THE INFLUENCE OF VARIETY ON THE YIELD AND CONTENT OF PROTEIN AND NUTRIENTS OF PEAS (*PISUM SATIVUM*)

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Abstract
Pisum sativum L. (field or garden pea), is widely cultivated in Europe. The purpose of this investigation was to see whether pea varieties differ in their yield and content of protein and nutrients. Another aim was to select the best varieties suitable for breeding or production. A field experiment with different varieties of peas ('Bruno', 'Capella', 'Clara', 'Mehis' and 'Vitra') was carried out at the Estonian Crop Research Institute in 2014. Yields (t ha^{-1}) were not statistically different. Crude protein content (g kg^{-1} in dry matter) was lowest in 'Clara'; all other varieties had a higher content of protein, within much the same range. The lowest N content was found in 'Clara', followed by 'Capella' and 'Vitra', 'Mehis' (44) and the highest in 'Bruno' (45). The lowest P content was found in 'Clara', followed by 'Capella' and 'Vitra'; the highest was found in 'Bruno' and 'Mehis'. The lowest K content was found in 'Mehis', then 'Clara', followed by 'Capella' and 'Vitra' and the highest in 'Bruno'. The lowest Ca content was found in 'Clara', followed by 'Capella' and 'Mehis', 'Vitra', and highest in 'Bruno'. The lowest Mg content was found in 'Capella', followed by 'Clara' and the highest in the other varieties 'Bruno', 'Mehis' and 'Vitra'. Thus, choice of the right variety for pea cultivation is very important, but depends on the local agro-climatic conditions. This investigation has been developed with the help of the project EUROLEGUME, funded from the European Union Seventh Framework Programme for Research, Technological Development and Demonstration under the grant agreement no. 613781.
Key words: nutrients, pea, protein, variety, yield.

Introduction

Pisum sativum L., field or garden pea, is widely cultivated in Europe (Brežna et al., 2006). It is an herbaceous annual crop in the *Fabaceae* (formerly *Leguminosae*) family. Pea originates from the Mediterranean basin and the Near East, but is now widely grown for its seedpod or legume (a simple dry fruit containing several seeds and splitting along its seams on two sides). Pea is an important human food crop. Green pea production worldwide in 2011 was 17 Mt (FAOSTAT, 2013) and pea is grown on over 6.7 million hectares worldwide (Kittson, 2008). Dry peas are the most widely grown legume crop in the European Union (EU) (Aiking et al., 2006). Peas are widely consumed due to their high nutritional value; they contain fibre, protein, vitamins (folate and vitamin C), minerals (iron, magnesium, phosphorus and zinc), and lutein (a yellow carotenoid pigment that benefits vision). Dry weight is high in protein and carbohydrates (mostly sugars) (Issako, 1989).

The protein content of field peas is determined by plant genetics, strongly influenced by growing conditions. Field pea contains on average 230 g kg^{-1} protein. Field pea is a very good protein crop alongside soybean and faba bean (Narits, 2008).

Surveys carried out by the FAO, the European Commission and agricultural authorities of the EU, suggest that by increasing the cultivation of protein crops in the EU, it is possible to achieve a considerable reduction of imported protein crops while increasing the quality of agricultural products and revenue of the producers. A possible increase in conventional oilseed and protein seed acreage could replace 10-20% of EU imports of soybeans and soybean meal. Replacement of soybean meal by locally grown high nutritional quality protein sources in feed and the development of new feed products are challenging objectives.

Seed and biomass yields of legumes vary widely, influenced by habitat quality, weather conditions during the growing season and the yielding ability of available cultivars (Jeuffroy and Ney, 1997; Poggio et al., 2005).

Genotype has the most significant influence on the variability but Europe has abundant genetic resources of different peas in its gene banks, research institutions and farms. The ECPGR (The European Cooperative Programme for Plant Genetic Resources) Pisum Database documents 32,503 accessions of peas. However, a large number of local genotypes grown on farms and propagated by farmers are not included in these databases.

