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1.4. General and special research methods in agronomy

Modern methods of general scientific and special methods of research in agronomy, theoretical foundations of experiment planning and basic methods of statistical analysis using applied computer programs used to evaluate and interpret the results of field, vegetation and laboratory experiments inherent in agronomic experimentation are covered.
Key words: general, special research methods, agronomy.

General scientific research methods. The most commonly used general scientific methods in agronomy are hypothesis, experiment, observation, analysis, synthesis, induction, deduction, abstraction, specification, analogy, modeling, formalization, inversion, and generalization.

Hypothesis is a scientific assumption whose true value is uncertain. Hypotheses are distinguished as a method of developing scientific knowledge and as an integral part of a scientific theory. When hypotheses are used to develop knowledge, certain assumptions are first made, which are then tested in an experiment. Hypotheses can be based on known knowledge, and in this case they are reasonable assumptions.

If a breeder proposes a new crop variety, the working hypothesis about the prospects of the variety is based on its characteristics, which are given by the State Commission for Testing and Protection of Varieties. There are the following rules for making hypotheses:

- ✓ the correspondence of hypotheses to the facts to which they relate;
- ✓ the hypothesis that explains the largest number of facts is the most suitable;
- ✓ in order to explain the facts, the hypotheses should be closely related to them;
- ✓ contradictory hypotheses cannot be true at the same time;
- ✓ when proposing a hypothesis, one should be aware of the probability of their conclusions.

An experiment is a method of cognition that studies an object and the processes that take place in it under artificial but controlled conditions. An experiment tests the hypotheses that are put forward when planning an experiment.

Modern science uses different types of experiments: qualitative, quantitative (measuring), mixed, thought and computational.

The main purpose of qualitative experiments is to identify the phenomenon predicted by hypotheses or theories (whether it exists or not). For example, according to a characterization, one sorghum variety is resistant to smut, while the other is resistant to lodging. This can be tested in an experiment. Qualitative experiments can also answer questions such as whether a variety is frost-resistant or not, early-ripening or late-ripening, etc.

Observation is the purposeful focus of the researcher's attention on the phenomena of the experiment or nature, their quantitative and qualitative registration.

The purpose of observations in scientific agronomy is to identify the best elements of agricultural practices, technologies, varieties, soils, etc. that contribute to increasing yields and improving their quality.

The main requirements of observation are as follows:

- ✓ obtaining unambiguous research results;
- ✓ objectivity, i.e. the possibility of control through repeated observation;
- ✓ use of accurate instruments for observation;
- ✓ correct interpretation of observation results.

Analysis is a research method by which the object under study is mentally or practically dismembered into its component parts for the purpose of a more detailed study (for example, the experiment is first analyzed by repetitions, and each repetition is analyzed by separate sites, variants). Plants in the dynamics of their growth are analyzed either after a certain period of time - once a decade, a month – or by the phases of plant development. To determine the chemical composition of plants, they are first dissected into separate organs - leaves, stems, fruits, roots, etc.

Synthesis is the combination of the disaggregated and analyzed parts of the object under study or several objects into a single whole. The task of synthesis is to obtain the necessary data for more complete conclusions and generalizations based on a detailed analysis. To a certain extent, synthesis is the opposite of analysis, but they are interdependent and interrelated.

Induction is a method of research that uses judgment to lead from facts to specific conclusions. If the leaves of plants turn yellow, it is concluded that there is insufficient nitrogen nutrition; if they turn purple, it is a lack of phosphorus in the plant; if the leaves wither, it is the basis for concluding that the water regime of the soil is deteriorating.

Deduction is a research method that allows you to draw partial and individual conclusions by analyzing general statements and facts. The application of any general statement, law, or regularity to partial conclusions is also carried out by the deductive method.

Abstraction is the mental separation of the main thing in the object of research, its most significant connections.

Two types of abstractions are used:

- ✓ identification - to create concepts of systems and classes;
- ✓ isolation – to distinguish the essential from the extraneous, which is the most important issue of abstraction.

Thus, among dozens of experiment variants, the researcher identifies the most effective ones that differ significantly from others in terms of key indicators.

Concretization is a research method that moves from the abstract to the concrete.

Analogy is a method by which knowledge about already known objects, subjects or phenomena is transferred to other unknown but similar to known and previously studied ones. The conclusion is drawn by analogy.

Modeling is a method of studying objects, processes and phenomena on their models. The essence of modeling is to replace objects that are difficult to study with a specially created analog of a convenient model.

Formalization is a method of studying objects using individual elements of their forms that reflect the content of the object. Most often, formalization is applied with the use of mathematics, presenting proofs in the form of sequential formulas.

Inversion is a method of unusual study of an object, phenomena, or objects from a certain angle or even from the opposite side to the one studied earlier. This is a violation of the usual order of studying objects or phenomena, a combination of incompatible things, a division of the indivisible.

