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THE INFLUENCE OF THE INTERACTION OF SOME MINERAL FERTILIZERS ON THE ACCUMULATION OF SOME NUTRITIVE ELEMENTS IN WHEAT GRAINS

Elena ROȘCULETE, Cătălin Aurelian ROȘCULETE

University of Craiova, Faculty of Agronomy, 13 A.I. Cuza Street, 200585 Craiova, Romania

Corresponding author email: catalin_rosculete@yahoo.com

Abstract

In the paper, it is presented the influence of the combined fertilization of phosphorus-potassium and phosphorus-nitrogen on the content of wheat grains in certain nutritive elements. The experience, in a three year stationary rotation (soybean-wheat-corn), was located on a baticalcaric argic chernozem and the research aimed at studying the influence of the combined application of different doses of nitrogen, phosphorus and potassium, at wheat culture. The wheat grains were determined in terms of their nitrogen, phosphorus, potassium, calcium, magnesium, copper, manganese and zinc content. The determinations were performed on the fertilized variants with P_0, P_{40}, P_{80}, P_{120}, on constant grounds K_0, K_{80}, respectively N_0, N_{100} and N_{200}. The application of progressive doses of phosphorus on constant levels of nitrogen and potassium, has led to the increase of nitrogen, phosphorus, potassium, magnesium and manganese content, but to the decrease in calcium, copper and zinc content in all analyzed samples. It is also noted that the application of the P_{120} dose did not result in increases for the content of the determined nutrients, and moreover, they often resulted in decreases in their content.

***Key words**: doses, fertilizers, nutritive elements, wheat grains.*

INTRODUCTION

Research on the efficacy of wheat mineral fertilizers at the national and international level has shown a strong influence on the yield and quality of wheat fertilizers.

In the soil-plant-fertilizer system there is a permanent circuit of nutrients. Wheat plants extract different amounts of N, P and K from the soil through both the active organs and the grains, and at harvesting the roots, a part of the plant mass, remain on and in the soil. Thus, a wheat crop whose yield is of 5-6 t / ha, extracts the following average amounts of nutrients from the soil: 100-140 kg/ha N, 50-60 kg/ha P_2O_5, 130-160 kg/ha K_2O, 19-24 kg/ha Ca, 12-24 kg/ha Mg, 10-21 kg/ha S, 0.2-0.4 kg/ha Zn, 0.5-0.6 kg/ha Mn, 0.6-3.5 kg/ha Fe, 0.08-2 kg/ha Cu, 0.006-0.2 kg/ha B and 0.004-0.01 kg/ha Mo (Hera Cr., Borlan, 1980).

To provide a high yield-forming effectiveness of fertilizers, one shall maintain the adequate ratios between the nutrients applied (Kostadinova, 2014; Hirzel, Matus, 2014).

The content of wheat grain in nutrients differs according to the cultivated variety, soil type, soil water supply, fertilizer doses and their application period. The efficiency of the chemical fertilizers applied to wheat on the protein content of the kernel, the improvement of the technological indices of flour processing (Oproiu, 1981; Popescu et al., 1981) was demonstrated.

The quantitative and qualitative yield increase at the level of current requirements is not possible without the use of fertilizers (Petcu et al., 2003).

In long-term experiments, fertilization can cause soil and concentration changes in available macro-elements, which in turn can also affect the micro-element concentration (Li et al., 2007).

For example, the application of phosphorus in humidity conditions greatly decreases the water solubility of micro-nutrients and implicitly their extraction from the soil (Bierman, Rosen, 1994).

Wheat grains contain almost all the nutrients indispensable to human existence, representing an important source of nutrients in human and animal nutrition, in the form of proteins, lipids, carbohydrates or mineral substances.

The content of magnesium, potassium, sodium and calcium as well as the quantitative ratios between them make it possible to determine the nutrition applicability of the plants grown for animal feed, as well as the nutritional value of the yield allocated to human consumption (Wojciech et al., 2017). An excessive uptake of specifications or anions limits the content of other, sometimes very important, macro- and microelements. High potassium contents deteriorate, whereas high calcium and magnesium contents improve the quality of animal feed (Murawska et al., 2013).

The presence of micro-elements in crop plants is not only a topical issue in agricultural technology, but also an essential quantitative indicator in food and feed standards (Fageria et al., 2008; Van Campen, Glahn, 1999). The deficiencies of some micro-elements in the soil also affect the quality of the yield, with repercussions even on the human body.

For example, zinc deficiency is the most widespread in the world (Fageria et al., 2002). Worldwide, about 50% of the soils are deficient in Zn, and a high proportion of Zn low-grain foods may be a major factor in the occurrence of Zn deficiency in humans (Welch, 1993).