Mineral nutrients perform several functions; they participate in various metabolic processes in the plant, such as protein, nucleic acid and cell wall syntheses, maintenance of osmotic concentration of cell sap, electron transport systems, enzymatic activity, are a component of the chlorophyll molecule, and major constituents of macromolecules, co-enzymes and nitrogen-fixing (Weisany et al., 2013).

Mineral nutrients can influence nitrogen fixation in legumes; for example, the presence of mineral nitrogen in the soil inhibits both nodule formation and nitrogenase activity. The deficiency of phosphorous supply and availability remains a severe limitation on nitrogen fixation and symbiotic interactions. Calcium plays a key role in symbiotic interactions at the molecular level (Weisany et al., 2013). Legumes also contain minerals such as magnesium, which is important for normal cardiac function (Kostyra, 1996).

The purpose of this investigation was to see, whether pea varieties differ in yield and their content of protein and mineral nutrients, and thus whether some varieties might be better than others.

Materials and Methods

A field experiment with different varieties of peas was carried out at the Estonian Crop Research Institute in 2014 at N 58°769' E 26°400'. The varieties were: 'Bruno', 'Capella', 'Clara', 'Mehis' and 'Vitra'. 'Capella' and 'Clara' are Swedish varieties, 'Bruno' and 'Vitra' are Latvian varieties, 'Mehis' is an Estonian variety. In our experiment the leafy varieties were 'Mehis' and 'Vitra' and semi-leafless varieties were 'Bruno', 'Capella' and 'Clara'. A completely randomized experiment design was used in 4 replications. Plot size was 10 m^2. Soil humus content was 3.15% and pH was 5.76. Soil type was soddy-calcareous podzolic soil in Estonian system (Astover, 2005), soil texture - sandy-clay. The preceding crop was winter rye. Conventional cropping system was used with ploughing in autumn 2013, and cultivation twice before sowing. Seed was sown on 28 April 2014 at a rate of 120 seeds per m^2 for all varieties and a depth of 4 cm. Plant spacing was 12.5 × 6.7 cm.

Fertilization was done with Yara Mila 7-12-25 (300 kg ha^{-1}) and weeds were controlled by Activus 330 (pendimethalin 330 g L^{-1}) EC 1.5 l ha^{-1} + Basagran 480 (bentazon 480 g L^{-1}) 1.5 l ha^{-1}, on 21 may 2014. No control measures against insects and diseases were applied. Disease damage on peas pods, pod spot (*Ascoshyta pisi*) and pulses rust (*Uromices ssp.*) was assessed at the plant development stage 71-79 (Strauß et al., 1994). Pod spot on 'Mehis', 'Bruno' and 'Vitra' was at a very low level, and on 'Clara' and 'Capella' at a low level. Pulses rust was absent on 'Clara', 'Capella' and 'Mehis', at a very low level on 'Bruno' and at a low level on 'Vitra'.

The weather during 2014 is shown in Table 1, and was characterized by a cold spring. The temperature at the end of June was 3-4 °C lower than normal, but July was near average with a mean temperature around 18 °C. Precipitation exceeded the average in June although it was quite dry in July; nevertheless plants grew well.

Peas were harvested between 6-12 August 2014, dried and the yield data (determined at moisture content of 14-15%) recorded for each plot and finally calculated for t ha^{-1}. Samples were analysed for their content of protein, nitrogen, phosphorus, potassium, calcium and magnesium. Determination of protein content was by the Kjeldahl method (EVS-EN-ISO 10520:200), for phosphorus in a Kjeldahl Digest by Fiastar 5000 (AN 5242; Stannous Chloride method, ISO/FDIS 15681), for potassium by the Flame Photometric Method (956.01), for calcium by the o-Cresolphthalein Complexone method (ISO 3696, in Kjeldahl Digest by Fiastar 5000) and for magnesium by Fiastar 5000 (ASTN90/92; Titan Yellow method). Analyses of variance were carried out on the data obtained using the programme Excel. Signs used: *** $p<0.001$; ** p= 0.001 – 0.01; * p= 0.01 – 0.05; NS not significant, $p>0.05$. On figures, on columns are marked bars, which are the bars of standard deviations.

