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SEED AGE AND pH OF WATER SOLUTION EFFECTS ON FIELD PEA (*PISUM SATIVUM L.)* GERMINATION

Bukvic, Gordana[1)], Sonja Grljusic[2)], Vlatka Rozman[1)], Dragana Lukic[1)], Rajka Lackovic[1)], D. Novoselovic[2)]

[1)] Faculty of Agriculture Osijek, Trg Sv. Trojstva 3, 31000 Osijek, Croatia; e-mail: gbukvic@pfos.os
[2)] Agricultural Institute Osijek, Juzno predgradje 17, 31000 Osijek, Croatia

Abstract. The laboratory experiment was conducted to evaluate the effects of seed age and water solution pH on field pea (*Pisum sativum* L.) germination energy, germination, seedling root length and stem height. Seeds aged 33 and 21 months and four water solution pH levels (5, 6, 7 and 8) were tested. The values of all investigated traits were significantly higher (p=0.01) for the 21 months old seed. Different water solution pH exerted an influence on germination, seedling root length, stem height (p=0.01) and germination energy (p=0.05). Irrespective of seed age, germination energy (61.50% in average) was highest at pH=7, whereas germination (70.75% in average) and root length (10.924 cm in average) at pH=6. Stem height of seedlings developed from 33 months old seeds was highest at pH=6. Furthermore, stem height of seedlings grown from 21 months old seeds was highest at pH=5.

Key words: field pea, seed age, pH, germination

INTRODUCTION

Legumes are, similar to a number of field crops, sensitive to soil acidity, to which they usually respond in yield and quality decrease (Bezdicek et al., 2003; Brkic et al., 2004). However, the response of genotypes to different pH values is variable among species. Bukvic et al. (1998) found significantly lower green mass yield and NPK content in the above-ground mass of 10 alfalfa genotypes grown on acid soil (pH=5.4) compared with the alfalfa yield and NPK content on neutral soil (pH=7.04). A genetic dissimilarity among genotypes was thus reported, regarding the genotypes' ability to grow on acid soil.

According to Mahler and McDole (1987), the minimum soil pH value for field pea production in USA (Idaho) is 5.52. At the same time, Mengel and Kirkby (1987) reported that the optimum pH values for production were 5.3 to 7.4. It can be asserted that pH values affect early seedling growth. Bukvic et al. (2007a, 2007b) found significant differences in seed germination and seedling growth in the case of white clover and alfalfa genotypes corresponding to different water solution pH values.

In addition to the influence of environmental conditions and cultivar characteristics, pea biomass production is also influenced by the quality of seeds used for sowing (Rapcan et al., 2006a, 2006b). Seed quality is a complex trait and depends on a number of factors. As such, according to Marcos-Filho and McDonald (1998) seed quality is defined by its genetic, physical, physiological and sanitary characteristics, which influence agro-ecological conditions of production (McDonald, 1998; Siddique and Wright, 2004; Nemeskeri, 2004; Fallon et al., 2006.; Fowler et al., 2006), seed processing (Schaffer and Vanderlip, 1999), and

storage conditions (Vieira et al., 2001). The percentage in pea germination is commonly decreased by the increase of the storage period (Saxena et al., 1987).

One of the seed traits, which ultimately influences yield, is germination. Evaluation of seed germination by standard germination tests includes implicitly ideal growth conditions, and therefore, results are valuable only for optimum field conditions (Siddique and Wright, 2004). Standard germination is usually higher than field emergence (Hamman et al., 2002), especially when seed is sown in low-pH soil. Factors that greatly influence germination are also seed size and temperature during germination. Sinck et al. (2004) tested the influence of temperatures (2, 5, 10 and 20°C) and seed size of different pea genotypes on germination and germination energy and found a significant positive correlation between seed size and growth, regardless of germination temperature.

The objective of this study was to evaluate the effects of seed age and water solution pH in laboratory tests on germination and early seedling growth of the field pea seed.