Copper is a component of antioxidant enzymes, and its deficiency in diet can affect the proper functioning of the human and animal body antioxidant system (Hänsch, Mendel, 2009).

MATERIALS AND METHODS

The experiments in a three-year stationary rotation (soybean-wheat-corn) were carried out at the Research and Development Unit of Caracal on a baticalcaric - argic chernozem, following the parcel three-factor subdivision, with three repetitions. The slightly alkaline soil (pH = 7.7) in the arable bed is poorly supplied with nitrogen (0.130% total N), medium to well supplied with phosphorus (43.7 ppm P mobile) and well to very well supplied with potassium (233.8 ppm K).

The following items were tested in the wheat culture: factor A - phosphorus fertilization with four graduations: $a_1= P_0$, $a_2= P_{40}$, $a_3= P_{80}$, $a_4= P_{120}$; factor B - potassium fertilization with two graduations $b_1= K_0$ și $b_2= K_{80}$; factor C - nitrogen fertilization with three graduations $c_1= N_0$, $c_2= N_{100}$, $c_3= N_{200}$.

Progressive doses of phosphorus were applied on constant nitrogen and potassium samples, also taking into account the initial soil content in the three macro-elements.

The influence of the interactions of fertilizer doses applied to the yield obtained during the three years of experimentation was examined, and at the end of the experimental period certain qualitative features of the yield were determined.

From the yield of the last year of experimentation, average samples were analyzed for the analyzed variants, from which determinations were made regarding the content of wheat grains in total nitrogen, phosphorus, potassium, calcium, magnesium, copper, manganese and zinc .

The Nt determination was performed using the Kjeldhal method (Kjeldhal Raypa wet/ acidification - Kjeldhal Pro-Nitro distiller and sodium hydroxide titration).

For the other nutrients analyzed (P, K, Ca, Mg, Cu, Mn and Zn), the mineralization of the samples was made by calcination at 450°C, and the mineral residue obtained was solubilized with 0.5 N hydrochloric acid. As far as the concentration of the macro- and micro-elements is concerned, the standard methods of determination were used.

Phosphorus was determined by the colorimetric method using the UV-VIS spectrophotometer, and K and Ca were determined by flame emission photometry using the Flame Photometer PFP 7.

The determination of the Mg, Cu, Mn and Zn content was achieved by atomic absorption spectrophotometry using the AA Spectrometer S Series.

RESULTS AND DISCUSSIONS

The autumn wheat culture responds positively to the application of mineral fertilizers, especially when the assortments and doses interact with primary macro-elements (NP or NPK) and the ratio between them is sufficiently balanced, more particularly between nitrogen and phosphorus (Borlan et al., 1994).

Long-term experiments play an essential role in understanding complex plant-soil-fertilizer interactions and provide data on fertilizer application, being a rich source of scientific information on the agronomic conditions over a long period of time (Lupu et al., 1993).

Nitrogen fertilization is one of the most effective yield-formation factors (Candráková et al., 2009; Jankovic et al., 2011). It demonstrates a comprehensive effect together with other crop management factors on the yield level, as well as on the quality characteristics of the grain (Liszewski, 2008; Valkama et al., 2013).

The right fertilization should be based on the balance of nutrients, considering their uptake from soil as well as from fertilizers (Staugaitis et al., 2014; Mandic et al., 2015).

Wheat is one of the world's most valued grain crops because wheat grains contain almost all the nutrients indispensable to human nutrition. Experimentally, 100 grams of grain contain on an average: 10.4 grams of protein, 61.7 grams of carbohydrate, 1.45 grams of lipids, 12.5 grams of fiber, 0.7 grams of B vitamins (B_1, B_2, B_3, B_6), 1.44 milligrams of vitamin E, 38 mg Ca, 493 mg P, 126 mg Mg, 3.21 mg Fe, 397 mg K, 2.63 mg Zn, 2 mg Na.

Together with the achievement of increased yield on the surface unit, there is widespread concern for obtaining adequate agri-food products for human and animal nutrition.

The yield quality of the last year of experimentation was evaluated by the content of macro- and micro-elements in wheat grains, being directly influenced by the doses of mineral fertilizers applied, as well as by their interaction.

Constantly using K_0 and K_{80}, depending on phosphorus fertilization, the wheat grain content was analyzed in primary and secondary macro-elements (N, P, K, Ca and Mg - Table 1), and in micro-elements (Cu , Mn and Zn - Table 2).