Table 1

Weather conditions of field pea vegetation period in 2014 and long term weather averages

Period	Average of air temperature, °C*				Summary of precipitation, mm*	
	In decade	Long term average	Max	Min	In decade	Long term average
21-30 April 2014	9.3	6.2	21.7	-4.7	0.0	13.2
1-10 May 2014	5.9	8.4	17.1	-5.2	18.9	12.6
11-20 May 2014	13.1	10.6	30.5	-1.6	41.2	17.5
21-31 May 2014	15.6	11.8	29.4	5.3	4.0	19.8
1-10 June 2014	16.1	13.5	27.4	3.2	76.5	14.4
11-20 June 2014	11.9	14.4	21.3	2.2	37.1	25.4
21-30 June 2014	11.3	15.5	20.0	2.2	43.5	27.9
1-10 July 2014	17.5	16.5	27.1	8.1	19.1	22.5
11-20 July 2014	18.6	17.0	25.7	8.0	3.7	26.4
21-31 July 2014	21.5	17.0	30.5	10.7	25.0	30.6
1-10 Aug 2014	20.8	16.5	29.7	9.6	2.9	30.4
11-20 Aug 2014	16.2	15.4	27.7	9.8	31.4	28.5
21-31 Aug 2014	12.8	14.1	19.7	3.7	88.7	29.9

*according to Jõgeva Meteorological Station

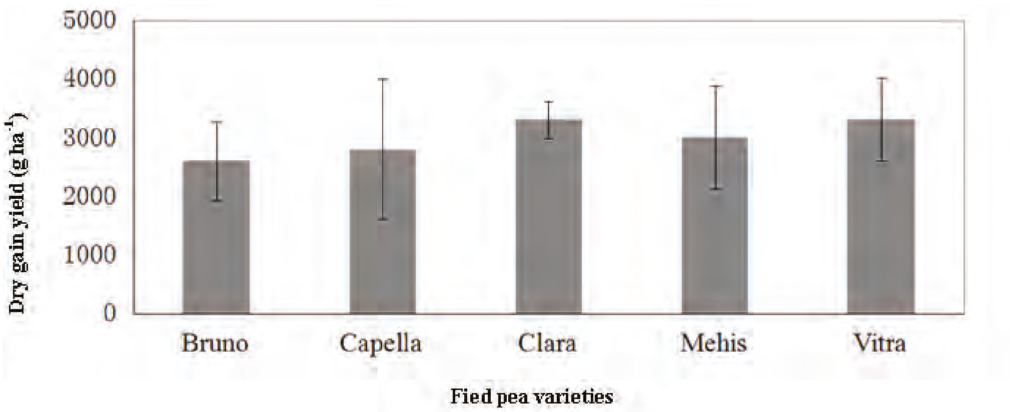

Figure 1. Dry grain yield (kg ha^{-1}) of different field pea varieties (p NS).

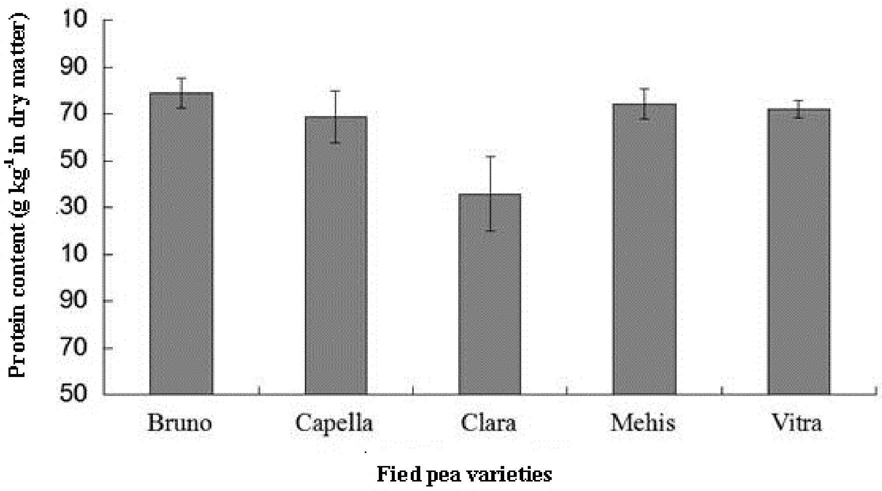

Figure 2. Average protein content (g kg^{-1} in dry matter) of different field pea varieties (p ***).

