Piotr SZULC, Hubert WALIGÓRA, Witold SKRZYPCZAK
University of Life Sciences, Department of Agronomy
ul. Mazowiecka 45/46, 60-623 Poznań
e-mail: pszulc@up.poznan.pl

ROOT SYSTEM DEVELOPMENT OF MAIZE „STAY-GREEN" TYPE IN CONDITIONS OF DIFFERENTIATED MINERAL FERTILIZATION

Summary

Pot experiment was carried out in the Department of Agronomy, University of Life Sciences in Poznań. Two maize fertilization methods were analyzed; without mineral fertilization and with the use of NPK fertilization. Furthermore, in the NPK fertilization, was applied together with kieserite which is permitted to be used in ecological agriculture. The effect of this method on the development of the root system of „stay-green" maize hybrid in the phase of BBCH 89 was studied. Significantly the highest fresh matter, dry matter, root system volume in a single plant and the highest dry matter content in the roots was obtained in the object, where NPK + kieserite > NPK > zero NPK was applied.

ROZWÓJ SYSTEMU KORZENIOWEGO KUKURYDZY TYPU „STAY-GREEN" W WARUNKACH ZRÓŻNICOWANEGO NAWOŻENIA MINERALNEGO

Streszczenie

Doświadczenie wazonowe wykonano w Katedrze Agronomii, Uniwersytetu Przyrodniczego w Poznaniu. Porównywano w nim zróżnicowane nawożenie mineralne kukurydzy tzn. bez nawożenia mineralnego i nawożenie NPK. Ponadto w nawożeniu NPK stosowano łącznie również kizeryt, który jest dopuszczony do stosowania w rolnictwie ekologicznym. Badano wpływ zróżnicowanego nawożenia mineralnego na rozwój systemu korzeniowego mieszańca kukurydzy typu „stay-green" w fazie BBCH 89. Istotnie największą świeżą masę, suchą masę, objętość systemu korzeniowego pojedynczej rośliny oraz zawartość suchej masy w korzeniu posiadała kukurydza na obiekcie NPK+kizeryt > NPK > 0 NPK.

1. Introduction

Growth and plant dry matter production are the results of metabolical processes, whose continuity requires the supply of sufficient amounts of nutritive components. The soil supplies water and nutritive components and they are taken up by plant roots. Therefore, the roots, or rather the root system zone represents the sphere where plants contact with the soil and with the mineral components [5]. It may be interesting to investigate the effect of differentiated mineral fertilization on the development of maize root system.

Therefore, the objective of the pot experimental was the determination of differentiated mineral fertilization effect on root system development in maize hybrid "stay-green" type.

2. Methodics

Pot experiments, in two series at the same time, were carried out in the year 2009 in the Department of Agronomy, University of Life Sciences in Poznań. They were one-factorial experiments, according to the methodics foreseen for such experiments [8]. Each experimental series was established in four replications. Three variants of mineral fertilization were studied: zero NPK, NPK and NPK + kieserite.

Nitrogen was applied in the form of ammonium nitrate NH_4NO_3 - 34% N, phosphorus in the form of granulated triple superphosphate 46% of P_2O_5 , potassium in the form of potassium salt 60% of K_2O. Magnesium was applied in the form of kieserite (magnesium sulphate - $MgSO_4$). This fertilizer contains (25% MgO) and sulphur 50% - SO_3 (20% S). It is permitted to be used in ecological agriculture.

For one pot, the following amounts of the particular mineral fertilizers were used: nitrogen – 0.9 g $fertilizer \cdot pot^{-1}$, phosphorus - 0.5 g $fertilizer \cdot pot^{-1}$, potassium – 0.5 g $fertilizer \cdot pot^{-1}$, magnesium (kieserite) – 0.3 g $fertilizer \cdot pot^{-1}$.

In each pot of 8000 cm^3 volume, 6 seeds were placed. After germination, plant thinning was carried out and then, in each pot, 2 plants were left until harvest. Biometrical root measurements were carried out in the BBCH 89 phase. The soil used in the experiment showed the following composition: 86 mg $P \cdot kg^{-1}$ of soil, 108 mg $K \cdot kg^{-1}$ of soil, 48 mg $Mg \cdot kg^{-1}$ of soil, pH 5.02).