Phosphorus application in progressive doses, in the absence of potassium or using K_{80}, slightly increased the content of macro-elements in wheat grains, with the exception of calcium (0.035% Ca for P_0K_0 at 0.034% for $P_{40}K_0$/ $P_{80}K_0$/ $P_{120}K_0$). Compared to calcium, nitrogen, phosphorus, potassium, and magnesium were found to have slightly increased at the same time with the values of phosphorus doses. The P_{120} dose did not bring any significant changes compared to P_{80}.

Applying progressive phosphorus doses against constant potassium levels caused a slight decrease in the concentration of the analyzed micro-elements as a result of increasing doses, except for manganese (43 ppm Mn for P_0K_0 at 52 ppm Mn for $P_{120}K_0$ and 49 ppm Mn for P_0K_{80}/$P_{120}K_{80}$ at 53ppm Mn for $P_{40}K_{80}$).

Table 1. Content of macro-elements (%) of wheat grains depending on phosphorus and potassium fertilization

Doses	K_0					K_{80}				
	N	P	K	Ca	Mg	N	P	K	Ca	Mg
P_0	2.31	0.27	0.33	0.035	0.121	2.14	0.28	0.34	0.036	0.125
P_{40}	2.49	0.37	0.34	0.034	0.131	2.44	0.35	0.40	0.035	0.133
P_{80}	2.38	0.42	0.41	0.034	0.135	2.41	0.41	0.41	0.035	0.136
P_{120}	2.49	0.42	0.39	0.034	0.137	2.45	0.38	0.36	0.028	0.129

Table 2. Content of micro-elements (ppm) of wheat grains depending on phosphorus and potassium fertilization

Doses	K_0			K_{80}		
	Cu	Mn	Zn	Cu	Mn	Zn
P_0	6.18	43	37	5.81	49	33
P_{40}	6.46	49	27	3.87	53	33
P_{80}	3.74	51	31	3.35	51	33
P_{120}	4.11	52	29	3.67	49	31

Ensuring a K_{80} agro-base reduced the content of wheat grains in copper and zinc and increased the content of manganese for all levels of phosphorus fertilization, and even for unfertilized variants where it had not been applied.

Depending on the phosphorus fertilization, the wheat grain content was analyzed in primary and secondary macro-elements against constant background of N_0, N_{100} and N_{200} (N, P, K, Ca and Mg - Table 3), but also in micro-elements (Cu, Mn and Zn - Table 4).

The application of progressive doses of phosphorus at constant nitrogen values led to an increase in the content of macro-elements in wheat grains, even in the absence of nitrogen fertilizers. The exception was calcium, the content of which decreased with increasing phosphorus doses at all levels of nitrogen fertilization (0.032% Ca for $P_0N_0$0 at 0.030% Ca for $P_{80}N_0$; 0.038% Ca for P_0N_{100} at 0.028% Ca for $P_{120}N_{100}$; 0.037% Ca for P_0N_{200} at 0.035% Ca for $P_{120}N_{200}$).

Regarding the micro-element content, phosphorus fertilization at constant nitrogen values caused a decrease in Cu and Zn concentrations and an increase in Mn concentrations, as phosphorus doses increased regardless of the nitrogenous agro-base.

Table 3. Content of macro-elements (%) of wheat grains depending on phosphorus and nitrogen fertilization

Doses	N_0					N_{100}					N_{200}				
	N	P	K	Ca	Mg	N	P	K	Ca	Mg	N	P	K	Ca	Mg
P_0	1.76	0.30	0.35	0.032	0.129	2.32	0.28	0.35	0.038	0.124	2.6	0.25	0.31	0.037	0.117
P_{40}	1.89	0.36	0.37	0.032	0.135	2.52	0.31	0.36	0.034	0.130	2.98	0.41	0.38	0.037	0.132
P_{80}	1.79	0.40	0.40	0.030	0.132	2.42	0.40	0.40	0.037	0.134	2.99	0.46	0.43	0.037	0.142
P_{120}	1.96	0.37	0.40	0.031	0.134	2.60	0.40	0.38	0.028	0.132	2.87	0.43	0.35	0.035	0.133

Table 4. Content of micro-elements (ppm) of wheat grains depending on phosphorus and nitrogen fertilization

Doses	N_0			N_{100}			N_{200}		
	Cu	Mn	Zn	Cu	Mn	Zn	Cu	Mn	Zn
P_0	5.34	51	29	5.96	45	37	6.69	43	39
P_{40}	4.39	56	21	3.72	49	28	4.67	49	41
P_{80}	3.51	54	21	3.30	51	31	3.82	49	40
P_{120}	3.62	55	22	3.46	48	29	4.61	49	39

The copper content dropped from 5.34 ppm for P_0N_0 to 3.51 ppm for $P_{80}N_0$; from 5.96 ppm for P_0N_{100} to 3.30 ppm for $P_{80}N_{100}$ and from 6.69 ppm for P_0N_{200} to 3.82 ppm for $P_{80}N_{200}$.

