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Abstract- Plant nutrition is one of the most important measures for obtaining high yields and quality of products in agricultural production. Unlike conventional production where is possible to directly feed the plant, in ecological production nutrients are primarily introduced into the soil, therefore fertile soil forms the basis of a balanced nutrition of plants. In addition, ecological farming is defined as sustainable management of resources, which should be conserved and aim to use local resources through cycle closing, especially in terms of nutrients and organic matter. It is very important to apply fertilizer in an adequate period, having in mind the characteristics of the soil, the nutrient content in it, as well as the needs of the cultivated plants, so it can therefore be said that the efficiency of the nutrients depends on the type of fertilizer and its time of application. When specifically talking about phosphorus as a biogenic element that forms part of many organic compounds, it has an impact on the processes of growth, development, resistance to low temperatures and grain quality. The grain color, as one of the physical properties is generally a varietal characteristic. However, often under the influence of certain factors, insufficient and unbalanced nutrition, there may lead to variations in color and grain size characteristic of the variety.

Keywords: *plant nutrition, ecological production, sustainability, quality, grain color.*

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The Influence of Fertilizer Application on Color, Size and Number of Grains in Ecological Wheat Production

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Abstract- **Plant nutrition is one of the most important measures for obtaining high yields and quality of products in agricultural production. Unlike conventional production where is possible to directly feed the plant, in ecological production nutrients are primarily introduced into the soil, therefore fertile soil forms the basis of a balanced nutrition of plants. In addition, ecological farming is defined as sustainable management of resources, which should be conserved and aim to use local resources through cycle closing, especially in terms of nutrients and organic matter. It is very important to apply fertilizer in an adequate period, having in mind the characteristics of the soil, the nutrient content in it, as well as the needs of the cultivated plants, so it can therefore be said that the efficiency of the nutrients depends on the type of fertilizer and its time of application. When specifically talking about phosphorus as a biogenic element that forms part of many organic compounds, it has an impact on the processes of growth, development, resistance to low temperatures and grain quality. The grain color, as one of the physical properties is generally a varietal characteristic. However, often under the influence of certain factors, insufficient and unbalanced nutrition, there may lead to variations in color and grain size characteristic of the variety.**

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I. Introduction

Fertilization significantly affects the stability of yields and soil fertility, which are very closely related, because higher fertility implies greater availability of nutrients and greater ability of the soil to neutralize some extent adverse seasonal impacts (eg. drought) and the adverse impact of insufficient or redundant nutrition (soil elasticity) and thus contributing to the stability of yields[1].The importance of plant nutrition in agricultural production is recognized at all levels, including in legislation where the differences between conventional, integral and organic agriculture are largely focused on nutrition and crop protection[1]. Fertilization affects most of the parameters in the agro ecosystem, including: height, quality and stability of yield, soil fertility, nutrient circulation, sustainability and cost-effectiveness of production. In ecological farming, environmental protection comes first, so a special attention is on the selection and application of fertilizers.

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One of the basic assumptions that makes production ecological is the use of organic fertilizers. Other types of fertilizers that can be used in ecological production are natural mineral fertilizers, ingredients of different rocks. Since soil as a resource was created by rock mineralization, the introduction of these fertilizers into the soil naturally mimics the process of land formation[2]. Mineral fertilizers are used primarily for phosphorus, potassium and calcium. Phosphorus is a very important element for all living organisms. It is necessary in the physiological processes and metabolism of energy and matter, in the constitution of vital compounds and in the reproduction. Plants adopt and demand it in large quantities. Phosphorus is one of the essential elements, from an agricultural point of view, extremely important for the growth and development of plants, where it plays a role in energy reactions in the plants, photosynthesis, respiration, and gene and nutrient transfer, but also a key nutrient for optimizing N fixation of Rhizobium bacteria in nodules of leguminous roots, so it is imperative that the P content be maintained above minimum levels to ensure sufficient N_2 fixation[3].Some varieties of legumes are adapted to mobilize rarely available sources of phosphorus in the soil and improve the phosphorus provision of the following crop in rotation. In addition to legumes, which have a high proportion of typical crop rotation in organic farming systems, there is also the possibility of using recycled phosphorus fertilizers, including those with higher and lower phosphorus bioavailability[3].Due to the limited application of effective mineral fertilizers, the potential need for phosphorous fertilizers in ecological production is greater than in conventional. For sustainable management, it is crucial that the nutrients being removed are returned to the soil. Much of the nutrient demand in ecological farming is covered by the internal circulation system, that is, the application of manure.