Fresh matter of the root system in a single maize plant was determined after an exact removal of plant roots together with the soil clod. Then, after precise rinsing and clearing of the roots from the soil, the roots were dried and weighed. The obtained result was divided by two and in this way, the fresh matter content in a single plant was obtained. In order to determine the root system dry matter of a single plant, dried and cleaned roots were placed in a drier at 105°C for a period of 10–15 hours. Then, the roots were weighed and the calculated result was divided by two which gave the amount of root system dry matter of a single plant. Having the amounts of fresh and dry matter of a single plant root system, the d.m. content in the root system was determined. The volume of the root system of a single plant was measured by the method of water removal [1]. The measurement was carried out in a special container which was completely filled with water. Then, the carefully washed and dried roots (using blotting paper) were immersed in water and the water, which overflowed, was measured with a graduated measuring cylinder. The obtained result was divided by two and in this way, the volume of the root system of a single plant was obtained.

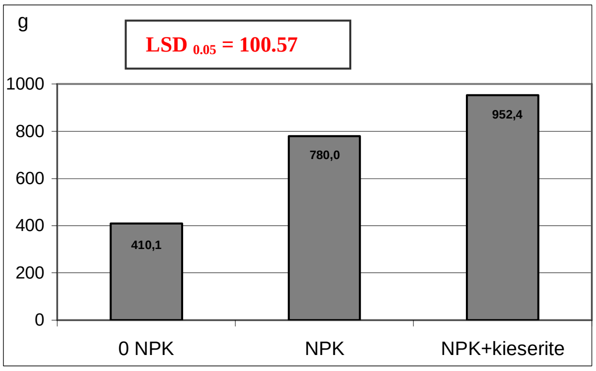

Fig. 1. Fresh matter of a single plant root system in BBCH 89 phase

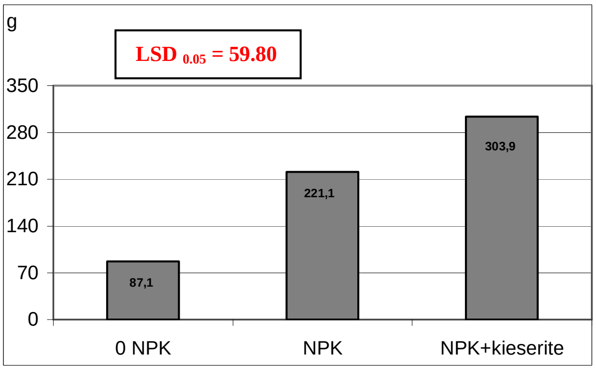

Fig. 2. Dry matter of a single plant root system in BBCH 89 phase

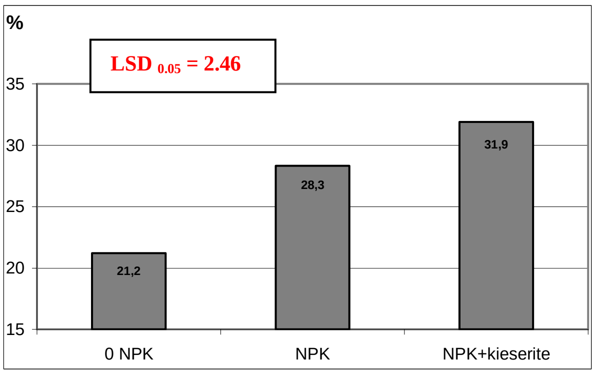

Fig. 3. Dry matter content in maize root in BBCH 89 phase

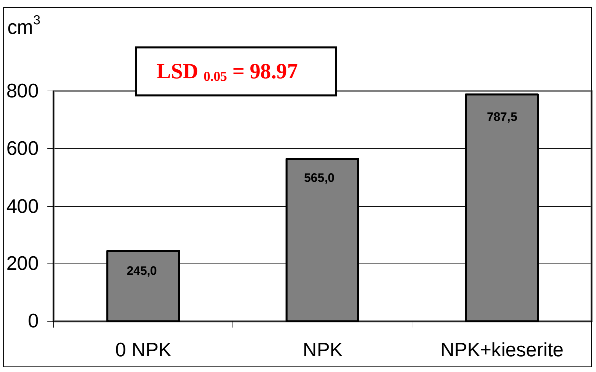

Fig. 4. Volume on single plant root system in BBCH 89 phase

Analysis of mineral components in the dry matter of the root system was carried out in the laboratory of the Department of Agronomy, University of Life Sciences in Poznań, according to the methods described by Gawęcki [2].

3. Results and discussion

In the presented experiment, the fresh matter of a single plant root system, its dry matter, the dry matter content and volume of the root system depended in a significant way on the particular variants of mineral fertilization (Fig. 1, 2, 3 and 4).

