J. Elementol. 2010, 15(2): 269–280

THE EFFECT OF WEED CONTROL METHODS ON MAGNESIUM AND CALCIUM CONTENT IN EDIBLE PEA SEEDS *(PISUM SATIVUM* L.*)*

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Abstract

A field experiment was carried out in 2006-2008 at the Experimental Farm in Zawady, owned by the University of Podlasie. The experimental design was a split-plot arrangement of treatments with three replicates. The factors examined included: factor I – three sowing densities (75, 100 and 125 plants per 1 m^2), and factor II – five weed control methods (control – mechanical weed control and four herbicidebased treatments). The objective of the study was to determine the effect of weed control methods as well as sowing density on magnesium and calcium content in the seeds of edible pea (*Pisum sativum* L.*)* of Merlin cultivar.

The highest seed yield was obtained in the plots where weeds were chemically controlled (Afalon Dyspersyjny 450 SC was sprayed just after sowing and followed by an application of a mixture of Basagran 600 SL + Fusilade Forte 150 EC when plants were 5 cm high). The yield from this treatment was 4.84 t ha^{-1}, on average. The lowest yield was harvested in the plots where weeds were mechanically controlled (the control) – on average 2.92 t ha^{-1}.

Variance analysis showed significant influence of weed control methods and weather conditions on magnesium and calcium contents in pea seeds. The herbicides applied in the experiment increased concentrations of the above elements compared with the control. The highest magnesium content (1.389 g kg^{-1}) in pea seeds was found in the plots where Afalon Dyspersyjny 450 SC was applied just after sowing at a dose of 1.5 dm^3 ha^{-1} and followed by a mixture of Basagran 600 SL at a dose of 2.0 dm^3 ha^{-1} + Fusilade Forte at a dose of 1.5 dm^3 ha^{-1} applied post-emergence. The highest calcium content was recorded for treatment 2, consisting of an application of Afalon Dyspersyjny 450 SC at a dose of 1.5 dm^3 ha^{-1} just after sowing and followed by post-emergence spraying with Basagran 600 SL at a dose of 2.0 dm^3 ha^{-1} – on average 0.989 g kg^{-1}. In turn, sowing density had no influence on the discussed characteristics although a tendency was observed towards increasing magnesium and calcium content in edible pea seeds.

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Key words: sowing density, weed control methods, pea seed yield, magnesium content, calcium content.

WPŁYW SPOSOBÓW PIELĘGNACJI NA ZAWARTOŚĆ MAGNEZU I WAPNIA W NASIONACH GROCHU SIEWNEGO JADALNEGO *(PISUM SATIVUM* L.*)*

Abstrakt

Doświadczenie polowe przeprowadzono w latach 2006-2008 w Rolniczej Stacji Doświadczalnej Zawady należącej do Akademii Podlaskiej w Siedlcach. Doświadczenie założono w układzie split-plot w trzech powtórzeniach. Badanymi czynnikami były: I czynnik – 3 gęstości siewu (75, 100 i 125 roślin na 1 m^2), II czynnik – 5 sposobów pielęgnacji (1 obiekt kontrolny – pielęgnacja mechaniczna i 4 obiekty, na których zastosowano herbicydy). Celem badań było określenie wpływu sposobów pielęgnacji oraz gęstości siewu na zawartość magnezu i wapnia w nasionach grochu siewnego jadalnego (*Pisum sativum* L.), odmiany Merlin

Analizując sposoby pielęgnacji łanu, największy plon nasion uzyskano na obiekcie, na którym zastosowano pielęgnację chemiczną (bezpośrednio po siewie opryskiwanie preparatem Afalon Dyspersyjny 450 SC i po osiągnięciu przez rośliny wysokości 5 cm opryskiwanie mieszaniną herbicydów Basagran 600 SL + Fusilade Forte 150 EC). Plon na tym obiekcie wyniósł średnio 4,84 t ha^{-1}, natomiast najniższy plon nasion stwierdzono na obiekcie kontrolnym, na którym zastosowano pielęgnację mechaniczną – średnio 2,92 t ha^{-1}