Generalization is a method by which one mentally moves from individual facts, phenomena, and processes to identification in thoughts or from one concept or judgment to a more general one.

Special research methods. Special research methods include those used in scientific agronomy, which is why they are also called specific scientific methods. This group includes the following main methods: laboratory, vegetation, lysimetric, vegetation-field, field, expeditionary. Each of them can be used in conjunction with other special and general scientific methods.

The **laboratory method** is used to analyze plants and their environment in the laboratory to study the interaction between the plant and environmental conditions, assess the quality of the crop, study plant metabolism, study the physical, chemical and microbiological properties of the soil, etc.

Chemical soil analyzes in the laboratory determine the availability of basic nutrients in different soils after different types of tillage, fertilization systems, etc. By determining the content of macro- and microelements in plants, plant weight, and making calculations, we can obtain data on the removal of nutrients from the soil by crops. Determining soil moisture, the content of weed seeds, their rhizomes and root sprouts, and studying the structure and other physical and chemical properties of the soil provides data on its cultivation and suitability for growing crops. Germination of seeds in thermostats is used to determine the germination of plant seeds, etc.

The laboratory method involves not only detailed analyses but also an objective and comprehensive synthesis of research results, followed by testing of proposals in practice. In years with excessive precipitation, the sugar content of beets can be significantly reduced, as evidenced by the results of laboratory analyzes. However, this does not mean that an increase in precipitation necessarily leads to a deterioration in sugar beet quality. It is necessary to comprehensively analyze other factors of plant life, including nutrient, air and soil temperature conditions, which, if improved with increased precipitation, will prevent deterioration in crop quality.

Almost all vegetation and field experiments cannot be conducted without a laboratory method of research. For example, laboratory analyzes are indispensable when selecting land for an experiment, planning and conducting it.

The **vegetation method** is a study of plants grown in glass houses under controlled environmental conditions for a period of several days to several months. For perennial plants, research can last for several years. The main goal of the vegetation method is to study the importance of individual plant life factors, the essence of the processes occurring in them, the soil, and the soil-plant system.

The vegetation method allows you to maintain various conditions within the limits of the experiment, such as humidity, nutrient supply, solution pH, lighting, temperature, etc. However, this method does not study the impact of individual factors on plant productivity under changing environmental conditions. Since in vegetation studies the environmental conditions are regulated and do not change as much as in the field, the number of growing seasons, i.e. repetitions of studies in time, can be reduced to a minimum.

Thanks to the vegetation method, many issues of agronomic science have been studied: the availability of phosphorus to plants from phosphate rock; the need for direct contact of the root system, which assimilates phosphorus, with the fertilizer itself; the role of nodule bacteria in the assimilation of nitrogen by legumes from the air; the importance of manure as a source of carbon dioxide for plants. The vegetation method is often used in conjunction with the field method.

The vegetation method proved to be very effective for studying the influence of various external factors on plant mineral nutrition and metabolism, for studying the dependence of plant growth on the temperature of the root zone and air. The vegetation method is used to study the role of water in plant nutrition, the phenomenon of photoperiodism, light intensity, day length, etc. In vegetation houses, you can compare the fertility of different soils and the efficiency of growing crops on them under the same conditions.

The main disadvantages of the vegetation method are as follows. Vegetation vessels do not have all the soil layers that are present in the field, and there is no subsoil, which changes the hydrological conditions of the study. They often have sand, water, gravel, etc. as a nutrient substrate. Therefore, this method does not answer the question of how the factor under study will affect crop yields in the field. One of the disadvantages is also the significant material costs for the construction of vegetation houses and their equipment. However, the vegetation method makes it possible to more accurately model various environmental conditions and identify the best ones for agricultural plants.

The **lysimetric method** is a study of plants and soil properties in the field to determine the balance of moisture and nutrients. Such studies are carried out in very large vessels - lysimeters, which are periodically weighed. This method differs from the vegetation method in that plant life and soil properties are not studied in vegetation houses, but directly in the field, where lysimeters are inserted into dug holes so that the aboveground part of the plants is in the same conditions as plants grown directly in the field. Two of the lysimeters have a hole through which wash water is collected for chemical analysis.

Depending on the purpose of the study and the plant, the height of the soil in the lysimeters can vary from 25 cm to 2 m (most often 1–1.5 m). According to the method of filling with soil, there are two types of lysimeters: bulk soil, i.e., with a violation of its natural composition and natural structure (a monolith of soil is placed in the lysimeter). In bulk lysimeters, soil is poured into the lysimeter in layers, sieved, mixed, and compacted to its natural volume. Depending on the objective of the experiment, lysimeters can be occupied by plants or without plants. Lysimeters can be concrete with a volume of 1–2 m3 of soil or metal with a diameter of 20–100 cm. Sometimes metal funnels with a diameter of up to 50 cm are used for lysimeters. To make it easier to collect the wash water, lighted corridors are equipped under the lysimeters. Special holes or rings are made in the lysimeters for periodic weighing. Regardless of the design, they are placed in separate groups according to the research topic near the laboratories (for easier maintenance).