Results and Discussion

There was a tendency that the highest yield was obtained in 'Clara' and 'Vitra' (3300 kg ha^{-1}), followed by 'Mehis' (3000 kg ha^{-1}) with lowest yields in 'Capella' (2800 kg ha^{-1}) and 'Bruno' (2600 kg ha^{-1}) (Figure 1), but differences were not statistically different.

Crude protein content was the lowest in 'Clara' (236 g kg^{-1}in dry matter) and higher in all other varieties, although not ranging much from each other (269…279 g kg^{-1} in dry matter) (Figure 2).

The lowest P content was found in 'Clara' (4.7 g kg^{-1} in dry matter), followed by 'Capella' (5 g kg^{-1} in dry matter) and 'Vitra' (5.1 g kg^{-1} in dry matter), with highest in 'Bruno' (5.4 g kg^{-1} in dry matter) and 'Mehis' (5.6 g kg^{-1} in dry matter) (Figure 3).

The lowest K content was found in 'Mehis' (7.9 g kg^{-1} in dry matter), 'Clara' (8 g kg^{-1} in dry matter), followed by 'Capella' and 'Vitra' (both 8.4 g kg^{-1} in dry matter), and highest in 'Bruno' (9.9 g kg^{-1} in dry matter) (Figure 4).

The lowest Ca content was found in 'Clara' (0.4 g kg^{-1} in dry matter), followed by 'Capella' (0.5 g kg^{-1} in dry matter) and 'Mehis', 'Vitra' (both 0.6 g kg^{-1} in dry matter), and highest in 'Bruno' (0.7 g kg^{-1} in dry matter) (Figure 5).

The lowest Mg content was found in 'Capella' (1.3 g kg^{-1} in dry matter), followed by 'Clara' (1.4 g kg^{-1} in dry matter) and highest in all other varieties 'Bruno', 'Mehis' and 'Vitra' (1.5g kg^{-1}in dry matter) (Figure 6).

There was no statistical difference in yield between the pea varieties. L. Narits (2008) reported that semi-leafless varieties have a higher seed yield but this was not evident in our investigation. Probably the cold spring delayed seed emergence which reduced the yield potential. Good early growth is important for a good yield. S. Kalev and L. Narits (2004) showed that in the years when the weather conditions favoured vegetative growth leafed types gave a higher yield and better quality than semi-leafless varieties. They also noticed that in the year of unfavorable weather conditions the situation was the opposite. Similarly, A. Kotlarz et al. (2011) reported that unfavorable weather conditions may negatively influence the crop yield. Differences in climate, soil, varieties, agronomic

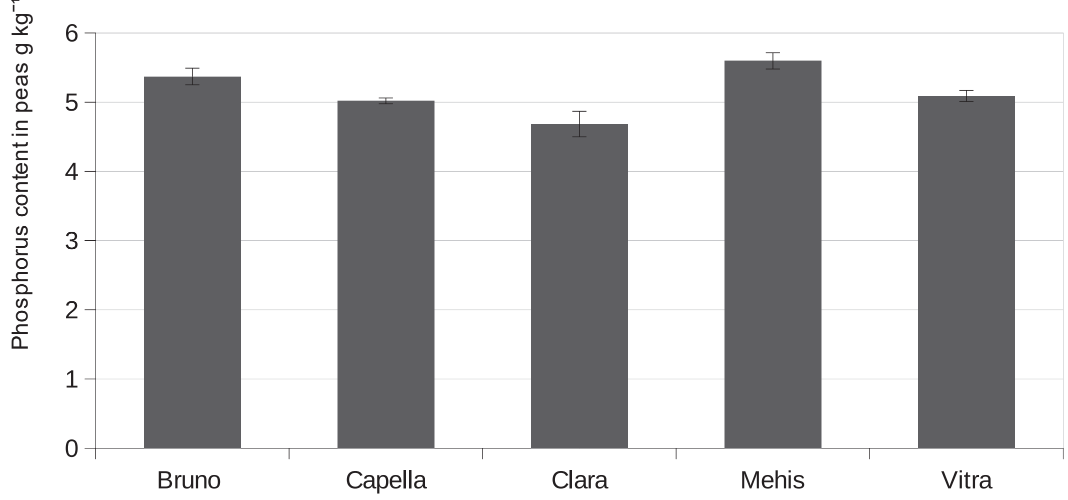

Figure 3. Average P content (g kg^{-1}in dry matter) of different field pea varieties (p ***).