Analiza wariancji wykazała istotny wpływ sposobów pielęgnacji i warunków pogodowych na zawartość magnezu i wapnia w nasionach grochu. Zastosowane w doświadczeniu herbicydy spowodowały wzrost zawartości omawianych pierwiastków w porównaniu z obiektem kontrolnym. Największą zawartość magnezu (1,389 g kg^{-1}) w nasionach grochu uzyskano na obiekcie, na którym zastosowano bezpośrednio po siewie Afalon Dyspersyjny 450 SC w dawce 1,5 dm^3 ha^{-1} i po wschodach mieszaninę herbicydów Basagran 600 SL w dawce 2,0 dm^3 ha^{-1} + Fusilade Forte w dawce 1,5 dm^3 ha^{-1}. Natomiast największą zawartość wapnia odnotowano na obiekcie 4. po zastosowaniu bezpośrednio po siewie preparatu Afalon Dyspersyjny 450 SC w dawce 1,5 dm^3 ha^{-1} i po wschodach preparatu Basagran 600 SL w dawce 2,0 dm^3 ha^{-1} – średnio 0,989 g kg^{-1}. Natomiast gęstość siewu nie miała wpływu na omawiane cechy, jednakże zaobserwowano tendencję do podwyższania zawartości magnezu i wapnia w nasionach grochu siewnego.

Słowa kluczowe: gęstość siewu, sposoby pielęgnacji, plon nasion grochu, zawartość magnezu, zawartość wapnia.

INTRODUCTION

Magnesium is one of the essential elements which are extremely important for the proper functioning of human body. Magnesium is a catalyst involved in around 300 metabolic pathways. The human body is not able to synthesize magnesium and, as a result, the Mg amount and proportion in a diet should be adequately adjusted (USTYMOWICZ-FARBISZEWSKA et al. 2000).

Appropriate nutrition is one of basic factors influencing the growth and development of organisms. Minerals play a significant role as they are both building blocks and regulators conditioning the course of a number of metabolic processes (STEFAŃSKA et al. 2003).

Over the last years, a growing interest in vegetarian food has been observed, including seeds of leguminous plants (KORUS 2002). Legume seeds are a valuable source of nutrients in the human diet as they supply minerals in addition to protein, carbohydrates and B-group vitamins. In many developed countries there is a tendency towards increased use of legume seeds in human nutrition. In Western Europe, an over threefold increase in legume seed consumption in the last years has been observed, reaching now about 3 kg per capita. In Poland, the level is much lower than recommended in the standards, i.e. 10-12 g per capita daily (PODLEŚNY 2005).

The objective of the study was to determine the effect of weed control methods as well as sowing density on magnesium and calcium contents in seeds of edible pea *(Pisum sativum* L.*)*.

MATERIALS AND METHODS

A field experiment was conducted in 2006–2008 at the Experimental Farm in Zawady, owned by the University of Podlasie in Siedlce. The experimental design was a split-plot arrangement of treatments with three replicates.

The following factors were examined:

factor I – three sowing densities:

1 – 75 plants per 1 m^2; 2 – 100 plants per 1 m^2; 3 – 125 plants per 1 m^2,

factor II – five weed control methods:

1. Control treatment – mechanical weed control (harrowing once between sowing and emergence, harrowing twice post-emergence and until the stage when plants were 5 cm high);

2. Chemical weed control (spraying with Afalon Dyspersyjny 450 SC at a dose of 1.5 dm^3 ha^{-1} just after sowing);

3. Mechanical and chemical weed control (harrowing once pre–emergence, harrowing twice until plants were 5 cm high, then spraying with Basagran 600 SL at a dose of 2.0 dm^3 ha^{-1});

4. Chemical weed control (spraying with Afalon Dyspersyjny 450 SC at a dose of 1.5 dm^3 ha^{-1} just after sowing followed by spraying with Basagran 600 SL at a dose of 2.0 dm^3 ha^{-1} when plants reached the height of 5 cm);

5. Chemical weed control (spraying with Afalon Dyspersyjny 450 SC at a dose of 1.5 dm^3 ha^{-1} just after sowing followed by spraying with a mixture of Basagran 600 SL at a dose of 2.0 dm^3 ha^{-1} + Fusilade Forte at a dose of 1.5 dm^3 ha^{-1} when plants reached the height of 5 cm).

