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EFFECT OF MINERAL FERTILIZATION AND GROWTH REGULATORS ON THE CONTENT OF MINERAL COMPONENTS IN PEA PLANTS

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Abstract

The aim of the study has been to determine the effect of mineral fertilization and growth regulators on the content of mineral components in plants of two pea cultivars. The research was based on a two-factor pot trial. Two cultivars of pea were gown: cv. Poker (sugar pea with traditional foliage) and cv. Wenus (a general use, narrow-leaf cultivar). The effect of traditional fertilization with single NPK fertilizers was compared to that with multi-component fertilizers: Polifoska 6 and Amofoska 3 (alone or with the growth regulators: auxins IBA and NAA, triacontanol, L-tryptophan, adenine and cyokinin BA). Seeds of sugar pea cultivar Poker contained more phosphorus, potassium and calcium than those of universal cv. Wenus. Higher concentration of potassium in vegetative organs was found in cv. Wenus. Fertilization with Polifoska 6 increased the content of phosphorus in seeds and vegetative organs whereas Amofoska 3 stimulated mainly the accumulation of potassium. The growth stimulators tended to depress the content of phosphorus, potassium and magnesium in seeds but raised their levels in vegetative organs. Cultivar Poker, a traditional pea variety, was characterised by a more desirable distribution of phosphorus, potassium, calcium and magnesium than narrow-leaf cv. Wenus. Mineral fertilization, compared to the control, stimulated more strongly the uptake of phosphorus than that of calcium and consequently lead to the narrowing of the mol calcium to phosphorus ratio.

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In contrast, the growth regulators improved that ratio owing to the increased transfer of calcium to seeds. Cv. Wenus was characterised by a broader K : (Ca + Mg) ratio in all examined aerial organs than cv. Poker. Mineral fertilization considerably increased these values.

K e y w o r d s: pea, cultivars, growth regulators, mineral components, phosphorus, potassium, calcium, magnesium.

INTRODUCTION

Owing to the symbiosis with nodule bacteria, pea - like all other papilionaceous plants - can take advantage of atmospheric oxygen, which makes it somewhat independent from the concentration of oxygen in soil. For the proper growth and development, beside nitrogen, pea needs optimum quantities of all other nutrients. The chemical composition of pea seeds is largely shaped under the influence of genetic traits (KOTECKI et al. 1996) as well as rates and form of fertilizers (MICHAŁOJĆ 1997, 1998).

Yield volume and quality of pea can be improved by proper fertilization as well as the use of growth stimulators. The effectiveness of the latter depends on several factors including the way they are supplied. Growth stimulators can be used both in seed covers (WIERZBOWSKA 2006C) and together with mineral fertilizers (WIERZBOWSKA ŻUK-GOŁASZEWSKA 2006).

The aim of this study has been to determine the effect of fertilization and growth regulators on the content of mineral components in plants of two pea cultivars.

MATERIAL AND METHODS

A two-factor pot experiment was set up according to a completely random design with three replication in a greenhouse at the University of Warmia and Mazury in Olsztyn. Pea was grown in modified Kick-Braukmann pots filled with 10 kg light soil of the granulometric composition of heavy loamy sand. Soil was slightly acidic in reaction (pH = 5.52 in 1 mol $KCl \cdot dm^{-1}$) and was very abundant in available nutrients (P – 170, K – 207 and Mg – 100 $mg \cdot kg^{-1}$).

Two pea cultivars were grown: a traditional sugar variety (cv. Poker) and a general use narrow-leaf variety (cv. Wenus). The following fertilization variants were applied: without fertilization (K), traditional NPK fertilization (NPK), Polifoska 6 (P6), Amofoska 3 (A3) and a multi-component fertilizer with growth regulators: Amofoska 3 + IBA (α-indolebutyric acid) (A3+IBA), Amofoska 3 + NAA (α-naphtylacetic acid) (A3+NAA), Amofoska 3 + tria (triacontanol) (A3+tria), Amofoska 3 + try (L-tryptophan) (A3+try), Amofoska 3 + ade (adenine) (A3+ade), Amofoska 3 +BA (benzyladenine) (A3 + BA).

The NPK fertilization treatment consisted of 0.3 g N (ammonium nitrate), 1.0 g P (triple superphosphate) and 2.8 g K (potassium salt) per pot. Polifoska 6 was applied at a dose of 6 g (0.36 N) and Amofoska 3 at 10 g per pot. Acryl amide gel, which Amofoska 3 was coated with directly before seeding, was used as a carried of the growth regulators. The fertilizers were point introduced to soil prior to seeding. The following doses of the growth regulators were used: IBA and NAA 10 mg each, tria – 5.2 mg, try – 90 mg, ade – 40 mg and BA – 30 mg per pot.