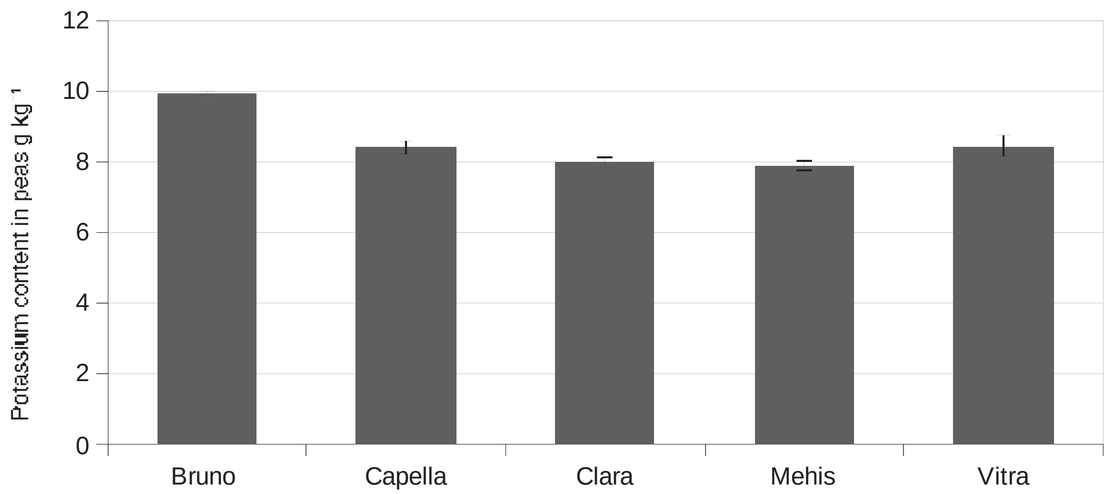

Figure 4. Average K content (g kg^{-1}in dry matter) of different field pea varieties (p ***).

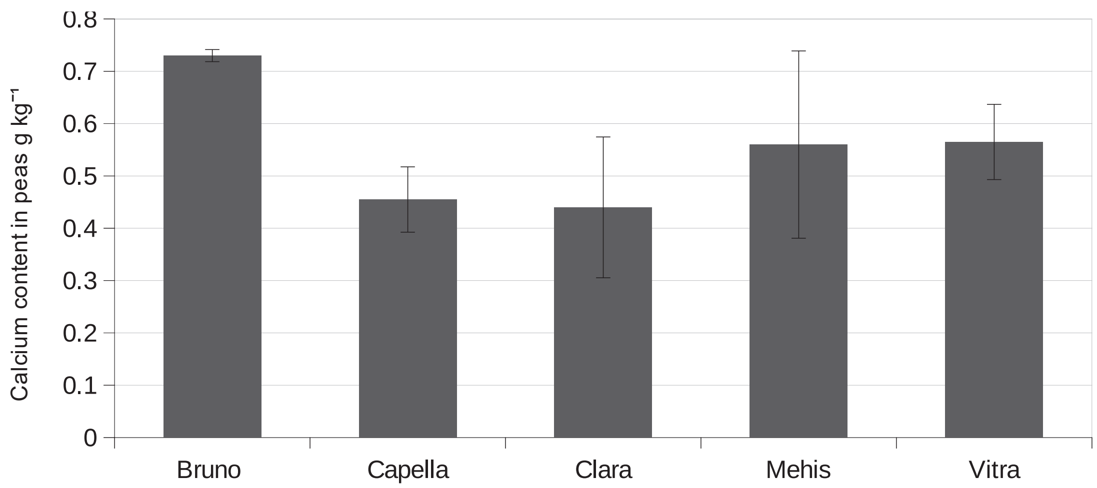

Figure 5. Average Ca content (g kg^{-1}in dry matter) of different field pea varieties (p *).