The edible pea cultivar Merlin, registered in 2001, was grown in the experiment. It is suitable for cultivation to harvest seeds for cooking or as animal feed. The experimental plots lie on light to medium soil, whose composition is similar to loamy fine sand, quality classes IVa and IVb, very good rye complex of soil.

Pea followed cereals (triticale, rye, triticale) in rotation. After harvesting the preceding crop, post-harvest cultivation treatments were performed and followed by winter ploughing in autumn. The first spring treatment was dragging, after which a cultivation unit was applied. Mineral fertilization with the complex fertilizer Polifoska 6 at a rate of 400 kg ha^{-1} was applied pre-plant.

Pea seeds were sown in the first decade of April at a row spacing of 25 cm. Harvest was performed when seeds reached the stage of full maturity. Seed yield was calculated on the basis of the weight of seeds harvested from an area of 20 m^{-2} and expressed in tones per 1 ha. After weighing, a representative seed sample was taken in order to determine thousand-seed weight and perform chemical analyses. Magnesium and calcium contents were determined by atomic absorption spectrophotometry AAS.

The results were statistically analysed by means of variance analysis. Significance of sources of variation was checked using the F (Fisher-Snedecor) test and significance of differences between mean values was determined using Tukey's test at a significance level of P=0.05 (TRĘTOWSKI, WÓJCIK 1991).

Variable weather conditions prevailed in each growing season of the study period (Table 1). The highest precipitation of 337.7 mm was recorded in the growing season of 2006 but the distribution of rainfall was very uneven in the individual months. Large fluctuations were observed in the summer months, which are decisive for the growth, development and yield of edible pea. On the basis of the calculated hydrothermal coefficient (K=1.01), it was inferred that the growing season of 2007 was free from drought over the months of rapid growth and yield accumulation (June, July), with the respective values of hydrothermal coefficient equal 1.08 and 1.23. The growing season of 2008 was warm but the moisture conditions varied in individual months. The highest precipitation was recorded in May, July and August. The growing seasons of both 2007 and 2008 favoured the growth and yield accumulation of edible pea.

RESULTS AND DISCUSSION

The analysis of the results of the experimental factors demonstrated that the sowing density, weed control methods and weather conditions in the individual years had a significant impact on edible pea seed yield.

Table 1

Weather conditions during the pea vegetation period in 2006-2008
(Zawady Meteorological Station)

Years	Months					Apr – Aug
	Apr	May	June	July	Aug	
Rainfalls (mm)						Sum
2006	29.8	39.6	24.0	16.2	228.1	337.7
2007	21.2	59.1	59.0	70.2	31.1	240.6
2008	28.2	85.6	49.0	69.8	75.4	308.0
Multiyear average (1987-2000)	38.6	44.1	52.4	49.8	43.0	227.9
Air temperature (^{o}C)						Mean
2006	8.4	13.6	17.2	22.3	18.0	15.9
2007	8.6	14.6	18.2	18.9	18.9	15.8
2008	9.1	12.7	17.4	18.4	18.5	15.2
Multiyear average (1987-2000)	7.8	12.5	17.2	19.2	18.5	15.1
Sielianinov's hydrothermic coefficients						Mean
2006	1.18	0.99	0.47	0.24	4.18	1.40
2007	0.82	1.37	1.08	1.23	0.53	1.01
2008	1.04	2.18	0.93	1.25	1.36	1.35

The highest average seed yield of 4.02 t ha^{1} was obtained at the assumed sowing density of 125 plants per 1 m^2. The lowest was the seed yield (on average 3.21 t ha^{-1}) at the assumed sowing density of 75 plants per 1 m^2. Similar results were reported by SAWICKI et al. (2000) as well as KOZAK and KOTECKI (2006).