The plant material underwent the following determinations: phosphorus by the vanadium-molybdenum method, magnesium by ASA and calcium and potassium by ESA.

RESULTS AND DISCUSSION

Concentration of mineral components in seeds is a cultivar-specific trait. Higher concentration of phosphorus, potassium and calcium was determined in seeds of sugar pea cultivar Poker, whereas seeds of general use cultivar Wenus contained slightly more magnesium (Tab. 1). Among the fertilization treatments tested, Polifoska 6 had the most favourable effect on the content of phosphorus as it raised its concentration in seeds of the sugar pea cultivar by 50% versus the control and by 30% compared to the NPK treatment. In seeds of general use cv. Wenus, the increase was 37 and 9%, respectively. The growth regulators applied in conjunction with Amofoska 3 decreased the content of phosphorus in seeds below the

Table 1
Tabela 1

Content of mineral components in pea seeds ($g \cdot kg^{-1}$ d.m.)
Zawartość składników mineralnych w nasionach grochu ($g \cdot k^{g-1}$ s.m.)

Object	Cv. Poker				Cv. Wenus			
	P	K	Mg	Ca	P	K	Mg	Ca
K	4.77	11.69	3.02	2.32	3.85	10.57	4.00	1.32
NPK	5.51	14.83	4.00	2.52	4.86	13.75	3.94	1.12
P6	7.20	15.20	3.82	2.32	5.29	14.29	3.79	1.12
A3	6.57	15.39	4.10	2.42	4.09	12.70	4.10	1.12
A3 + IBA	4.61	15.39	3.57	2.32	4.23	13.05	3.97	1.12
A3 + NAA	5.18	13.93	4.31	2.52	3.92	11.86	3.97	1.12
A3 + tria	4.50	15.02	3.57	2.32	3.62	11.86	3.97	1.22
A3 + try	4.09	13.84	3.87	1.97	3.62	11.69	3.84	1.17
A3 + ade	4.66	15.67	3.35	2.22	3.87	12.88	3.49	1.27
A3 + BA	3.85	15.20	3.89	2.32	3.92	11.86	4.05	1.12
Mean for cultivar	5.09	14.62	3.75	2.32	4.13	12.45	3.91	1.17

values obtained from the treatment involving Amofoska 3 application alone, and in many cases the content of the minerals was less than the control. Fertilization, and Polifoska 6 application in particular, contributed to an over 30% increase in the concentration of potassium in seeds versus the control. Similar results were obtained when Amofoska 3 was applied to fertilize sugar pea cv. Poker. Amofoska 3 favoured the accumulation of magnesium in seeds of both pea varieties. The growth regulators, in most cases, decreased the content of potassium and magnesium in comparison to the seeds of pea plants fertilized exclusively with Amofoska 3. The level of calcium in seeds depended primarily on a pea cultivar and was less affected by the fertilization and growth regulator application.

Analogously to pea seeds, the concentration of minerals in aerial vegetative parts of pea plants was correlated with a pea cultivar (Tab. 2).

Table 2
Tabela 2

Content of mineral components om aerial vegetative parts of pe ($g \cdot kg^{-1}$d.m.)
Zawartość składników mineralnych w nadziemnych organach wegetatywnych grochu ($g \cdot kg^{-1}$ s.m.)

