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USE OF OPTICAL SENSOR EQUIPMENT IN IMPROVING SOIL FERTILITY

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Abstract.
In the agriculture of our republic, great measures are being taken on the correct application of mineral fertilizers. Today, the use of modern information technologies in almost all fields is of great importance for the development and prospects of the field. The use of modern equipment in the field dramatically increases work efficiency and creates the basis for good results. To increase soil productivity, the use of optical sensor equipment is one of the directions of innovative technology. This article covers such issues.
Keywords.
Optical sensor equipment, chlorophyll meter SPAD-502, FieldSpec, CropScan, GreenSeeker, Yara N-Senso, infrared NIR, mineral fertilizer.

Enter. Many approaches have been proposed for the efficient use of mineral fertilizers, especially nitrogen, in agricultural crops. One of them is plant diagnosis, which is carried out in the laboratory and in the field in order to determine the level of supply of nutrients to crops.

Chemical diagnosis performed in the laboratory by taking plant samples from the field is highly accurate, but it requires a lot of manpower and time. In the latter case, the real state of the plant can be known only after 5-6 days (this involves taking a plant sample from the field, preparing it for chemical analysis, and conducting a chemical analysis), which leads to delays in applying fertilizers.

In order to eliminate the above-mentioned shortcomings, it is proposed to use various optical sensor equipment [8]. One of them is the indirect determination of nitrogen fertilizer application rates in wheat, cotton, corn and other crops using the chlorophyll meter SPAD-502 (SPAD - Soil-Plant Analysis Development) in foreign countries [9].

Chlorophyllmeter SPAD-502 Minolta Co. of Japan. Ltd. in 1984, this equipment was originally aimed at the relative determination of the content of chlorophyll in plant leaves. Later, with the help of the SPAD-502 chlorophyll meter, the idea was put forward that it is possible to determine the nitrogen status of the plant and the nitrogen rate intended for the planned harvest according to the biological requirement of the plant [3]. Chlorophyll meter SPAD-502 is a diagnostic tool used instead of traditional plant analysis, it measures the amount of chlorophyll in the leaf and closely helps in determining the nitrogen requirement of the plant. This equipment uses two wavelengths (red rays with a wavelength of 650 nm and infrared rays with a wavelength of 940 nm) (Figure 1).

A certain part of the rays sent from the upper part of the measuring part of the chlorophyll meter is absorbed by the leaf, and the rest passes through the leaf and falls on the silicon photodiode in the lower part of the SPAD and is converted into an electrical signal (Fig. 2).

The amount of light falling on the photodiode is inversely proportional to the amount of chlorophyll in the leaf. The amount of chlorophyll in a leaf is displayed in the range of arbitrary numbers (0-99.9). Pigments in the leaf (chlorophyll, carotene, anthocyanin) absorb light energy for the process of photosynthesis. A plant experiencing a lack of nitrogen nutrition has been observed to quickly reduce the amount of chlorophyll in its leaves compared to carotenoids. The amount of anthocyanin in the leaves of a young and not fully developed plant is characterized by a relatively high amount, but precisely it was determined that the rate of photosynthesis is low in these leaves.

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Figure 1. Minolta SPAD-502 chlorophyll meter overview (left) and the part where the leaf is inserted and measured (in it)

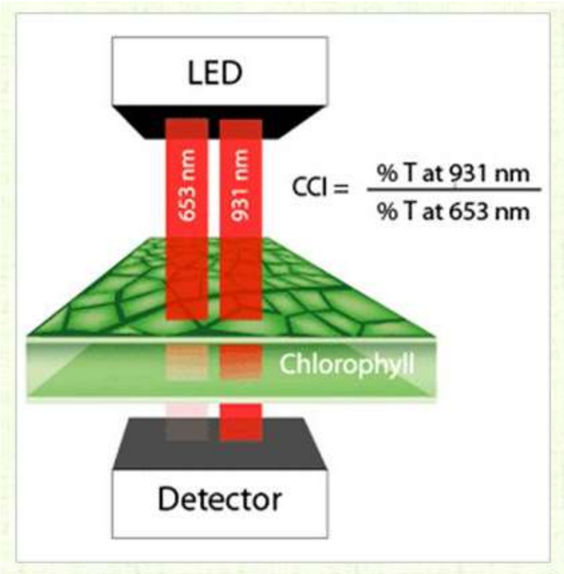

Figure 2. Chlorophyll meter SPAD-502 operating procedure
(https://www.hpssociety.info)

As a result, nitrogen fertilizers (rates and periods of application) have a strong effect primarily on the amount of chlorophyll in plant leaves and the process of photosynthesis in general.

Based on the results of studies with different crops, a number of scientists have concluded that measurements using SPAD-502 should be carried out on a fully developed leaf located at the top of the plant stem [6,7]. At present, sensor optical equipment is widely used to determine the nitrogen status of plants (winter wheat, rice, cotton, corn, and vegetable crops) and to differentiate fertilization. Methods of effective use of phosphorus fertilizers in crops with the help of censored equipment are now being established. Therefore, we found it necessary to provide a brief analysis of various optical sensor equipment used in the rapid determination of the nitrogen status of plants in the effective use of N-fertilizers in agricultural crops.

Proximal beam sensors. Proximal sensors based on measuring the light reflected from above-ground biomass of the plant aimed at assessing the nitrogen status of the plant are divided into passive (passive) and active types, depending on the light source. Passive sensors include FieldSpec, CropScan and digital cameras, while GreenSeeker, Yara N-Sensor are active sensors.

Figure 3. FieldSpec 3MAX Proximal Beam Sensor

Figure 4. CropScan Proximal Beam Sensor.

There are two types of photodetectors in passive sensors. The first type of photodetector measures the light falling on the plant biomass, which reports the irradiance conditions when the equipment is operating. The second photodetector measures the light reflected from the plant biomass [107; p. 2-23]. For example, the FieldSpecspectro-radiometer sensor (Analytical Spectral Devices, Inc., Boulder, CO, USA) has 512 channels in hyperspectral equipment, and this equipment is capable

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of measuring sunlight with a wavelength of 325-1075 nm reflected from above-ground plant biomass [95; pp. 77-85]. All types of passive sensors require initial adjustment and are dependent on sunlight since they do not have a light source.

Figure 5. GreenSeeker is a partitive spark that detects plant biomass

Figure 6. Yara N-Sensor active sensor partitive spark

Active sensors (GreenSeeker, Yara N-Sensor, CropCircle) are a new generation of proximal equipment, which have a light source. Scientific research aimed at managing N-fertilizer use in crops using active sensors has been intensively carried out in the last 20 years. Measurements are carried out by placing the proximal sensors at a height of 0.4-3.0 m from the plant biomass. In this case, the proximal sensors measure the specific length of the wave absorbed by the plant and returned from it, and provide information on the nitrogen status of the plant. Plant tissues absorb about 90% of visible light of 390-750 nm and reflect 50% of near-infrared light (NIR) of 750-1300 nm [7.]. A N-deficient plant reflects more visible light and less NIR than a plant with optimal nitrogen status.

Conclusion: The above-described color chart and various optical sensor equipment have effectively helped to alter nitrogen nutrition of plants in different field conditions, seasons and crop varieties, and made a significant contribution to improving the economic performance of foreign farms. Because determination of plant nitrogen status with the help of these devices and immediate appropriate decision making on application of N-fertilizer in the crop requires taking measures to eliminate excessive use of fertilizer. As a result, it is possible to successfully make appropriate corrections to conventional fertilization recommendations by making measurements using optical sensor equipment during the growing season of winter wheat (at tillering and tillering).

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