According to some authors (PODLEŚNY et al. 1993, KSIĘŻAK 2007), it is possible to obtain high yields when complex weed control is applied, which was confirmed in the present work. Compared with the control, significantly higher seed yields were obtained in the remaining plots, where either single herbicides or their mixtures were applied. The highest yield (on average 4.84 t ha^{-1}) was recorded in treatment 5, where sowing was immediately followed by spraying with Afalon Dyspersyjny 450 SC at a dose of 1.5 dm^3 ha^{-1} and then Basagran 600 SL at a dose of 2.0 dm^3 ha^{-1} + Fusilade Forte 150 EC at a dose of 1.5 dm^3 ha^{-1}, the mixture being applied when the plants reached the height of 5 cm. The lowest average yield of 2.92 t ha^{-1} was recorded in the control treatment, where mechanical weed control was applied.

Weather conditions in each growing season influenced the yield of edible pea seeds (Table 2). The highest yields were recorded in the growing seasons of 2007 and 2008. They reached 3.90 and 3.98 t ha^{-1}, respectively, and were significantly higher than the yield harvested in 2006 (3.09 t ha^{-1}). According to ALVINO and LEONE (1993), MICHALSKA (1995), FOUGEREUS and DORE (1997), SZWEJKOWSKA (2004) as well as BORÓWCZAK and RĘBARZ (2007), weather conditions have great influence on the level of edible pea seed yield. Variance analysis indicated that there was a significant interaction between weed control methods and sowing density as well as study years and weed control methods.

Table 2

Yield of pea seeds (t ha^{-1})

Weed control methods	Sowing density seeds per 1 m^2			Years			Mean
	75	100	125	2006	2007	2008	
Control – mechanical weed control – 3x	2.51	2.95	3.29	2.36	3.18	3.22	2.92
Afalon Dyspersyjny 450 SC	2.79	3.23	3.62	2.71	3.46	3.48	3.21
Harrowing 3x + Basagran 600 SL	2.91	3.57	3.63	3.01	3.58	3.52	3.37
Afalon Dyspersyjny 450 SC + Basagran 600 SL	3.64	3.98	4.25	3.34	4.18	4.35	3.96
Afalon Dyspersyjny 450 SC + Basagran 600 SL+Fusilade Forte	4.19	5.03	5.29	4.04	5.11	5.36	4.84
Mean	3.21	3.75	4.02	3.09	3.90	3.98	-
$LSD_{0.05}$ between: years – 0.12; sowing rate – 0.12; weed control methods – 0.25; Interaction: weed control methods x sowing rate – 0.32; weed control methods x years – 0.41							

Thousand-seed weight (Table 3) was found to be significantly influenced by the sowing density, weed control methods and weather conditions. As for the sowing density, the highest thousand-seed weight was recorded for pea seeds harvested from the plots with the densities of 75 and 100 seeds per 1 m^2 – the mean value was 262.8 g; the lowest thousand-seed weight (259.0 g) was characteristic of the plots with the highest sowing density – 125 seeds per 1 m^2. The findings agree with the results obtained by KSIĘŻAK (1996) as well as KOZAK and KOTECKI (2006). In contrast, KULIGA et al. (1999) and SAWICKI et al. (2000) reported that plant density had no significant influence on the characteristic in question.

The weed control methods significantly influenced thousand-seed weight. The most favourable method, which affected the value of TSW, was the procedure based on Afalon Dyspersyjny 450 SC followed by a mixture

Table 3

Thousand seed weight (g)