However, phosphorus deficiency is caused by the fact that the phosphorous contained in the manure cannot compensate for the needs of the plants in ecological farming. In order to compensate for the needs of the plants, it is possible to apply recycled fertilizers that can balance the nutrition and get high yields without damaging the environment. In addition to high yields, quality is also very important. One of the good and essential features of recycled fertilizers is that

they release nutrients slowly, which is good for sustainable phosphorus management[4].Its "recovery" itself is a step in closing the cycle of nutrient cycling and contributes to sustainable management[5].However, the efficiency of recycled fertilizers depends on the soil type due to differences in solubility and sorption properties of the soil. It is most effective in soils of moderate or low pH, but its efficiency is limited in soils with low fertility and high pH. The solubility of the fertilizer improves under acidic conditions, increasing efficiency. Acidic conditions result in increased P adsorption into the soil and hence its dissolution and availability. The use of recycled fertilizers helps to realize some additional benefits, some of them are loss reduction and encourage the uptake of other nutrients. Depending on the variety, soil type and nutrient, wheat grains can differ in grain size, color and shape, as well as protein composition, carbohydrates, fats, minerals and vitamins. The shape and size of the grain play a large role, especially in grain processing. The grain shape is characteristic for each type of cereals, so the wheat is characterized by an elongated ellipsoidal shape, but preferred grains are closer to the round shape. A grain size is also a very significant indicator. Larger grains generally have a higher endosperm content[6]. Certainly, genetic potential is taken into account when selecting wheat varieties. Each variety of wheat has DNA (deoxyribonucleic acid) that gives it certain genetic traits. In the wheat kernel, the DNA is located in the germ, which is the embryo or sprouting section of the seed. Some varieties of wheat grow better in drought conditions while others are better at resisting certain pests. Some wheat varieties have a higher moisture content or contain higher percentages of protein[7]. This paper focuses on the impact of fertilizers (manure, P-Rock Morocco, Dolophos, Berliner Pflanze) and control samples oncolor, size and number of wheat grains, variety SW Kadriljin ecological production system.

II. Methods

The experiment was conducted during the wheat growing season in 2018. at the experimental station of the Institute for Agricultural and Urban Ecological Projects in Berlin. The experiment was set up in Mitscherlichpots in a greenhouse in Berge (Nauen). The vegetation experiment in Mitscherlich pots is based on the cultivation of plants according to a well-defined plan to determine the impact of certain elements of the plant nutrition, canceling out the significant influence of environmental factors. The Mitscherlich cultivation vessel is made of porcelain enamelled steel plate. For the experiment were selected pots which are 20 cm in diameter and with a capacity of 6.2 l. For grain counting was used Contador grain counter which provides fast counting speed and exact results. Wheat grain quality is a complex concept and includes several properties. To evaluate the quality based on the physical properties of the grain, it is easiest to determine the properties of hectolitermass and thousand grain mass. Unfortunately, due to the insufficient quantity of samples it was not possible to determine the quality on that way, so visual assessment and comparasion of size, shape and grain color was made.

a) Soil selection, preparation and preculture sowing

The soil was taken from two different locations, which have been in the ecological / organic production system for years. Both types of soil, light and heavy were used because each type has both advantages and disadvantages, and the aim was to compare yields and changes on plants as well as on grain from that aspect. After collection, soil was sifted in order to remove mechanical and biological impurities. The soil is well mixed with inert quartz sand. The mixing of soil and sand was performed in order to achieve good water-air regime. For the trial, a total of 40 pots were selected, with 4 replications for each treatment with heavy and light soil. For each pot were prepared 6 kilos of soil and 1g of fertilizer. The bottom half of the mixture in the pot is well compacted and the top half is left friable. In 2017. growing season, a broad bean (*Viciafaba*), a one-year-old plant from the legume family, was in the pots as a preculture. Since it is useful plant as a nitrogen fixer, the goal was to keep the soil rich in nitrogen after growing it.