MATERIALS AND METHODS

Laboratory tests were conducted in April 2006. Seeds of field pea variety "Timo" produced in 2003 (seeds aged 33 months) and in 2004 (seeds aged 21 months) were used as a material in this study. Some seed traits are given in Table 1.

Table 1

Traits of field pea variety "Timo" seeds differentiated in age

Seed traits	Seed age	
	33 months	21 months
Dry matter (%)	91.12	91.17
Protein (%)	27.74	25.30
Carbohydrates (%)	53.32	55.80
Fats (%)	1.26	1.37
Fibre (%)	5.58	5.34
Ash (%)	3.22	3.36
1000 seed weight (g)	182.0	162.0
Germination after 9 months (%)	95.0	94.5

Germination energy, germination, seedlings root length and stem height were determined at four water solution pH levels: 5, 6, 7 and 8.

Field pea germination was conducted in growth chambers. 50 seeds were placed on soaked filter paper in four replications. The paper was soaked in variants of water solutions: 1) Water from the public water supply – pH = 7. 2) Water from the public water supply – pH = 5 and pH = 6 (made by addition of HCl (1M) to desired pH). 3) Water from the public water supply – pH = 8 (made by addition of NaOH, 1M, to desired pH). The seed on the filter paper was rolled, wrapped in plastic folia and placed in growth chambers to germinate at a constant temperature of 20ºC. Germination energy was determined after four days, while germination after seven days. Seedlings' root and stem were separated from the seed on the seventh day. Root length and stem height were measured on 20 randomly chosen seedlings by a ruler. Values were also added to determine a total seedling length.

The analysis of variance (ANOVA) was carried out by VVSTAT software (Vukadinovic, 1985).

RESULTS AND DISCUSSIONS

LSD values for all investigated traits of field pea seed aged 33 and 21 months and for all tested pH values are given in Table 2.

Table 2

LSD values for investigated traits of field pea seed

LSD	Seed traits			
	Germination energy	Germination	Root length	Stem height
Seed age				
0.05	3.3119	2.7843	0.7564	0.9443
0.01	6.0795	5.1109	1.3885	1.7334
pH				
0.05	7.187	4.1892	1.2671	1.0151
0.01	ns	5.7385	1.7357	1.3905
Seed age x pH				
0.05	ns	ns	ns	1.5869
0.01	ns	ns	ns	2.4425

ns – Non-significant difference

Both, 33 and 21 months old seeds had a similar response to different pH, as to germination energy, but older seeds had significantly (p=0.01) lower germination energy values (Figure 1). On an average, for pH levels, 33 months old seeds had lower germination energy (51.38%) compared to 21 months old seeds (62.88%). Rapcan (2006) tested germination energy of the "Timo" variety by a standard method (pH=7) and found that germination energy of the seed produced in 2003 (after 21 months of storage) was 88% and that of the seed produced in 2004 (after 9 months of storage) was 93%. A comparison between the cited study and this research (55% of germination energy for the seed produced in 2003 and 67% for the seed produced in 2004 at pH=7) indicates that the germination energy of the seed produced in 2003 was decreased by 33%, while that of the seed produced in 2004 was decreased by 26%, during 12 months of storage. Therefore, it seems that, over the same period, the older seed lost more intensive germination energy than the younger one.

On an average, for seed age, differences in germination energy among tested pH levels were significant (p=0.05). The lowest value was recorded for pH=8. Although the highest germination energy value was recorded at pH=7, there were no significant differences between values obtained at pH 7, 6 and 5.