Weed control methods	Sowing density seeds per 1 m^2			Years			Mean
	75	100	125	2006	2007	2008	
Control – mechanical weed control – 3x	260.4	261.7	259.0	246.2	267.3	267.5	260.3
Afalon Dyspersyjny 450 SC	261.9	262.0	258.1	246.6	267.0	268.4	260.7
Harrowing 3x + Basagran 600 SL	261.6	262.1	257.9	246.6	266.8	268.2	260.5
Afalon Dyspersyjny 450 SC + Basagran 600 SL	262.0	262.4	258.8	247.1	268.0	268.1	261.1
Afalon Dyspersyjny 450 SC + Basagran 600 SL+Fusilade Forte	268.0	265.9	261.3	249.7	272.5	272.9	265.0
Mean	262.8	262.8	259.0	247.2	268.3	269.0	-
$LSD_{0.05}$ between: years – 0.36; sowing rate – 0.36 ; weed control methods – 0.51; Interaction: weed control methods x sowing rate – n.s.; weed control methods x years – 1.03							

n.s. – not significant

of Basagran 600 SL + Fusilade Forte 150 EC applied post-emergence. The average TSW was 265.0 g, and this result is confirmed by Szwejkowska (2006).

The weather conditions over the growing season influenced thousand-seed weight, too. The highest and lowest mean TSW values were recorded in the year 2008 (269.0 g) and 2009 (247.2 g), respectively. Szukała and Maciejewski (1995) as well as Kulig et al. (1999) reported that thousand-seed weight was significantly affected by both precipitation and air temperature.

Statistically significant interactions of years and sowing density, and of years and weed control methods were found. The interactions indicate an individual response of sowing density to weather conditions as well as herbicides applied in the particular growing seasons.

The analysis of an impact of sowing density on magnesium content indicated no significant differences between magnesium concentrations, with the mean values ranging between 1.345 and 1.350 g kg^{-1}. The results were confirmed by Kotecki and Grządkowska (1997).

The variance analysis revealed that weed control methods significantly influenced magnesium content in pea seeds (Table 4). The herbicides involved in treatment 3 (Basagran 600 SL), 4 (Afalon Dyspersyjny 450 SC + + Basagran 600 SL) and 5 (Afalon Dyspersyjny 450 SC + Basagran 600 SL + + Fusilade Forte 150 EC) significantly increased magnesium content compared with the control. Reduced magnesium content was recorded in treatment 2, where only Afalon Dyspersyjny 450 SC had been applied. The highest magnesium content (1.389 g kg^{-1}) in pea seeds was recorded in the plots which, following sowing, were sprayed with Afalon Dyspersyjny 450 SC at a dose of 1.5 dm^3 ha^{-1} and then a mixture of Basagran 600 SL at a dose of 2.0 dm^3 ha^{-1} + Fusilade Forte at a dose of 1.5 dm^3 ha^{-1}, applied post-emergence. Similar conclusions were reached by CISZEWSKA (1977). In their studies, ZARZECKA et al. (2002) found a significant response of potato tubers, in terms of increased magnesium and calcium content, to an application of herbicides and their mixtures. By contrast, ADOMAS and PIOTROWICZ-CIEŚLAK (2007) found no significant influence of an application of herbicides on the magnesium level.

The weather conditions in every growing season significantly affected magnesium content in pea seeds (Table 4). The highest value was recorded in the growing season of 2007, which was characterised by the most favourable precipitation and temperature distributions. In turn, the lowest magnesium content was obtained in the growing season of 2006, when precipitation was unevenly distributed in individual months. Marked fluctuations were recorded in June and July – the key months for the development and yield accumulation of edible pea. STĘPNIAK-SOŁYGA and WOJTASIK (2003) reported significant influence of moisture conditions on seed mineral composition. The variance analysis showed that there was an interaction of sowing density and weed control methods.