Object	Pea pods				Stems				Leaves			
	P	K	Mg	Ca	P	K	Mg	Ca	P	K	Mg	Ca
Poker												
K	0.17	25.58	3.02	10.92	0.35	25.11	2.33	10.72	0.77	16.58	2.56	24.45
NPK	0.20	33.99	4.00	16.22	0.44	50.54	3.11	17.42	0.88	38.10	5.42	44.81
P6	0.21	36.20	3.82	10.42	0.86	54.57	3.18	19.72	1.48	40.06	5.53	50.29
A3	0.22	38.76	4.10	14.92	0.42	43.84	3.54	18.52	0.88	42.31	6.27	45.59
A3 + IBA	0.29	42.02	3.57	13.32	0.60	45.40	3.45	21.32	1.16	46.74	6.17	43.63
A3 + NAA	0.20	33.17	4.31	13.02	0.34	48.26	4.15	24.92	0.61	41.05	8.08	47.94
A3 + tria	0.26	51.20	3.57	18.52	0.57	48.90	3.40	21.82	0.86	46.74	5.32	42.46
A3 + try	0.19	46.34	3.87	18.22	0.72	48.26	4.07	22.42	0.86	45.68	5.32	44.42
A3 + ade	0.77	47.61	3.35	20.72	0.55	45.71	3.79	18.82	0.78	39.08	5.53	35.80
A3 + BA	0.29	56.65	3.89	18.92	0.66	48.26	4.15	19.82	1.28	54.51	6.49	47.94
Mean for cultivar	0.28	41.15	3.75	15.52	0.55	45.88	3.52	19.55	0.95	41.09	5.67	42.73
Wenus												
K	0.15	40.82	4.00	16.22	0.20	24.24	1.68	9.62	0.29	17.23	3.01	24.45
NPK	0.60	65.69	3.94	13.92	0.45	49.88	1.85	9.32	0.68	51.95	3.41	28.76
P6	1.34	62.36	3.79	12.92	0.95	52.54	2.43	9.32	1.30	43.85	4.06	29.15
A3	0.38	67.58	4.10	17.82	0.15	49.88	1.94	5.22	0.58	52.79	3.86	30.32
A3 + IBA	0.80	62.00	3.97	16.12	0.67	52.20	1.49	7.32	0.62	47.01	3.44	16.23
A3 + NAA	0.62	54.23	3.97	12.92	0.31	51.20	2.13	7.32	0.61	48.63	4.46	35.80
A3 + tria	0.55	58.76	3.97	8.32	0.39	53.89	2.02	9.82	0.60	45.94	4.01	27.97
A3 + try	0.56	52.87	3.84	5.72	0.26	40.23	1.79	7.82	0.44	45.15	3.17	26.41
A3 + ade	0.60	52.54	3.49	12.92	0.35	49.23	1.61	6.62	0.51	46.21	2.29	25.23
A3 + BA	0.34	57.35	4.05	12.02	0.30	51.20	1.70	8.62	0.51	44.37	2.20	25.62
Mean for cultivar	0.59	57.42	3.91	12.89	0.40	47.49	1.86	7.83	0.61	44.31	3.39	26.99