Zinc had the same downward trend, along with increasing phosphorus doses, except for the N_{200} agrobase, where the values remained at about the same level (39-40-41 ppm). Manganese is the microelement whose concentration increased simultaneously with the applied phosphorus doses.

If we follow the variation of the concentration of the analyzed micro-elements for each level of phosphorus fertilization, depending on the nitrogen agrobase, it can be observed that zinc and copper are the micro-elements whose content is higher when N_{200} is secured and the Mn content is higher on unfertilized variants.

In all the samples in the analyzed variants the minimum and maximum nutrient content varied as follows:

- the total nitrogen content ranged between 1.76% for P_0N_0 and 2.99% for $P_{80}N_{200}$;;
- the phosphorus content was between 0.25% for P_0N_{200} and 0.46% for $P_{80}N_{200}$;
- the K content ranged between 0.31% for P_0N_{200} and 0.43% for $P_{80}N_{200}$;
- the Ca content was between 0.028% for $P_{120}K_{80}$ and 0.037% for $P_{80}N_{200}$;
- the Mg content ranged between 0.117% for P_0N_{200} and 0.142 for $P_{80}N_{200}$;
- the Cu content was between 3.30 ppm for $P_{80}N_{100}$ and 6.69 for P_0N_{200};
- the Mn content ranged between 43 ppm for P_0K_0 and 56 ppm at $P_{40}N_0$;
- the Zn content was between 21 ppm to $P_{80}N_0$ and 43 ppm for $P_{80}N_{200}$.

The application of fertilizers with phosphorus and nitrogen resulted in an increase of the total nitrogen content in wheat grains, the highest content of 2.99% being recorded on the $N_{200}P_{80}$ variant.

Regarding the wheat grains' phosphorus content, we can observe that on a constant background of nitrogen, it increases to the dose of P_{80}, after which, at the application of the maximum dose of P_{120}, there is a decrease of the phosphorus content both at N_0 and at N_{200}, as well as a restriction on the N_{100} agrofond.

On the background of N_0, N_{100} and N_{200}, the potassium content of the berries increases at the same time as the increase of phosphorus doses up to the P_{80} level, and the application of the P_{120} dose resulted in a restriction of the potassium content for N_0 and a decrease for the N_{100} and N_{120} variants.

On a constant background of nitrogen, there is generally a decrease in grains' calcium content along with the increase in the applied phosphorus doses.

On a constant background of nitrogen, an increase in the magnesium content for the grains may be attributed to the increase in the applied phosphorus doses, with a peak reached on the $P_{80}N_{200}$ variant.

On a constant background of nitrogen, the administration of progressive doses of phosphorus lead to a decrease in copper content for wheat grains.

In terms of manganese content, the application of different phosphorus doses on a constant nitrogen background led to an increase in nitrogen, while the application of different doses of nitrogen on a constant background of phosphorus resulted in a decrease in phosphorus.

On a constant background of N_0 and N_{100}, the progressive application of phosphorus doses led to a decrease in zinc content for wheat grains, but on the background of N_{200} it increased, with a maximum value of 43 ppm for the $P_{80}N_{200}$ variant.

CONCLUSIONS

Experimenting the combined application of phosphorus and potassium fertilizers and phosphorus and nitrogen fertilizers to wheat crops also allowed for a qualitative assessment of the yield obtained under such conditions and depending on the interaction between the examined factors.

Providing a constant nitrogen pool (N_{100} and N_{200}) on which progressive phosphorus doses were applied resulted in better nitrogen, phosphorus, potassium, magnesium and manganese grains. Calcium, copper and zinc decreased simultaneously with the increase of the phosphorus dose on the same nitrogen agrobase.

Against the K_{80} agrobase, the application of increasing phosphorus doses leads to an increase in nitrogen, phosphorus, potassium, magnesium and manganese concentrations, and a decrease in the calcium, copper and zinc content. The same trend is also evident for the agrobase K_0. The application of phosphorus fertilizers influences the accumulation in wheat grains, especially in macro-elements, with the exception of calcium.

Regardless of the provided agrobase, there are no significant differences in the concentrations of the analyzed elements between the doses of P_{80} and P_{120} so that the maximum phosphorus dose can be justifiedfrom an economic point of view.

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