Table 4

Content of magnesium in pea seeds (g kg^{-1})

Weed control methods	Sowing density seeds per 1 m^2			Years			Mean
	75	100	125	2006	2007	2008	
Control – mechanical weed control – 3x	1.328	1.316	1.303	1.280	1.334	1.332	1.316
Afalon Dyspersyjny 450 SC	1.317	1.298	1.308	1.289	1.327	1.307	1.307
Harrowing 3x + Basagran 600 SL	1.342	1.339	1.354	1.318	1.362	1.356	1.345
Afalon Dyspersyjny 450 SC + Basagran 600 SL	1.370	1.380	1.387	1.368	1.386	1.383	1.379
Afalon Dyspersyjny 450 SC + Basagran 600 SL+Fusilade Forte	1.376	1.393	1.398	1.357	1.407	1.403	1.389
Mean	1.346	1.345	1.350	1.322	1.363	1.356	-
$LSD_{0.05}$ between: years – 0.006; sowing rate – n.s.; weed control methods – 0.08; Interaction: weed control methods x sowing rate – 0.011; weed control methods x years – 0.013							

n.s. – not significant

Calcium content in pea seeds varied depending on sowing density. The highest content was obtained at the sowing density of 125 plants per 1 m^2 – on average 0.928 g kg^{-1}. In turn, the lowest was the content associated with the sowing density of 75 plants per 1 m^2 – on average 0.923 g kg^{-1}. However, the differences were not significant. The findings were confirmed in the studies by KOTECKI and GRZĄDKOWSA (1997).

The statistical calculations indicated that the herbicides applied in the experiment significantly increased the calcium content in pea seeds compared with the control (Table 5). The highest calcium concentration (0.989 g kg^{-1}) was obtained in the pea seeds harvested from the plots where Afalon Dyspersyjny 450 SC, applied just after sowing at a dose of 1.5 dm^3 ha^{-1}, was followed by Basagran 600 SL at a dose of 2.0 dm^3 ha^{-1}, applied when plants were 5 cm high.

Table 5

Content of calcium in pea seeds (g kg^{-1})

Weed control methods	Sowing density seeds per 1 m^2			Years			Mean
	75	100	125	2006	2007	2008	
Control – mechanical weed control – 3x	0.879	0.888	0.883	0.817	0.919	0.914	0.883
Afalon Dyspersyjny 450 SC	0.890	0.897	0.911	0.832	0.942	0.923	0.899
Harrowing 3x + Basagran 600 SL	0.933	0.931	0.912	0.866	0.961	0.950	0.926
Afalon Dyspersyjny 450 SC + Basagran 600 SL	1.016	0.970	0.980	0.887	1.060	1.019	0.989
Afalon Dyspersyjny 450 SC + Basagran 600 SL+Fusilade Forte	0.899	0.951	0.954	0.837	0.994	0.973	0.935
Mean	0.923	0.927	0.928	0.848	0.975	0.956	-
$LSD_{0.05}$ between: years – 0.02; sowing rate – n.s.; weed control methods – 0.03; Interaction: weed control methods x sowing rate – n.s.; weed control methods x years – n.s.							

n.s. – not significant

The weather conditions influenced the calcium content in edible pea seeds. The highest content, on average 0.975 g kg^{-1}, was recorded in 2007, when both precipitation and temperature distributions were favourable. The lowest calcium content, i.e. 0.848 g kg^{-1}, was found in 2006, when precipitation was unevenly distributed. The differences in Mg and Ca content linked to the impact of weather conditions were confirmed in the study by JADCZAK et al. (2006). Significant influence of weather conditions on magnesium and calcium content was reported by ZARZECKA et al. (2002).

CONCLUSIONS

1. Application of herbicides in edible pea cultivation contributed to increased seed yields as well as seed robustness. The highest yield and thousand-seed weight were obtained in the plots of the treatment where weeds were controlled with Afalon Dyspersyjny 450 SC applied just after sowing and followed by a mixture of Basagran 600 SL + Fusilade Forte 150 EC applied post-emergence.

2. The herbicides and their mixtures examined in the experiment significantly increased magnesium and calcium content compared with the control. The highest Mg and Ca content was associated with an application of three herbicides, namely Afalon Dyspersyjny 450 SC and a mixture of Basagran 600 SL + Fusilade Forte 150 EC.

3. Magnesium and calcium concentrations in edible pea seeds were significantly affected by weather conditions in individual growing seasons. The highest concentrations of the macroelements in pea seeds were obtained in the growing seasons characterised by an even distribution of precipitation and temperature.