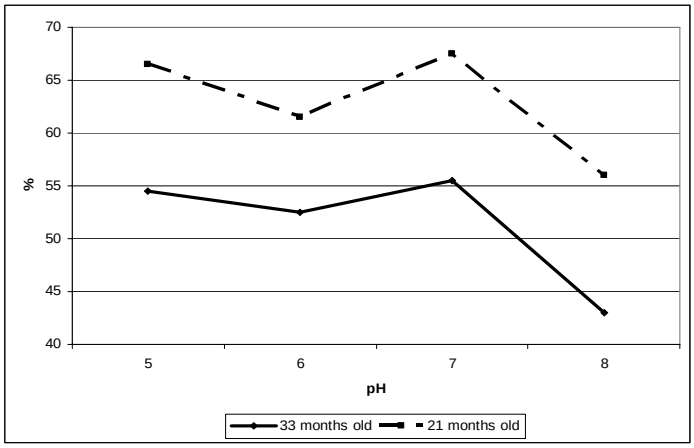

Figure 1. Germination energy (%) of field pea seed differentiated in age and influenced by pH of water solution

The germination of the pea seed differentiated according to age, at tested pH levels, ranged from 58.5 to 77%. Obtained values were much lower than the average pea seed germination. Fowler et al. (2006) reported that the standard germination of pea, dependent on the tested cultivar, varied from 82 to 95%. The study results may be explained by the statement of Saxena et al. (1987) who concluded that the increasing seed age decreases the percentage of germination.

The germination of the pea seed differentiated according to age, was similar at the same pH level (Figure 2). Significantly (p=0.01) lower germination values were obtained for the seed aged 33 months (61.5%) than with seed aged 21 months (70.88%). As reported by Rapcan (2006), standard germination of the "Timo" variety seed produced in 2003 (after 21 months of storage) was 90% and that of the seed produced in 2004 (after 9 months of storage) was 94.5%. Therefore, the germination of the older seed (60% at pH 7), as well as the germination of the younger seed (65.5%), during the 12 months storage period, similarly decreased (approximately 30%).

Seed germination was different at different pH levels (p=0.01). The highest germination (70.75%) was obtained at pH=6. It differed from the germination values at pH=5 (p=0.05; 64.75% of germination), pH=7 (p=0.01; 62.75% of germination), and pH=8 (p=0.05; 66.50% of germination).

Mengel and Kirkby (1987) reported that optimum soil pH values for pea production ranged from 5.3 to 7.4. The results of this study indicate that optimal pH value for germination of the "Timo" pea variety might be 6.

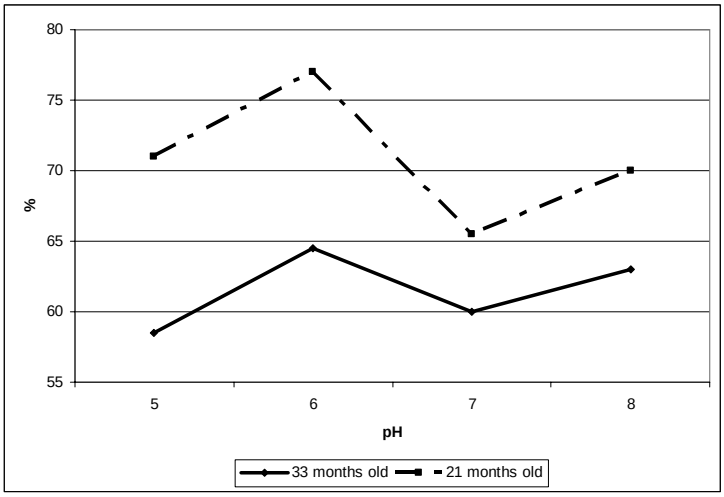

Figure 2. Germination (%) of field pea seed differentiated in age and influenced by pH of water solution

A comparison between germination energy and germination of field pea seed differentiated according to age, at different water solution pH levels, showed that germination energy and seed germination irrespective of seed age had an opposite trend at different pH levels. Germination energy decreased, as the pH level increased from 5 to 6. Germination increased, as the pH level increased from 5 to 6. Germination energy increased and germination decreased, as the pH level increased from 6 to 7. Germination energy decreased and germination increased, as the pH level increased from 7 to 8.

Seedling root length followed the same direction independently of seed age (Figure 3). At average water solution pH levels, 21 months old seeds had a longer seedling root length (10.68 cm) than seedlings of the 33 months old seed (8.17). Differences were significant at p=0.01. Significant differences (p=0.01) were also found for values obtained at different pH

values. The highest root length was found at pH=6 (10.92 cm), and the lowest at pH=5 (7.99 cm).

