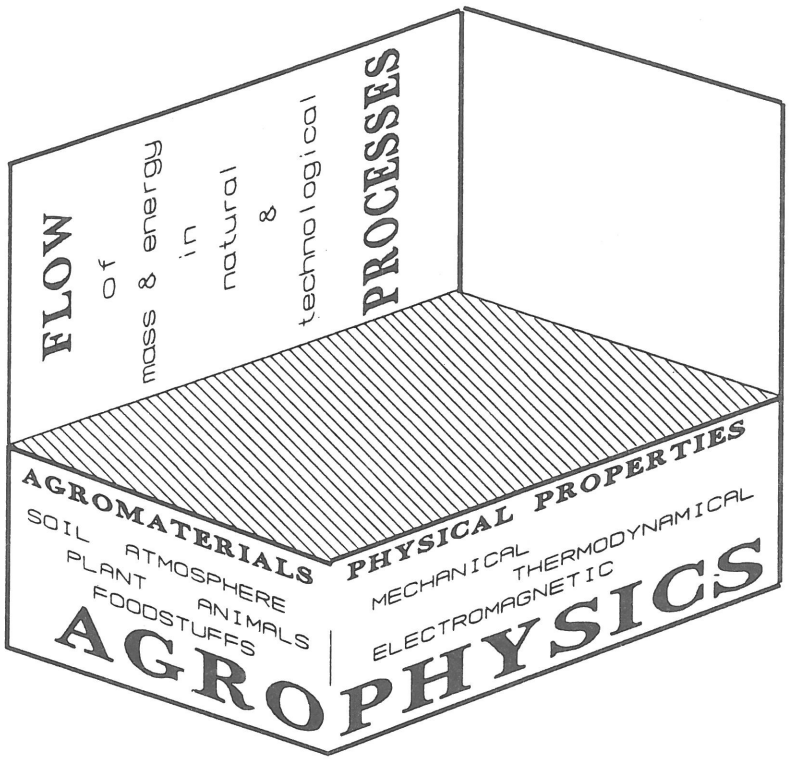
Scheme 1. Basic scheme of agrophysical research.
s-a: soil-atmosphere, s-p: soil-plant, p-a: plant-atmosphere.

processes occurring during the storage of plant materials are not yet well known, especially for cereals, root plants, fruits and vegetables.

In this situation the physical properties both of the environment of plant growth and of plants themselves appear to be an important factor in any further increase in crop yield and in the improvement of its quality.

The specificity of the investigations of the above mentioned properties and their production. The main topics of agrophysical investigations are mass (water, air, plant nutrients) and energy (light, heat) transport in the soil (s)- plant (p) -atmosphere (a) continuum and way their regulation to reach biomass of high quantity and quality (Scheme 1). In a wider meaning agrophysics concerns also animal and animals products.

Agrophysical investigations can be presented in the form of a three-parameter system of classification (Scheme 2).



Scheme 2. Three-dimensional scheme of agrophysical research.

role in agriculture has created a new branch of science called **agrophysics.**

This term similarly to "Agrochemistry", "Agrobiology", "Agromelioration", "Agroclimatology" or "Agroecology" has been fully accepted as an agricultural specialization.

Agrophysics according to its fundamental definition is a science dealing with physical properties and processes affecting plant

From a physical point of view the material forming the subject of examination may be solid (grain crops, plant stem, bone, skin, horn, etc.), liquid (tomato juice, fruit juice, oil, blood, milk, etc.), or gaseous (air, carbon dioxide, biogas, etc.). Whichever of the agricultural materials we take, it can be considered as structure composed of the former elements.

In the field of agriculture, materials

directly connected with production can be placed in 4 main groups [4].

The first group is the soil whose fundamental role need not be emphasized; on the other hand, we must point out that in the course of the agricultural activity optimum cultivation is possible only with a knowledge of the characteristic parameters and their influence. It is enough to mention the load capacity of the soil, a very important factor in constructing buildings, water supply establishments, road systems, furthermore, the various methods of soil cultivation which provide the best conditions for crop production taking at the same time the optimum utilization of agricultural machines into consideration.

The second group is formed by the plants, as one of the aims of agricultural activity. Perhaps the most important point is to know their characteristic factors; this is especially difficult in view of the diversity of plants, and even within a plant because of its components such as: root system, stem, foliage, fruit, not to mention the complex structure of each component. Further sharp distinction has to be made as regards masses of plants, which may be bulk-or stored crops, or chopped or even pressed material. Finally, in the course of processing, liquid, mealy, granulated, viscous, etc, materials are also found. The importance of knowing the different parameters and their role with the view of optimum handling must repeatedly be emphasized [6, 7].