REFERENCES

ADOMAS B., PIOTROWICZ-CIEŚLAK A.I. 2007. *Chemiczna ochrona łubinu a jakość plonu.* Cz. I. *Herbicydy stosowane w ochronie łubinu a jakość plonu nasion [Chemical control of lupine plantations versus yield quality.* Part I. *Herbicides applied to lupine plantations versus yield quality].* Zesz. Prob.. Post. Nauk Rol., 522: 87-98. (in Polish)

ALVINO A., LEONE A. 1993. *Response to low soil water potential in pea genotypes (Pisum sativum L.) with different leaf morphology.* Scient. Hort., 53: 21-34

BOROWCZAK F., RĘBARZ K. 2007. *Produkcyjne i ekonomiczne efekty różnej intensywności uprawy grochu siewnego odmiany Agar [Production-related and economic effects of different levels of agronomic cultivation of cv. Agar seed pea].* Zesz. Probl. Post. Nauk Rol., 522: 167-175. (in Polish)

CISZEWSKA R. 1977. *Fitotoksyczność i selektywność herbicydów triazynowych oraz ich wpływ na niektóre chemiczne składniki roślin [Phytotoxicity and selectivity of triazine herbicides and their effect on some chemical components of plants].* Post. Nauk Rol., 217: 197-203. (in Polish)

FOUGEREUS J.A., DORE T. 1997. *Water stress during reproductive stages affects see and yield of pea (Pisum sativum* L.*).* Crop. Sci., 37 (4): 1247-1252.

JADCZAK D., GRZESZCZUK M., REKOWSKA E. 2006. *Content of macroelements in fresh seeds of faba bean.* J. Elementol., 11(2): 143-149.

KORUS A. 2002. *Zawartość składników mineralnych w świeżych i konserwowanych nasionach dwóch odmian lędźwianu siewnego (Lathyrus sativus* L.*) o niepełnej dojrzałości fizjologicznej [Content of minerals in fresh and preserved seeds of two varieties of grass pea (Lathyrus sativus) of incomplete physiological maturity].* Acta Sci. Polon. Technol. Aliment., 1(2): 37-46. (in Polish)

KOTECKI A., GRZĄDKOWSKA A. 1997. *Wpływ gęstości siewu na rozwój, plonowanie i gromadzenie makroskładników u dwóch odmian grochu [Effect of sowing density on development, yield and accumulation of macronutrients in two pea cultivars].* Biul. IHAR, 203: 209--218. (in Polish)

KOZAK M., KOTECKI A. 2006. *Następczy wpływ odmian grochu siewnego na rozwój i plonowanie pszenicy ozimej.* Cz. I. *Wpływ ilości wysiewu na rozwój i plonowanie grochu siewnego [An after-effect of seed pea cultivars on development and yield of winter wheat.* Part I. *The effect of amounts of sown seeds on the development and yield of seed pea].* Zesz. Nauk. UP Wrocław, 546: 133-147. (in Polish)

KSIĘŻAK J. 1996. *Ocena plonowania wybranych odmian grochu siewnego w zależności od gęstości siewu [Evaluation of yields produced by some seed pea cultivars depending on sowing density].* Fragm. Agron., 2: 95-106. (in Polish)

KSIĘŻAK J. 2007. *Wpływ wybranych herbicydów na rozwój i plonowanie wąskolistnej odmiany grochu siewnego [Effect of some herbicides on development and yield of a narrowleaf seed pea cultivar]* . Prog. Plant Protect./Post. Ochr. Rośl. 47 (3): 169-172. (in Polish)

KULIG B., ZIÓŁEK W., OLEKSY A. 1999. *Wpływ składowych plonu na plon nasiona zróżnicowanych morfologicznie odmian grochu przy różnych poziomach plonowania [Effect of yield components on seed yield of morphologically varied pea cultivars AT different yield levels].* Zesz. Nauk. AR Kraków, Rol., 36: 57-69. (in Polish)