b) Nutrition

As noted in the introduction part of this study, for nutrition were used four treatments: manure, P-Rock Morocco, Dolophos and Berliner Pflanze. Manure is considered to be the most important organic fertilizer and generally contains all the nutrients needed for plant nutrition.The manure repairs the physical, chemical and biological properties of the soil[1]. A fully composted manure was used for this experiment. As the second treatment was used P-Rock Morocco. It is a crude phosphate of magmatic rock deposits originating in Morocco. P-Rock Morocco contains 25-34% of P_2O_5 and is authorized for use in ecological production under Regulation (EEC) No. 2092/91 and Regulation (EC) No. 834/2007 but it is important that cadmium content (Cd) not exceeding 90 mg / kg P_2O_5[8].Dolophos is a granular fertilizer with different P_2O_5 content (11% or 26%). 26% was used for the experiment. It has the effect of slow release during vegetation, which is an advantage for sustainability. However, the release rate is also regulated by the soil pH. It also contains important secondary nutrients, including CaO, 2% MgO, and manganese, zinc, copper, and molybdenum. It is also approved for use on farms that are in the ecological production system[9].The last treatment was a recycled, high-quality, slow-release fertilizer under the factory name Berliner Pflanze. It sells itself according to German and European Fertilizer Regulations (VO 2003/2003) as

a compound fertilizer containing 5% N, 23% P and 12% MgO[10].

c) Main crop (wheat) sowing – variety SW Kadrilj

In spring of the season 2018, 3 g of K_2O was added to each pot, and then the main crop, wheat (Triticumaestivum), of the SW Kadrilj variety was sown. It is a high-yielding variety, which is very tolerant of bearing. It is medium early variety, characterized by high and stable yields and good disease resistance, which is an advantage in ecological production[11]. The seeds of this variety are certified as organic. In each pot was seeded 15 grains of wheat, and after sprouting, the number was reduced to 10. The pots were placed in appropriate places, on tables, below which were the receptacles for accepting drainage water. Wheat characteristics of the Kadrilj variety are shown in table 1.

Table 1: The characteristics of wheat – variety SW Kadrilj
(adopted from: https://www.syngenta.de/produkte/saatgut/sommerweizen/sw-kadrilj)

The characteristics of wheat - variety SW Kadrilj	
Plant height	Short to medium (4)
Earing	Early to middle (4)
Thousand grain mass	Medium (5)
Inclination to bearing	Low (3)
Disease resistance	Mediumto high (6)
Maturity	Medium (5)
Quality	High (7)
Crude protein content	High (7)

d) Grain counting

Seed counter – Contador was used for counting wheat grains. This grain counter is suitable for counting and filling of all seeds from 0.3 mm to 15 mm. The Contador is an optical counter with integrated vibration channel. The counting speed is automatically controlled depending on the size of the material to be counted, so that the counting time is minimized and a high degree of counting accuracy is achieved. The feed container is held by a magnet and is easy to change. Both a sample change and a crop type change can therefore be carried out very quickly. The Contador can be controlled using the keyboard on the device or using the serial interface. Particles that are significantly smaller in size are not counted. Thus, for example, rapeseed seeds in a pea sample fall into the pot but do not count. By manually adjusting the seed size, it is possible to control the counting of the material. The Auto Mode screen shows the set quantity and number of grains counted. In manual mode it also displays the selected counting speed and seed size. The keyboard is used to select different modes. There are 3 types of containers for counting grains according to their size[12]. For this experiment, tank number 2, which is adequate for wheat grains, was used.

III. Results and Discussion

In the framework of the conducted research, the results in this part are given in order to discuss the same and determine the differences in the physical properties of wheat grains in relation to the treatments applied. Wheat grain quality and physical properties are always strongly influenced by the variety, but nutrition also has a major impact on changes in color, grain size and number of the same wheat variety. Nutrition has an impact especially during the grain filling period, and nitrogen, phosphorus, potassium as well as magnesium and zinc are very important. Differences in the color of SW Kadrilj wheat grains with respect to the treatment applied are shown in Figures 1 and 2.