The third group concerns a near ground atmosphere which form a microclimate of a cultivated field with plant canopy. In this group processes of evapotranspiration play an important role.

The fourth group contains the materials of animal origin, another important aim of agricultural production. In livestock breeding it is obviously of paramount importance to know the characteristics of the animal organism as well as possible. Further, it is enough to refer here to the role of factors mentioned above in designing the buildings, machines, transporting facilities of livestock farming. The same applies to the animal products, be they egg, milk, wool, etc. Finally, let us speak of processing where materials in all physical conditions occur. Here again, the optimum accomplishment of processing, transport and storage requires a knowledge of the characteristic feature of the material.

As seen from the foregoing we face a high diversity of agricultural materials, besides their occurring in many different states. For this reason the problems arising in practice are extremely complex.

For the proper plant development and yield the most important appear to be proportions between water, heat, air and mechanical resistance in soil, which are shown in Scheme 3. These proportions are found optimal only in some soils of a good aggregation which are not to heavy or too light, and when climatic conditions and human activity are proper.

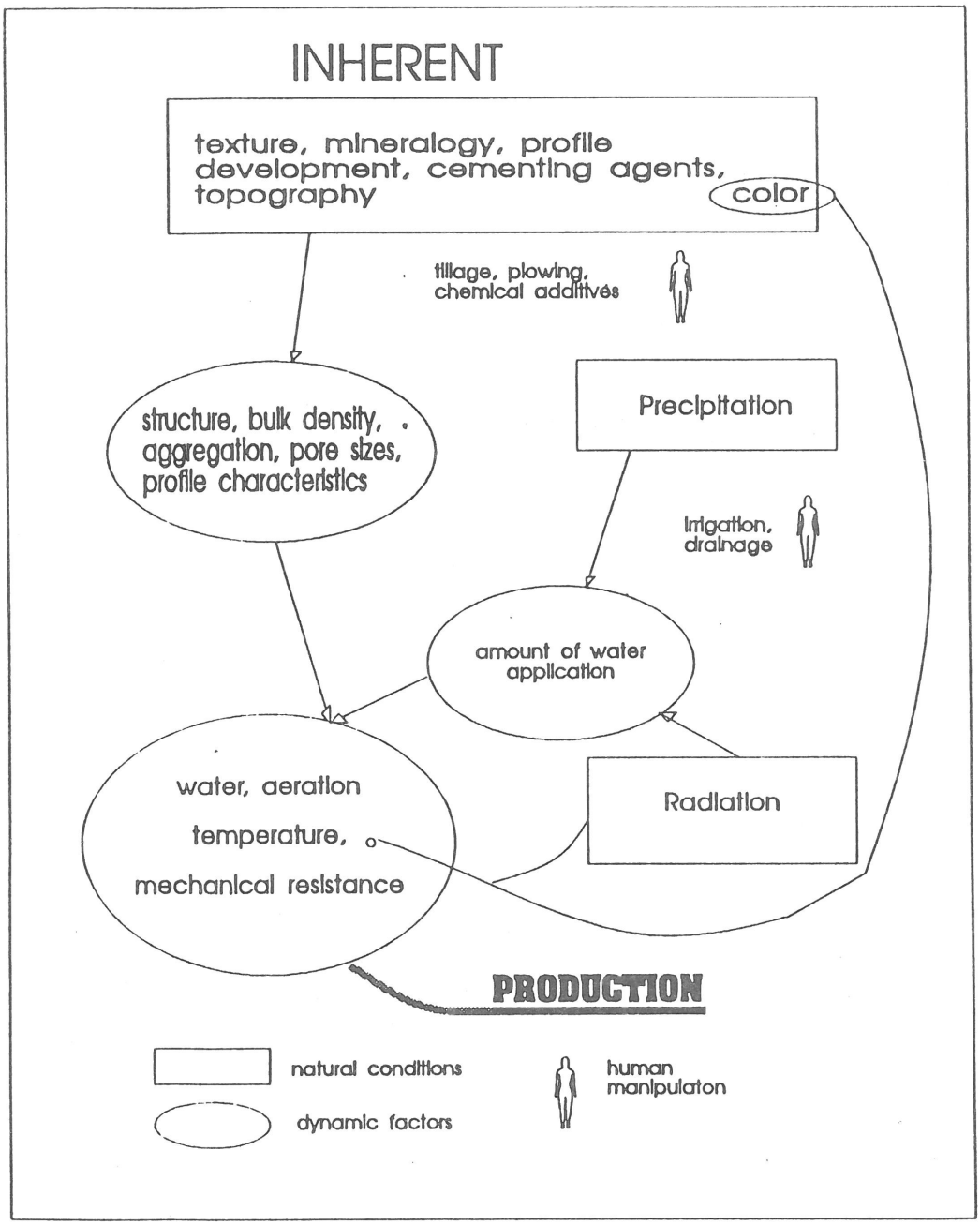
In considering soil physical properties which are important in crop production, it is necessary to separate factors which directly affect plant growth from those which affect it indirectly.