MICHALSKA B. 1995. *Wpływ czynników meteorologicznych na zmienność plonowania grochu pastewnego w Polsce [Effect of meteorological conditions on the variability of yields produced by folder pea in Poland].* Zesz. Nauk. AR Szczecin., Rol. 60: 49-58. (in Polish)

PODLEŚNY J. 2005. *Rośliny strączkowe w Polsce – perspektywy uprawy i wykorzystanie nasion [Legumes in Poland – prospective cultivation and seed utilization].* Acta Agroph., 6(1): 213-224. (in Polish)

PODLEŚNY J., LENARTOWICZ W., KSIĘŻAK J. 1993. *Przydatność niektórych herbicydów do zwalczania chwastów w zasiewach grochu [Applicability of some herbicides to fight weeds in pea fields]* . Fragm. Agron., 3: 177-178. (in Polish)

SAWICKI J., BOROS L., WAWER A. 2000. *Wpływ zagęszczenia roślin w łanie na cechy użytkowe trzech wąsolistnych genotypów grochu siewnego (Pisum sativum* L.*) [Effect of denser plant stands on usability features of three narrow-leaf genotypem of seed pea (Pisum sativum)].* Biul. IHAR, 214: 253-261. (in Polish)

STEFAŃSKA E., KARCZEWSKI J., OSTROWSKA L., CZAPSKA D. 2003. *Zawartość magnezu i cynku w całodziennej racji pokarmowej studentów Akademii Medycznej w Białymstoku [Content of magnesium and zinc in all-day ford ration of student of the Medical University in Białystok].* J. Elementol., 8(1): 31-39. (in Polish)

STĘPNIAK-SOŁYGA P., WOJTASIK J. 2003. *Zawartość składników pokarmowych i mineralnych w nasionach grochu (Pisum sativum), lędźwianu (Lathyrus dativus), soczewicy (Lenus culinaris) i soi (Glicyne max) [Content of nutrients and minerale in sedes of pea (Pisum sativum), grass pea (Lathyrus datiwus), lentil (Wenus culinaris) and soybean (Glicyne max)].* Ann. UMCS, Sect. EE, 76: 175-185. (in Polish)

SZUKAŁA J., MACIEJEWSKI T. 1995. *Wpływ deszczowania i obsady roślin na plonowanie różnych typów grochu [Effect of sprinkling and plant stand on yield of different types of pea].* Pr. Kom. Nauk Roln. Kom. Nauk Leśnych PTPN, 79: 120-125. (in Polish)

SZWEJKOWSKA B. 2004. *Wpływ sposobów uprawy na plonowanie grochu siewnego [Effect of cultivation techniques on yield of seed pea].* Fragm. Agron., 3: 120-125. (in Polish)

SZWEJKOWSKA B. 2006. *Reakcja odmian grochu siewnego (Pisum sativum* L.*) na różne metody zwalczania chwastów [Response of seed pea (Pisum sativum* L.*) cultivars to different methods of weed control].* Acta Sci. Pol., Agricult., 5 (1): 71-82. (in Polish)

TRĘTOWSKI J., WÓJCIK R. 1991. *Metodyka doświadczeń rolniczych [Methods in agricultural experimentation].* Wyd. WSRP Siedlce, 1-500. (in Polish)

USTYMOWICZ-FARBISZEWSKA J., SMORCZEWSKA-CZUPRYŃSKA B., KARCZEWSKI J. 2000. *Porównanie zawartości magnezu w racjach pokarmowych dzieci szkół podstawowych Białegostoku i okolic [Comparison of the content of magnesium in food rations of children from primary schools in and around Białystok].* Biul. Magnezol., 5(4): 339-347. (in Polish)

ZARZECKA K., GUGAŁA M., GĄSIOROWSKA B., MAKAREWICZ A. 2002. *Fluktuacja magnezu i wapnia w bulwach ziemniaka pod wpływem stosowanych herbicydów i ich mieszanek [Fluctuation of magnesium and calcium in potato tubers under the influence of herbicides and mixed herbicides].* Biul. Magnezol., 7(4): 309-315. (in Polish)