INFLUENCE OF MAGNETIC POLES ON THE PROPERTIES OF FIELD PEA (*Pisum sativum* L.) SEED OF DIFFERENT AGES

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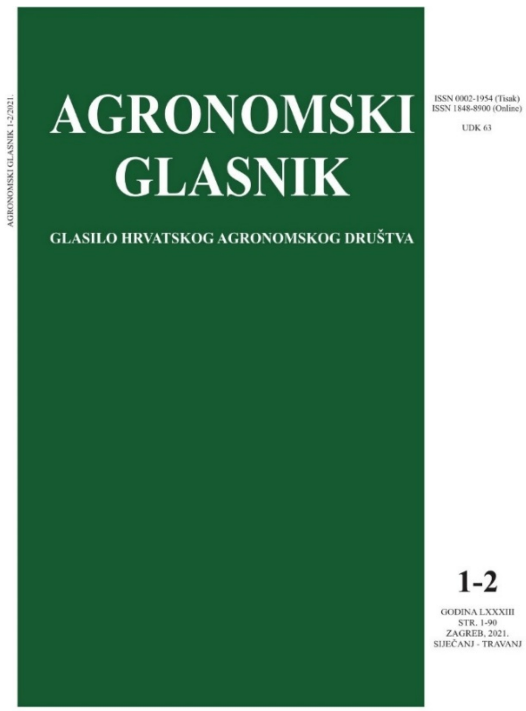

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ABSTRACT

The study on the influence of magnetic poles on field pea seed of the 'Bera' variety of different ages was carried out under laboratory conditions in a growing chamber. Field pea seed were exposed to a neodymium magnet's positive and negative magnetic poles with a magnetic flux density of 250 mT for 24 hours. Germination of untreated as well as magnetically poled treated seed was carried out according to ISTA rules.

Seed characteristics, germination energy, and germination were determined by counting. The root and stem length of the seedlings were measured, and the total length of the field pea seedlings was added up. The total mass of the seedlings was determined by weighing.

On average, seed age and magnetic poles significantly ($p<0.05$) increased the traits: stem length, total length, and seedling weight. On average, significant differences ($p<0.05$) were found for untreated and magnetic poles treated seed for all the studied traits except seedling stem length. Significant interaction ($p<0.05$) between magnetic pole treatment and seed age was found for all the traits studied.

Key words: field pea, magnetic poles, seed, seedlings

SAŽETAK

Istraživanje utjecaja magnetnih polova na sjeme krmnog graška kultivara „Bera“ različite starosti provedeno je u laboratorijskim uvjetima u klima komori. Sjeme graška izloženo je djelovanju pozitivnog i negativnog magnetnog pola neodimijskog magneta gustoće magnetskog toka 250 mT tijekom 24 sata. Naklijavanje netretiranog kao i magnetnim polovima tretiranog sjemena obavljeno je sukladno pravilima ISTA.

Brojanjem su određena svojstva sjemena, energija klijanja i klijavost. Mjerenjem je određena dužina korijena i stabljike klijanaca te zbrajanjem ukupna dužina klijanaca krmnog graška. Vaganjem je izmjerena ukupna masa klijanaca.

U prosjeku za starost sjemena, magnetni polovi su značajno ($p<0,05$) utjecali na: dužinu stabljike, ukupnu dužinu kao i masu klijanaca. U prosjeku za netretirano i sjeme tretirano magnetnim polovima, dobivene su značajne razlike ($p<0,05$) za sva ispitivana svojstva osim dužine stabljike klijanaca. Značajna interakcija ($p<0,05$) tretmana magnetnih polova i starosti sjemena dobivena je za sva ispitivana svojstva.

Ključne riječi: krmni grašak, magnetni polovi, sjeme, klijanci

INTRODUCTION

Increasing climate change causes yield and quality losses in field crops. In addition to the selection and acquisition of new genetic material for specific agro-ecological conditions, the yield and quality of crops are improved by using mineral fertilizers and pesticides, which pollute the environment. The use of the magnetic field in agricultural production has shown a beneficial effect on plant biomass production while conserving the environment (Radhakrishnan, 2019). The use of a magnetic field on crops seed also enables the production of plants with improved disease resistance and tolerance to stressful conditions and better uptake of nutrients and water from the soil (Sarraf et al., 2020).

One of the most important factors for crop yield and quality is seed quality. Quality of seed is mostly improved by chemical methods, i.e., treatments with chemical solutions which can contain various hazardous ingredients for the environment. (Jakubowski, et al., 2015, Jalali and Salehi, 2013). Therefore, research is focused on other methods of seed preparation before sowing, including the application of a magnetic field.

Da Silva et al. (2016) reported that magnetic fields could affect seed germination and seedling growth and development in various plant species, including cereals, forage, and industrial crops. The advantage of magnetic field treatment is that it is a non-residual and non-toxic method.