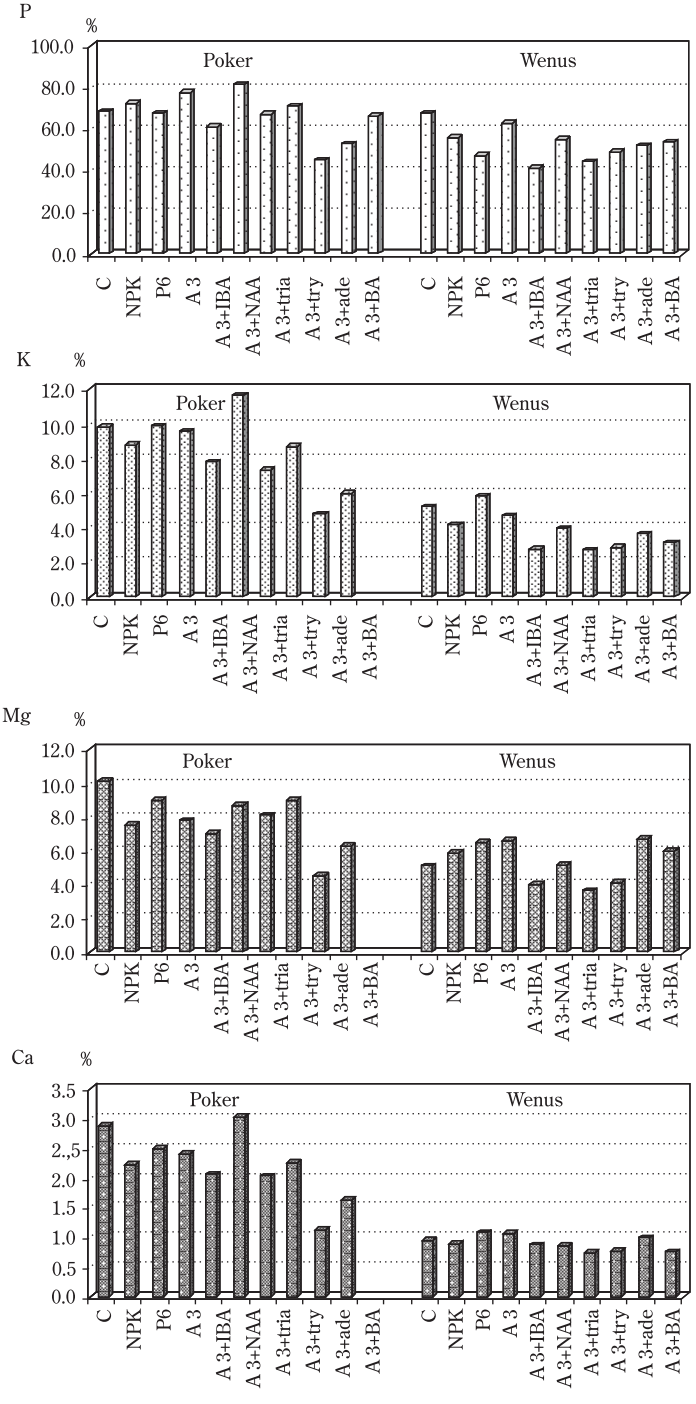

Fig. 1. Index of mineral components accumulation

Except potassium, higher levels of the minerals were found in stems and leaves of cv. Poker, which had traditional foliage. Contrary to this, concentration of the minerals in pods was higher in cv. Wenus. Fertilization with Polifoska 6 caused elevated content of phosphorus in vegetative organs while Amofoska 3 lead to higher potassium content. KOCOŃ (2002) found than pea grown under optimum potassium supply conditions was characterised by a higher amount of this element compared to pea plants growing on soil deficient in potassium. Similar results were reported by PODLEŚNA (2000), who tested horse bean.

The growth regulators, compared to the results obtained from pea plants fertilized with Amofoska 3 alone, generally increased the concentration of the mineral components in vegetative parts of plants, but their influence was not completely unambiguous and depended on both a pea cultivar and type of a growth stimulator applied (Tab. 2). In her studies on spring wheat WIERZBOWSKA (2006a and b) observed a positive effect of kinetin and auxin on the content of potassium in grain and vegetative organs. In addition, the growth regulators rather modified the content of calcium and magnesium than the mineral fertilization, which was especially evident in vegetative parts of wheat.

Cultivar Poker was characterised by a higher accumulation index of all the elements (Fig. 1). Seeds of this pea cultivar contained on average over 66% of the phosphorus taken up by the plants, *ca* 8.5% potasium, nearly 8% magnesium and over 2% calcium. The respective values for general use cv. Wenus were: 53% P, ca 4% K, less than 5.5% Mg and less than 1% Ca. Mineral fertilization, and especially the application of Polifoska 6, increased the contribution of seeds in the accumulation of potas-