Figure 1: Grain color differences (light soil)

Figure 2: Grain color differences (heavy soil)

a) Grain color

Each of used treatments have shown a different color of the Kadrilj wheat kernel, which is a clear indicator that, in addition to all the factors that can cause color change, nutrition plays a large role. For light soil types, the darkest grain color was shown by samples where manure was used, so that color of grain is not a variety characteristic. In addition, the grains where this treatment was applied do not, by hardness, shape or size, meet the quality criteria of the physical characteristics of SW Kadrilj variety. This was definitely influenced by the nitrogen content of the manure, which led to prolonged vegetation, and a considerable number of wheat ears in pots labeled with this treatment continued to have a color on the transition from green to yellow, which was reflected in the grain filling, and ultimately to the color and quality of the grain. Although the number of kernels under this treatment was highest, the kernels were shrunken and fractured compared to other treatments. Also, for light soil type, the color is lighter than grain samples obtained on heavier soil using manure. For other samples where used (P-Rock Morocco, Dolophos and Berliner Pflanze) and samples that were in control, the grain color difference was evident in shades, and samples where Dolophos was applied and samples in control showed almost the same color, while the grain samples where P-Rock Morocco was applied showed a lighter color with a distinct golden tone in light soil type, compared to samples in the heavier type, which showed a darker color without gold tone. In addition to the color of the grain, the application of different fertilizers also affected the number of grains, which can be seen in Tables 2. and 3.

Table 2: Overview of the difference in the grains number in relation to the applied treatments (light soil)

Treatment	Soil type (light)	Total number of grains
Control	1	886
Manure	1	2359
P Rock Morocco	1	807
Dolophos	1	893
Berliner Pflanze	1	1502

Table 3: Overview of the difference in the grains number in relation to the applied treatments (heavy soil)

Treatment	Soil type (heavy)	Total number of grains
Control	2	946
Manure	2	2784
P Rock Morocco	2	1024
Dolophos	2	978
Berliner Pflanze	2	1705

As shown in the results, the largest number of grains in light as well as in heavy soil was obtained by applying manure, which is quantitatively excellent, but qualitatively, as previously shown through physical properties very poor. Following samples under manure, the best result in the total number of grains in both soil types was shown by samples where was used Berliner Pflanze fertilizer, which is an additional indication that this recycled fertilizer has a positive effect on yield and quality. Behind it, by the total number of grains obtained on light soil type are samples where a fertilizer called Dolophos was used and for heavier soil types, samples where P-Rock Morocco was used. A better result of applying P-Rock Marrocco to heavier soil types was influenced by its exceptionally favorable impact on that type of soil. The smallest total number of grains was shown by the samples that were in control. These results are indicative of the crucial influence of the nutrition with nitrogen and phosphorus, where the proportion of phosphorus nutrients is significantly increased.

b) Grain size

Certainly, various studies have been done over the years to show on what the nutrition can affect, and thus its effect on grain size has been proven, especially during the filling grain phase. Certainly, in the last years various studies have shown the influence of fertilization on wheat growth and development, on yields and thus its effect on grain size has been proven, especially during the filling grain phase. The grain size is genetically determined, that is, depends on the variety and the length of the filling period. Immediately after pollination, the embryo and endosperm begin to develop, so that the plant directs all photo synthates and previously stored starch and proteins (in leaves and stems) to these developing grains. The longer this period of grain fill is, the larger wheat grain size is likely to be. Nitrogen management will have the most impact on final wheat grain size and weight. Applications made early will ensure a canopy that is large, containing high levels of stem carbohydrate that is translocated to the developing grain during maturation. It is important to monitor plant nitrogen levels ensuring the canopy does not senesce early and curtail the grain filling period. However, except for nitrogen, phosphate has a major role in the supply of energy for plant processes. Redistribution of stored carbohydrate requires energy making phosphate nutrition important in achieving good wheat grain size[13].Positive results during this research

were shown by applied fertilizers with an emphasis on phosphorus content, and in particular recycled fertilizer - Berliner Pflanze.

IV. Conclusions

1. Fertilization is one of the agro-technical measures that is indispensable in wheat production, without which high and stable yields and good grain quality cannot be expected.
2. Comparing all used treatments, the best results in grain quality were shown by the application of recycled fertilizer Berliner Pflanze, while the highest number of grains was obtained by applying manure.
3. The grains obtained from plants using the treatments P-Rock Marroko, Dolophos, and Berliner Pflanze showed good physical properties, unlike grains from plants where the manure was used, which were smaller, darker and shriveled.
4. Phosphorus is an important macronutrient without which plants cannot grow and develop normally, and through this work it is shown that nutrition with phosphorous fertilizers definitely affects a number of processes in plants, and ultimately has an effect on the height and quality of yield, color, size and uniformity of wheat grain.
5. In ecological wheat production where nutrition remains a challenge and where it is very difficult to strike a balance, through this study it has been shown that the color deviations characteristic of a particular variety can be minimized by the use of recycled fertilizers.

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