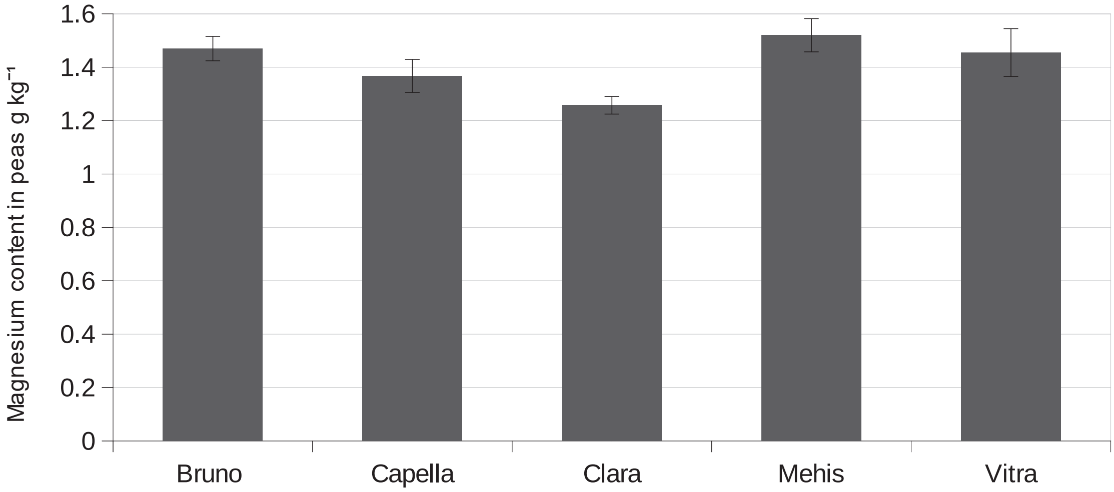

Figure 6. Average Mg content (g kg^{-1}in dry matter) of different field pea varieties (p ***).

practices may cause a different chemical composition when grown in various parts of the world.

The results obtained in this study show that variety had a significant influence on the levels of crude protein in the field pea. Similarly, A. Kotlarz et al. (2011) found that the varieties differed in protein content. L. Narits (2008) contended that the field pea contains on average 230 g kg^{-1} protein. In our experiment, even the variety Clara, which had the lowest protein content, contained 6 g kg^{-1} more than average, while all the other varieties contained 30-40 g kg^{-1} more protein. L. Narits (2008) concluded that when the field pea is grown for seed with the aim to get a high protein yield, then attention to the leaf type is important as leafy types usually have a higher protein content. In our experiment, the leafy varieties 'Mehis' and 'Vitra' also had a higher yield than the semi-leafless varieties 'Bruno' and 'Capella'. Only 'Clara', also a semi-leafless type, had quite a high protein content.

The present investigation showed that the varieties differed in nutrient content, as also shown by A. Kotlarz et al (2011). The same authors also reported that chemical content of pea seeds can vary. Genetic (variety) and environmental factors (location of cultivation area, soil characteristics, exchangeable cations, trace elements, cropping year, total rainfall, relative humidity, solarisation, temperature) are of importance (Kotlarz et al., 2011), as well as technological treatments (dehulling, cooking, soaking, germination, extrusion).

In our experiment, Ca content also varied with variety. A higher Ca-content is positive, because high Ca content reduces diseases and insect attacks, and improves transportability and storability (Olle, 2013). Moreover, a high level of Mg is desirable because it reduces the incidence of insect pests and diseases (Cakmak, 2013).

Conclusions

Choice of the right variety for pea cultivation is very important, but depends on the local agro-climatic conditions. The chemical content of pea varieties varies, but one promising variety is 'Mehis', due to the fact that 'Mehis' had the highest content of P and Mg and a middling content of Ca. A high content of Mg is desirable because Mg reduces the incidence of insect pests and diseases.

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