Water, oxygen, temperature and mechanical resistance impairing seedling emergence or root growth all directly affect plant growth and yield [1-3, 8].

These factors are determined by the influx of water and heat into the soil, and by agrotechnical measures which change soil porosity.

The rapid development of computerization systems creates enormous possibilities for the programming and prediction of phenomena and processes in the agricultural environment. Such programming and predictions however, need experimental data which can be obtained only with the use of agrophysical methods and specialists of high agrophysical qualifications.

Agrophysical investigations through the application of physics and physicochemistry to agriculture are focussed on increasing the efficiency of plant production, decreasing soil degradation and lowering quantita-



Scheme 3. Relationship between climatic and soil physical conditions and human manipulation in affecting crop production (after Letey J. [5]).

tive and qualitative losses of plant materials.

The development of a theoretical basis in the field of agrophysics is of great importance for many agricultural specializations, e.g., soil science, soil technology, land reclamation, agricultural engineering, agroclimatology, agrochemistry, plant breeding and plant technology.

The need for agophysical investigations was noted a hundred years ago by Joffe, a founder of the first Agrophysical Institute in St. Petersburg. Nevertheless, the term "agrophysics" was for a long time connected only with soil physics. Since the Institute of Agrophysics was founded in Poland a rapid development of agrophysical science has taken place.

The Institute is one of the institutes of the Polish Academy of Sciences. It was founded by Professor Bohdan Dobrzański in 1968 in Lublin and now represents a strong scientific unit carrying out basic investigations in the field of agrophysics.

The staff of the Institute consists of 100 workers, including 35 scientific with Ph. D. degrees. According to an interdisciplinary character of agrophysics they represent various specializations: physics, physicochemistry, soil science, agricultural engineering, mechanics, biology, geography, mathematics and electronics. These scientists have very high qualifications reached durign long training in domestic and foreign centres.

The Institute carries out its scientific activity in two buildings covering a surface of 5 000 m^2 and in the structure of four departments: Soil Physics, Soil Physicochemistry, Basic Problems of Soil Improvement and Physics of Plant Materials.

The Institute is well computerized and equipped with modern apparati. It is an editor of the journal "International Agrophysics".

The most important achievements of the Institute are in:

- elaboration of methods and apparati;
- physics of soil water;
- agromechanics;
- soil physicochemistry;
- aeration status of soils;
- climate of agricultural fields;
- non-conventional methods of soil improvement;
- physical properties of plants and plant materials;
- relation between soil physical properties and plant roots;
- development of agrophysics terminology.

These achievements are also due to a wide international co-operation.

Within these cooperative efforts, mostly on the basis of bilateral agreements, common investigations, the exchange of methods, analytical materials and instruments; and the exchange of scientists for short visits and long-term training are realized.

Under the inspiration of the Institute bilateral and multilateral international agrophysical conferences have been organized.

To facilitate this international co-operation, the Agrophysical Dictionary in six languages (English, French, German, Spanish, Russian and Polish) was elaborated and published by the Institute in 1991.

Summarizing the role of agrophysical investigations in a modern agriculture we can say that they help in:

- limiting of soil physical degradation caused by erosion, compaction, sealing and crusting and structure destruction;
- increasing of effectiveness of water and nutrient management;
- improving of the technology of soil cultivation, crop harvesting, storing and processing to decrease quantitative and qualitative losses of those materials;
- improving of agricultural machinery for its more effective use;
- improving of plant breeding through creation the physical properties of plants important for high yield.

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