Research has shown that exposure of seed to a magnetic field of varying strength has a stimulatory effect on the early stages of plant growth of pea

(Martínez et al., 2009; Carbonell et al., 2011), maize (Racuciu et al., 2008), soybean (Radhakrishnan et al., 2012), radish (Fu, 2012), cotton (Bilalis et al., 2013), strawberry (Eşitken and Turan, 2004). Based on the study results on pretreatment of soybean seed with a pulsating magnetic field, Radhakrishnan et al. (2012) concluded that magnetic field improves the productivity of soybean by increasing protein activity. While mineral and enzyme accumulation was higher, which leads to more intensive plant growth and consequently higher yields. Katsenios et al. (2016) obtained higher germination of durum wheat seed treated with a pulsed electromagnetic field for different exposure periods, which they attributed to a higher reading of α-amylase. They also observed higher chlorophyll content, photosynthesis and transpiration rate, leaf area, and yield of treated durum wheat seed under field conditions. Seed quality is influenced by agro-ecological conditions during vegetation (McDonald, 1998), processing (Schafferi and Vanderlip, 1999), and storage conditions and duration (Saxena et al., 1985). Nevertheless, seed storage decreases seed quality even under optimal conditions (Bukvić et al., 2018).

This study aimed to investigate the influence of magnetic field - north and south poles of neodymium magnet on the characteristics of seed and seedlings of peas of different age: germination and germination energy of seed, root length, stem length, and total length of seedlings and their total mass.

MATERIALS AND METHODS

The study was conducted using field pea seed of the Bera variety from 2019 and 2020. Seed was exposed to the magnetic field of the north (positive) and south (negative) poles of a neodymium magnet with a magnetic flux density of 250 mT for 24 hours.

Treated and untreated pea seed of different age were sown on moistened filter paper, and germination was carried out in a growing chamber according to ISTA regulations.

The germination energy and germination of the seed were determined by counting the seed, then by measuring the determined length of the stem and roots of the seedlings and adding the total length of the seedlings. The mass of the seedlings was determined by weighing.

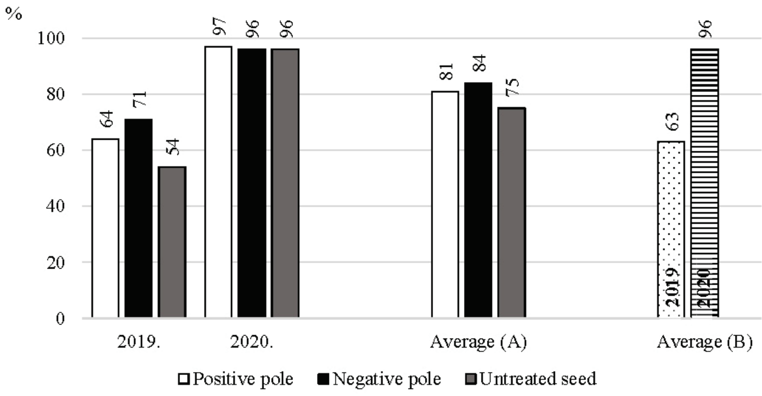
Statistical data analysis was performed using SAS 9.4 software (SAS Institute Inc.). The significance of the studied traits was tested using the LSD test.

RESULTS AND DISCUSSION

Treatment of seed with magnetic field had no statistically significant effect on the energy and germination of the pea seed (Figure 1 and 2). When investigating the influence of an alternating magnetic field, Namba et al. (1994) observed an effect on plant growth and germination. They concluded that magnetic field frequency was a more important factor than polarity.

The average germination energy in all treatments was 80%. Seed age and the interaction of seed age and magnetic polarity had a significant influence on germination energy ($p<0.05$).

On average, pea seed from 2020 had 33% higher germination energy than seed from 2019. The poles of the magnet, as well as the control, did not differ regarding the germination energy values of the seed from 2020, but the magnetic field increased the germination energy of the seed from 2019. The negative pole increased the germination energy for older seed by 17% and the positive pole by 10%. Regarding the influence of poles and seed age, the differences were greatest for untreated seed at 42%, while the least differences were observed for the negative pole at 25%.