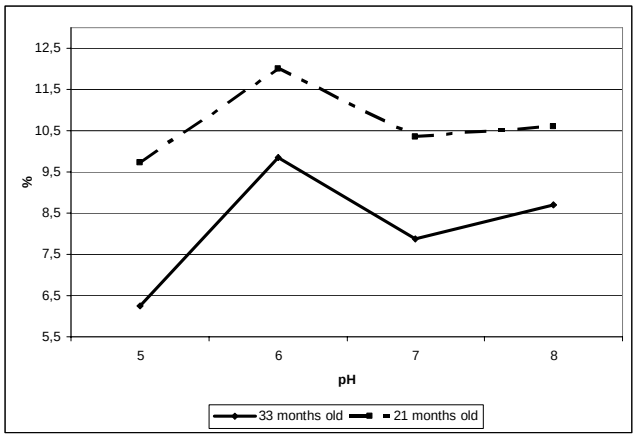

Figure 3. Root length (cm) of field pea seedling influenced by seed age and pH of water solution

Differences (p=0.01) in seedling stem height depended on seed age, water solution pH and seed age x pH interaction (Figure 4). Higher seedling stems were obtained in the case of seeds aged 21 months (12.24 cm) than in the case of seeds aged 33 months (10.18 cm). Although recorded stem height was the highest at pH=7 (12.02 cm), stem height differences, at pH levels 7, 6 (11.63) and 5 (11.70 cm) were not significant. Stem height differences (p=0.01) were encountered for seedlings grown at pH=8 (9.50 cm).

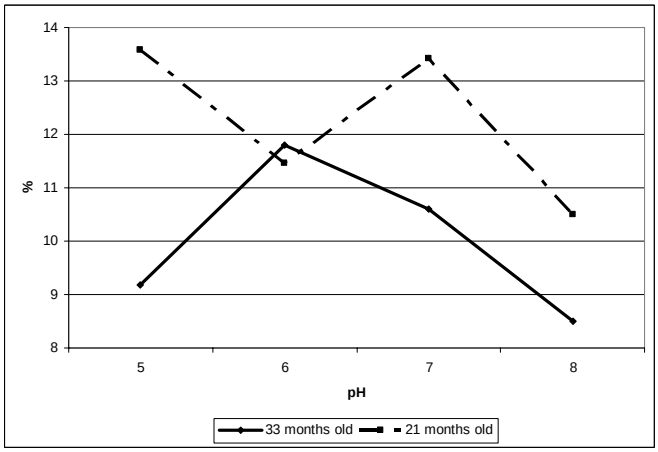

Figure 4. Stem height (cm) of field pea seedling influenced by seed age and pH of water solution

A number of authors indicated that larger seed germinates faster (Rogers and Lomman, 1988; Graven and Carter, 1990; Sinck et al., 2004). Although seed produced in 2003 had a higher 1000 seed weight (for 20 g in comparison with seed produced in 2004), the development of seedlings was slower. This result was congruent with results of Saxena et al. (1987) who indicated that seed age directly influenced seedling growth.

Same variety seed, differentiated in age responded similar to different pH values for most of the investigated traits. Total seedling length (root and stem) indicates that seedlings from 21 months old seed was less sensitive to the changes in pH level with the exception of the development in alkali solution pH (Figure 5). Older seed (33 months old) responded more

intensively to tested pH levels. The optimum pH value for the growth of older seed was 6. Trait values of these seeds for the alkali (pH=8) and acid (pH=5) water solutions were significantly lower.