The main issues that are studied using the lysimetric method are the following: soil moisture dynamics; precipitation flushing; composition of water filtered through the soil; leaching of mineral salts from soil and fertilizers; loss of nutrients during long-term fertilization; transpiration and evaporation of moisture by the soil, soil permeability, etc.

Although lysimetric studies are conducted in the field, their conditions are not very close to field conditions. To overcome this drawback, the vegetation-field method is used.

The **vegetation-field method** is a study of plants directly in the field in metal vessels without a bottom (in cylinders). This method is intermediate between the vegetation and field methods.

The soil in the cylinders is separated from the field soil only from the side, and from the bottom it is in contact with it or the subsoil in the area under study. Such cylinders can be installed not only on specially prepared areas, but also directly in crop rotation fields where certain crops are grown on different agricultural backgrounds, on soils of different types, on areas with different exposure and steepness of slopes, etc.

This method is used to study the effectiveness of fertilizers, the fertility of soil genetic horizons, and to model soil conditions. To do this, different nutrients are added to the cylinders in different doses and proportions, creating different reactions of the soil solution, unequal soil compaction, etc. At the same time, the cylinders can be used to sow different crops in pure form and in mixtures with different seed rates and at different depths, with or without plant fertilization.

During the trial, metal cylinders 30 to 100 cm high are buried in the soil so that they are 10 cm above the soil surface. The replication should be at least three times. In the control variants, the conditions are the same as in the field where the lysimeters are installed. Thus, in this experiment, the influence of factors is studied in conditions close to natural.

The vegetation-field method is also used in breeding, agrometeorology, agriculture, and crop production to model the necessary soil conditions. The use of mobile climate chambers made of plastic films, where the air temperature is regulated, makes it possible to simulate different weather conditions and even climate depending on the phases of plant growth and development. This helps to reduce the negative impact of various environmental conditions on crop formation.

In addition to these advantages, the vegetation field method also has the advantage that it does not require special facilities with sophisticated equipment (vegetation houses, greenhouses, phytotrons). However, it should be noted that a more detailed study of crops is possible when using the field method.

The **field research method** is the conduct of field experiments (experiments). It is the main method of scientific agronomy, because it is the method that links theoretical research with practical research: based on its data, recommendations for agricultural measures, technologies and varieties for agricultural production are developed.

The main task of the field method is to identify reliable differences between experimental variants, quantify the impact of life factors on plant yields and product quality.

Almost all scientific problems of agronomic science are solved with the help of the field method of research. For example, the depth, timing, and methods of soil cultivation are studied directly in the field. This is also the way to study different crop cultivation technologies, the structure of sown areas, the best predecessors, irrigation methods and rates, measures to combat water and wind erosion, the effectiveness of organic and mineral fertilizers, soil reclamation measures, new varieties, hybrids, etc.

Field experiments are conducted in scientific institutions and in production settings with the ultimate goal of assessing the economic efficiency of options and implementing the best ones in production.

Although the field method is the main one in scientific agronomy, it cannot be contrasted with other special and general scientific methods. The effectiveness of this method is greatly increased when combined with other methods, the choice of which is determined by the research program.

The **expeditionary method** of research is used to study and generalize agronomic issues directly in production through surveys of fields and crops grown on them. The purpose of expeditionary surveys is to find out the causes of lodging of bread; death of winter and perennial grasses; study of conditions for growing high and low yields in individual farms, in a district or region; study of the causes of deterioration or improvement of product quality; study of the content of pesticides, radionuclides and nitrates in products that exceed permissible standards. Expeditionary research also reveals the spread of noxious and quarantine weeds, diseases and crop pests, the appropriate structure of sown areas, the best predecessors, the most rational crop rotations, and promising varieties for specific farms, their groups, the entire district or a particular soil and climatic zone. This method can also be used to study the effectiveness of tillage methods, timing, and depth. To combat soil erosion using the expeditionary method, the causes of its spread and the factors that contribute to its occurrence in specific farms or areas are first identified.

The expeditionary method is also used for soil research. In this case, soil transects are dug, described, and soil samples are taken for physical and chemical analysis. Geological drills are used to determine the level of groundwater, which is important for studying hydrological conditions in fields and crop rotations. Similar studies should be conducted periodically in scientific institutions that serve a particular region or zone. However, they can also be performed by individual scientists in educational institutions.

To determine the effectiveness of a particular agricultural measure, expeditionary research determines the yield of crops, taking into account the quality of products.

The yields for previous years are taken from the annual reports of the farms The collected data are adjusted according to the weather conditions for the respective years - air temperature and humidity, precipitation, soil temperature, etc.

Джерела

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