

Plant Nutrition Management – Modern Approaches

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Modern agriculture on a global scale is facing a number of challenges – the need to feed a growing population (projected to increase by 25% by 2050), the reduction of agricultural land (today 1 hectare of land feeds five people, compared to three fifty years ago), climate change and others. The need for a significant increase in productivity per unit area while at the same time minimizing greenhouse gas emissions and protecting the environment necessitates the choice of appropriate crop production technologies. An important element of these technologies is the management of plant nutrition.

Plants contain a large number of chemical elements, but 17 of them are absolutely essential for completing their life cycle. Just as the human diet needs to be healthy and balanced, so it is for agricultural crops. Fertilizers –

mineral or organic, supply the soils with elements vital for plants. When these elements are lacking or deficient, crop growth and yields are severely limited. The principles for successful plant nutrition management include producing sustainably high, quality crop yields and obtaining good income without exerting a negative impact on the environment. Important in this regard is ensuring a balance of nutrients at the entry and exit of the farm and of each individual field. These principles underlie all crop nutrition management systems – conventional, precision, organic, functional, integrated and other variants. The key to their successful implementation is innovation.

Agricultural science has developed the modern concept of ecological intensification of agricultural production. Ecological intensification is a process of increasing both yields and the environmental soundness of agricultural production, with a focus on precise management of all production factors and maintenance or enhancement of soil fertility, with the ultimate goal of sustainably feeding the world's population. In this context, the 4R (from English Right) concept has been developed. It includes the correct determination of the fertilizer rate, the proper choice of fertilizer form, timing of application and method of incorporation. When these elements of the fertilization technology are considered together, productivity, economic efficiency and environmental protection are ensured. The 4R approach provides farmers with a unique opportunity for effective production practices.

Precision management of agricultural production has become possible with the development of information technologies, the use of GPS equipment, powerful computers, aircraft, drones and now robots as well. These technologies enable precise management of crop nutrition by reflecting the variability in nutrient content within a given field and accordingly adapting fertilizer rates to the terrain.

In organic farming, crop nutrition management focuses on the utilization of the farm's internal resources, whereby nutrients are recycled and external inputs are minimized. Organic sources of nutrients such as farmyard manure and compost provide organic matter that improves soil structure and water-holding capacity, as well as a wide range of elements after mineralization, but usually in small and difficult-to-predict quantities. It is known that plants take up nutrients in the form of ions, i.e. organic fertilizers must first mineralize and release the elements in the same form as those from mineral fertilizers. Organic fertilizers also introduce microorganisms that enrich the beneficial soil microflora and biodiversity. However, there is also a potential risk of introducing harmful microorganisms such as *E. Coli* and *Salmonella*, and therefore rules are being developed for the proper storage and application of farmyard manure, especially for root and leafy vegetables. All this requires taking into account a number of additional factors and strict compliance with the rules.

Functional agriculture envisages, along with an increase in food production, providing people with almost all important minerals and organic substances needed to maintain the body and ensure the proper functioning of organs. Humans need at least 25 mineral elements, some in large quantities and others such as Fe, Zn, Cu, I and Se in trace amounts, because higher concentrations can be harmful. The source of a large share of these elements in food is plants. Unfortunately, mineral malnutrition in humans is observed both in developing and in developed countries, and it has been established that up to two-thirds of the world's population is at risk of deficiency of one or more mineral elements.

Agricultural crops do not always contain sufficient quantities of these elements to meet human needs. To “alleviate” the problem of mineral deficiencies in humans, scientists use cultivation practices and plant nutrition management methods that increase the concentration or bioavailability of mineral elements in agricultural produce. This approach is designated by the term agronomic biofortification. Strategies for increasing the concentration of mineral elements are applied in a number of countries, most often fertilization with iron and zinc, as well as selenium and iodine. Enrichment of the nutrient medium with macroelements important for health such as phosphorus and especially potassium and magnesium is also applied. In addition to being beneficial minerals, they support nitrogen metabolism and protein synthesis, as well as the synthesis of other organic compounds important for health such as vitamins, antioxidants, anticancer substances and others.

Regardless of which concept for managing the nutrition of cultivated crops is adopted, a key point for its successful implementation is compliance with the relevant Codes of Good Practice. A fundamental principle in all systems is to ensure balanced crop nutrition. For this purpose, it is important to compare the specific nutrient requirements of the crop for a given element with its availability in the soil through appropriate diagnostics.

Fertilization practices in Bulgaria have improved in recent years, but are still not at the required level. A characteristic feature for the country is unbalanced fertilization – an unfavorable ratio of the amounts of nutrients used, which is still heavily skewed in favor of nitrogen – in recent years the average annual ratio has been N: P₂O₅: K₂O = 100:20:10. With this ratio not only is the content of plant-available forms of phosphorus and potassium in soils depleted, but effective use of nitrogen cannot be achieved – it is known, for example, that the minimum permissible environmentally sound ratio of nitrogen to potassium is 100:40. There is a need to improve the nutrition of agricultural crops, and by applying the rules of good practice in accordance with the 4R concept, fertilization can be effective without risks to the environment and to product quality.

The use of efficiency indicators makes it possible to assess not only agronomic and economic efficiency, but also the utilization of nutrients supplied with fertilizers and the expected changes in soil nutrient reserves.

Modern efficiency indicators have been developed for evaluating the effectiveness of applied fertilizers. The most commonly used are:

- Partial factor productivity of the nutrient attributable to fertilization = yield/fertilizer rate.
- Agronomic efficiency of the applied nutrient = yield from fertilized – yield from unfertilized variant/fertilizer rate.
- Partial nutrient balance = removal of the element with yield/applied element with fertilizer (fertilizer rate).
- Recovery efficiency (utilization of a nutrient from fertilizer) = removal of the element from the fertilized variant – removal of the element from the unfertilized variant/fertilizer rate.

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