The significantly lowest values of these features were found in the object with zero NPK (410.1 g; 87.1 g; 21.2 % and 245.0 cm^3, respectively). On the other hand, significantly the highest values of the discussed features were found in the object where NPK + kieserite were used (952.4 g; 303.9 g; 31.9 % and 787.5 cm^3, respectively). Magnesium, as reported by Grzebisz [3], exerts an influence on the development of the root system creating the developmental dynamics of the whole plant and exerting an influence of the plant's uptake of mineral components. A well developed root system can help the plant to survive a drought period. In the above presented own studies, the combined application of NPK mineral fertilization with kieserite (magnesium + sulphur) caused a significant growth of fresh matter, dry matter, d.m. content and the volume of a single plant root system, as compared with NPK and zero NPK fertilizations. According to Grzebisz [5], the vertical reach of roots (their length) is conditioned by an insufficient soil oxygenation, low pH value and by the presence of toxic elements, i.e. by aluminium and magnesium. The biological result of a strong soil acidification is shown in the limitation of the vertical reach of the root system. Thereby, the plant uptakes a smaller amount of nutritive components, both the newly introduced to the soil and those translocated from the arable layer into the deeper soil profile strata. The production effects of these processes are visible in a slower growth of the cultivated plants resulting in the loss of the biological yield. At the same time, there appears a threat to the natural environment evoked by the out washing of nitrates into the underground waters [6, 7]. The soil, which was utilized for the establishing of the pot experiment, showed a pH = 5.02 (acid reaction), hence the application of kieserite (magnesium + sulphur) limited the toxic influence of aluminium and manganese ions, which disturb the processes of cell division in the meristem of the top roots and they also impede the growth of root cells [4]. Therefore, the introduction of kieserite into the soil permitted to limit the negative action of aluminium and thereby the correct function of the root system was restored. In this way, even in acid soils, one can realize plant life processes through the uptake of water and mineral components. The content of nitrogen, phosphorus, potassium and magnesium in the dry matter of maize root system depended in a significant way on the particular mineral fertilization variants (tab. 1). In case of the content of nitrogen, potassium and magnesium, a significant difference was found between the zero NPK variant and the variant of NPK + kieserite. On the other hand, for phosphorus, its significantly lowest content in the dry matter of root system was found in the object without mineral fertilization (1.32 $g\cdot kg^{-1}$ d.m.), while the highest d.m. content was shown by the variant NPK + kieserit (1.75 $g\cdot kg^{-1}$ d.m.) – table 1.

Table. 1. Content of mineral components in root dry master in BBCH 89 phase6

Specification		Content of components in [g·kg^{-1}] dry matter					
		N	P	K	Ca	Mg	Na
Variants of mineral fertilization	0 NPK	5.45	1.32	3.30	1.85	2.37	3.45
	NPK	6.07	1.50	5.27	1.87	2.82	4.55
	NPK+kieserite	8.30	1.75	7.27	2.20	5.01	5.00
	$LSD_{0.05}$	1.547	0.127	2.479	n.s.	0.712	n.s.

n.s. – non significant differences

Table. 2. Uptake of mineral components

Specification		Uptake of a single plant by root system in [mg]					
		N	P	K	Ca	Mg	Na
Variants of mineral fertilization	0 NPK	474.7	114.9	287.4	161.1	206.4	300.5
	NPK	1342.1	331.6	1165.2	413.4	623.5	1006.0
	NPK+kieserite	2522.4	531.8	2209.3	668.6	1522.5	1519.5
	$LSD_{0.05}$	435.04	96.47	367.20	123.54	234.71	303.11

The uptake of mineral components with the dry matter of the root system of a single plant depended in a significant way on the particular fertilization combination (tab. 2). The significantly lowest amount of nitrogen, phosphorus, potassium, calcium, magnesium and sodium was accumulated by maize in the root system of the object without mineral fertilization, while the highest amount of these elements was found in the object, where NPK was applied with kieserite. Differences between those levels in the root system d.m. showed respectively: 2047.7 mg N·root^{-1} d.m. 416.9 mg P·root^{-1} d.m., 1921.9 mg K·root^{-1} d.m. 507.5 mg Ca·root^{-1} d.m., 1316.1 mg Mg·root^{-1} d.m. and 1219.0 mg Na·root^{-1} d.m. (tab. 2).

4. Conclusions

1. Significantly the lowest values of fresh matter, dry matter, volume of a single plant root system and the dry matter content in roots were found in the object without mineral fertilization, in comparison with the fertilization variants of NPK and NPK + kieserite. On the other hand, the combined application of NPK + kieserite significantly increased the values of the discussed features in relation to NPK fertilization.
2. The application of kieserite together with NPK increased in a significant way the accumulation of N, P, K, Ca, Mg and Na in the dry matter of a single plant root system in the BBCH 89 phase, in comparison with maize fertilized with NPK and zero NPK.

5. References

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