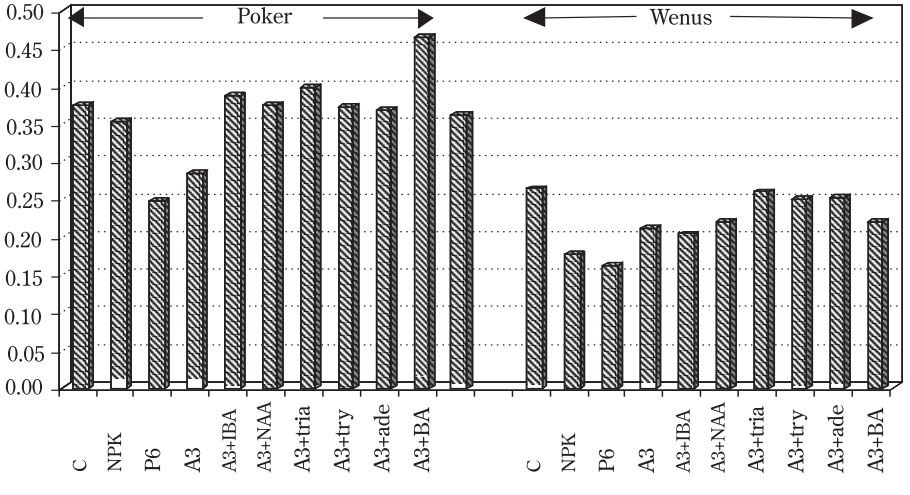

Fig. 2. The Ca : P mol ratio in seeds of sowing pea

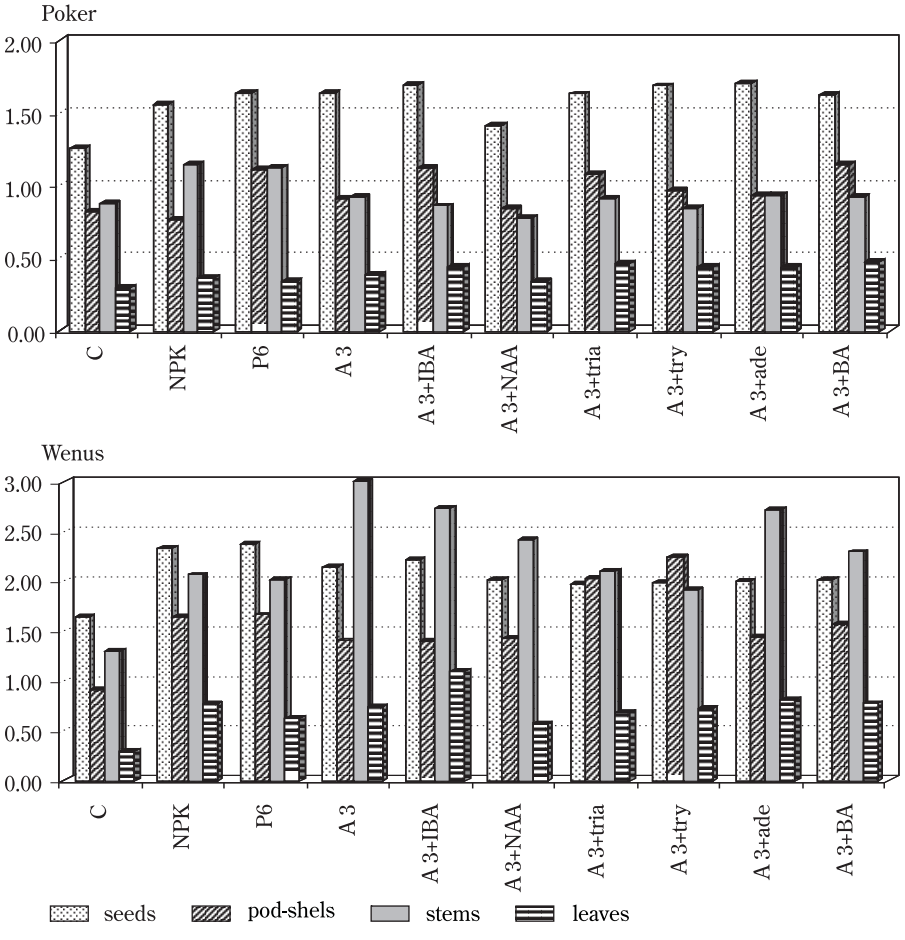

Fig. 3. The K : (Ca + Mg) mol ratios in aerial parts of pea

sium, magnesium and calcium but decreased that of phosphorus. Also the growth regulators, except NAA applied to cv. Poker, tended to depress the share of the mineral components accumulated in pea seeds as compared to the plants treated with Amofoska 3 alone.

The nutritive value depends not only on the concentration of mineral components but also on their mutual ratios. The optimum mol ratio of Ca to P in a diet of an adult human should be 1:1 and in children's diet it is set at 1.2–1.5:1 (SKORUPA, KARCZMAREWICZ 2004). Seeds of sugar pea cv. Poker had a more desirable calcium : potassium ratio than those of general use cv. Wenus (Fig. 2). Mineral fertilization, when compared to the control treatment, stimulated the uptake of phosphorus more strongly than that of calcium and as a result lead to the narrowing of the mol

calcium to phosphorus ratio. In contrast, the growth regulators stimulated the transfer of calcium to seeds and improved the Ca : P ratio.

General use cultivar Wenus was characterised by a broader K: :(Ca + Mg) ratio in all the analysed aerial parts of plants than sugar pea cv. Poker (Fig. 3). Mineral fertilization considerably increased these values. The growth regulators applied together with Amofoska 3 modified the ratios between these mineral components but their influence was not unambiguous. According to KRZEBIETKE and SIENKIEWICZ (2004), levels of particular kations and anions as well as their mutual proportions in a plant play a role in shaping the final yield. WIERZBOWSKA (2006b) found out that the K : (Ca + Mg) ratio in spring wheat was broadened under the effect of kinetin and auxin but narrowed following an application of giberelin.

CONCLUSIONS

1. Seeds of sugar pea cv. Poker contained more phosphorus, potassium and calcium than seeds of general use cv. Wenus. Higher concentrations of potassium in vegetative organs were determined for cv. Wenus.

2. Fertilization with Polifoska 6 increased the content of phosphorus in seeds and vegetative organs whereas Amofoska 3 favoured mainly the accumulation of potassium.

3. The growth regulators tended to depress the concentration of phosphorus, potassium and magnesium in seeds but raised their levels in vegetative organs.

4. Cultivar Poker, with traditional foliage, had a more desirable distribution of phosphorus, potassium, calcium and magnesium than narrowleaf cv. Wenus. Mineral fertilization, and especially the treatments involving Polifoska 6, increased the contribution of seeds in the accumulation of potassium, magnesium and calcium but depressed the level of phosphorus in seeds.

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