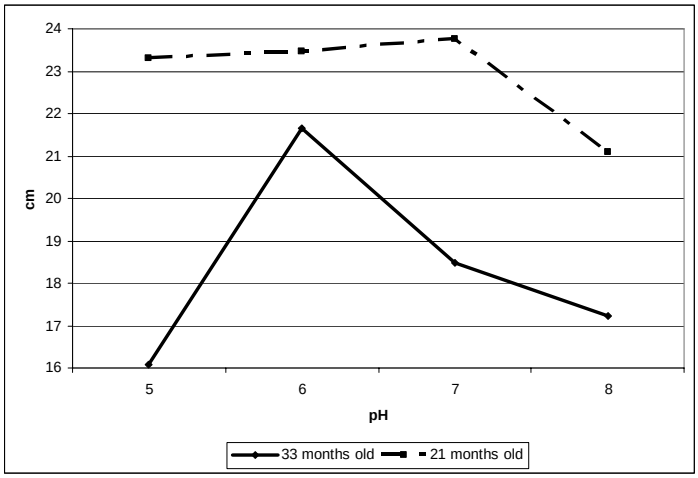

Figure 5. Total length (cm) of field pea seedling influenced by seed age and pH of water solution

CONCLUSIONS

Significant differences (p=0.01) for all investigated seed traits between seed aged 33 months and seed aged 21 months were found. Trait values were higher for the younger seed. Water solution pH value exerted an influence on germination, seedling root length, stem height (p=0.01) and germination energy (p=0.05).The interaction of seed age and pH value was found for the trait of seedling stem height.

Seed responded similar to tested pH levels, irrespective of age and environmental conditions during seed production year. Therefore, testing of genotypes at different pH levels and media in the earliest phases of growth might be helpful in the identification and selection of genotypes for particular location.

REFERENCES

1. Bezdicek, D.F., T. Beaver, D. Granatstein, 2003, Subsoil ridge tillage and lime effects on soil microbial activity, soil pH, erosion, and wheat and pea yield in the Pacific Northwest USA, SoilTillRes, 74 (1), 55-63.

2. Brkic, Suzana, Zlata Milakovic, A. Kristek, Manda Antunovic, 2004, Pea yield and its quality depending on inoculation, nitrogen and molybdenum fertilization, PlantSoilEnviron, 50 (1), 39-45.

3. Bukvic, Gordana**,** M. Stjepanovic, S. Popovic, Sonja Grljusic, D. Horvat, 1998, Influence of location and genotype on the N, P and K concentration in the above ground part of alfalfa, Agriculture, 4 (1), 17-23.

4. a. Bukvic, Gordana, Sonja Grljusic, Vlatka Rozman, S. Popovic, V. Lucin, 2007, Influence of temperature and pH value on germination of alfalfa genotypes, Book of Abstracts of 42nd Croatian & 2nd International Symposium on Agriculture, Opatija - Croatia, February 13-16, 2007, 85-86.

5. b. Bukvic, Gordana, Sonja Grljusic, Anita Liska, R. Gantner, Maja Jagic, Marija Karakas, 2007, Germination of white clover genotypes, Book of Abstracts of 42nd Croatian & 2nd International Symposium on Agriculture, Opatija - Croatia, February 13-16, 2007, 87-88.

6. Fallon, E., N. Tremblay, Y. Desjardins, 2006, Relationships among growing degree-days, tenderness, other harvest attributes and market value of processing pea (*Pisum sativum* L.) cultivars grown in Quebec, CanJPlantSci, 86(2), 525-537.

7. Fowler C.J.F., D.W. Turner, K.H.M. Siddique, 2006, Selection of field pea (*Pisum sativum* L.) cultivar and growing site improves germination and uniformity for sprout production, AustJAgrRes, 57 (12), 1249-1257.

8. Graven, L.M., P.R. Carter, 1990, Seed size/shape and tillage system effect on corn growth yield, JProdAgric, 3, 445-452.

9. Hamman, B., D.B. Egli, G. Koning, 2002, Seed vigour, soliborne pathogens, preemergent growth, and soybean seedling emergence, CropSci, 42, 451-457.

10. Mahler, R.L., R.E. McDole, 1987, Effect of soil pH on crop yield in Northern Idaho, AgronJ., 79, 751-755.

11. Marcos-Filho, J., M.B. McDonald, 1998, Sensitivity of RAPD analysis, germination and vigour testes to detect the intensity of deterioration of naturally and artificially aged soybean seeds, SeedSciTechnol, 26, 141-157.

12. McDonald, M.B., 1998, Seed quality, SeedSciRes, 8, 265-275.

13. Mengel, K., E.A. Kirkby, 1987, Principles of Plant Nutrition, International Potash Institute, Bern.

14. Nemeskeri, E., 2004, Heat tolerance in grain legumes, Bodenkultur, 55(1), 3-11.

15. a. Rapcan, I., G. Bukvic, S. Grljusic, T. Teklic, M. Jurisic, 2006, The influence of agroecological conditions and seed maturity on the grain yield and quality of field pea (*Pisum sativum* L.), Dairy, 56 (4), 331-342.

16. b. Rapcan, I., G. Bukvic, S. Grljusic, T. Teklic, M. Jurisic, 2006, Field pea (*Pisum sativum* L.) biomass production dependence on seed age and agroecological growth conditions, Agriculture, 12 (2), 29-35.

17. Rapcan, I., 2006, Laboratorijska kakvoca kultivara graska i njezin utjecaj na prinos, Sveuciliste J.J. Strossmayera u Osijeku, Poljoprivredni fakultet u Osijeku, PhD thesis.

18. Rogers, I.S., G.J. Lomman, 1988, Effect of plant spacing on yield, size and kernel fill of sweet corn, AustJExpAgr, 28 (6), 787-792.

19. Saxena, O.P., G. Singh, T. Pakeeraiah, N. Pandey, 1987, Seed deterioration studies in some vegetable seeds, Acta Horticulturae, 215, 39-44.

20. Schaffer, A.F., R.L. Vanderlip, 1999, The effect of conditioning on soybean seed quality, JProdAgric, 12, 455-459.

21. Siddique, A.B., D. Wright, 2004, Effects of date of sowing on seed yield, seed germination and vigour of peas and flax, SeedSciTechnol, 32 (2), 455-472.

22. Sinck, M., U. Bilgili, A. Uzun, E. Acikgoz, 2004, Effect of low temperatures on the germination different field pea genotypes, SeedSciTechnol, 32 (2), 331-339.

23. Vieira, R.D., D.M. TeKrony, D.B. Egeli, M. Rucker, 2001, Electrical conductivity of soybean seeds after storage in several environments, SeedSciTechnol, 29, 599-608.

24. Vukadinovic, V., 1985, VVSTAT Software.

REZUMAT

INFLUENȚA VÂRSTEI SEMINȚELOR ŞI A pH-ULUI APEI ASUPRA GERMINAȚIEI ÎN CÂMP LA MAZĂRE (*PISUM SATIVUM* L.)

Prin analize de laborator s-a evaluat influența vârstei seminței şi a pH-lui soluției apei asupra energiei de germinare în câmp la mazăre, determinându-se germinația în corelație cu lungimea rădăcinii şi înălțimii tulpinii răsadului. Au fost testate semințe cu vârsta cuprinsă între 33 de luni şi 21 de luni şi patru nivele ale pH-lui soluției apei (5, 6, 7 şi 8). Valorile caracterelor studiate au fost semnificativ mai mari (pentru p=0.01) pentru semințele în vârstă de 21 de luni. Diferitele valori ale pH-ului soluției apei influențează germinația, lungimea rădăcinii şi înălțimea tulpinii plăntuțelor (p=0.01) şi energia de germinare (p=0.05). Indiferent de vârsta seminței, cea mai mare energie de germinare (61.50% în medie), a fost la pH=7, şi cea mai mare germinație (70.75% în medie) şi lungime a rădăcinii (10.92 cm în medie) la pH=6. Cea mai mare înălțime a tulpinii plantelor obținute din semințe în vârstă de 33 de luni a fost la pH=6, iar cea mai mare înălțime a tulpinii plantelor provenite din semințe în vârstă de 21 de luni a fost la pH=5.