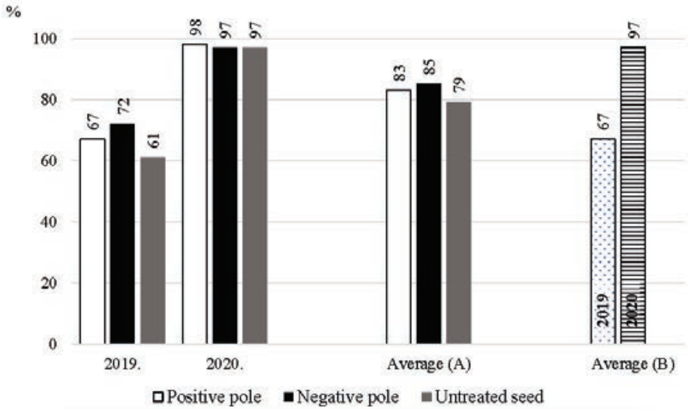
LSD 0.05	A	B	AB
	n.s.	4.78	4.23

*A – untreated and seed treated with magnetic field (for both years); *B – seed age (by years)

Fig. 1 Influence of magnetic pole and seed age on germination energy of field pea seed (%)

Grafikon 1. Utjecaj magnetnog pola i starosti sjemena na energiju klijanja sjemena krmnog graška (%)

Although magnet poles had no significant effect on pea seed germination, a statistically significant effect of seed age and the interaction of magnet pole and age was found ($p<0.05$). The average germination of seed was 82% on all treatments. On average for all treatments, pea seed from 2020 had a 30% higher average germination than seed from 2019. Bukvić et al. (2007) and Rapčan et al. (2006) determined the reduction in germination energy and seed germination of two pea cultivars in their studies. The differences in germination of seed from 2020 were not statistically significant, but the magnetic field increased germination of seed from 2019. Compared to the control, i.e. untreated seed, magnet's negative pole increased the seed germination by up to 11% and positive pole by 6%. Regarding the influence of poles and age of seed, the differences were highest in untreated seed (36%), while the least differences were observed in seed treated with the negative pole of the magnet (25%). Similarly, Jamil and Ahmad (2012) in studies on the effects of pretreatment of garden pea seed with the magnetic field of 60 mT, 120 mT, and 180 mT at different exposure time before sowing (5, 10, and 15 min) obtained higher values of germination energy and germination of treated seed. However, it was found that exposure of 5 minutes and magnetic field strength of 60 mT and 180 mT increased the values of the above properties of the seed to a greater extent than a longer exposure to the magnetic field. Increased germination due to seed treatment with a magnetic field was also found in other crops (Khristyuk, 2009, Prokop et al. 2020).

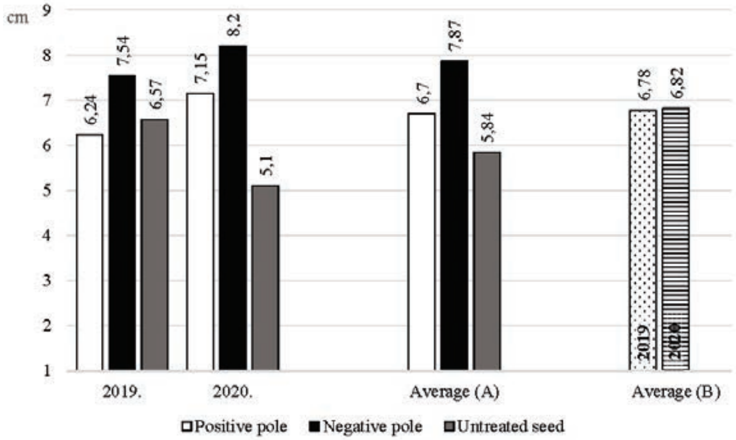


LSD 0.05	A	B	AB
	n.s.	4.35	6.17

*A – untreated and seed treated with magnetic field (for both years); *B – seed age (by years)

Fig. 2 Influence of magnetic pole and seed age on field pea seed germination (%)
Grafikon 2. Utjecaj magnetnog pola i starosti sjemena na klijavost sjemena krmnog graška (%)

Contrary to the germination energy and germination, the stem length of field pea seedlings was significantly affected by magnetic poles ($p<0.05$). Seed age did not affect the values of this seedling trait, but a significant treatment interaction was also found (Figure 3). The average stem length on all treatments was 6.80 cm. In 2019 seed, treatment with a positive magnetic pole had lower values (by 0.33 cm) compared to untreated seed. However, the negative magnetic pole increased seedling stem length by 0.97 cm. A significant effect of stationary magnetic field exposure for 24 hours on growth of field pea seedlings was found by Martinez et al (2009). After 7 days of germination, the authors determined higher values for stem length and total seedling length at a magnetic field strength of 125 mT, while stem mass and total seedling mass were higher at 250 mT. On average, pea seed from 2020 treated with a negative magnetic pole had stems 3.10 cm longer than untreated seed. The same seed treated with a positive magnetic pole had 2.05 cm longer seedling stem compared to untreated seed. Considering the influence of the poles and the length of the seedling stem, the differences were greatest in untreated seed and amounted to 1.47 cm, while they were the least in the negative pole treatment (0.66 cm).



LSD 0.05	A	B	AB
	0,73	n.s.	0.66

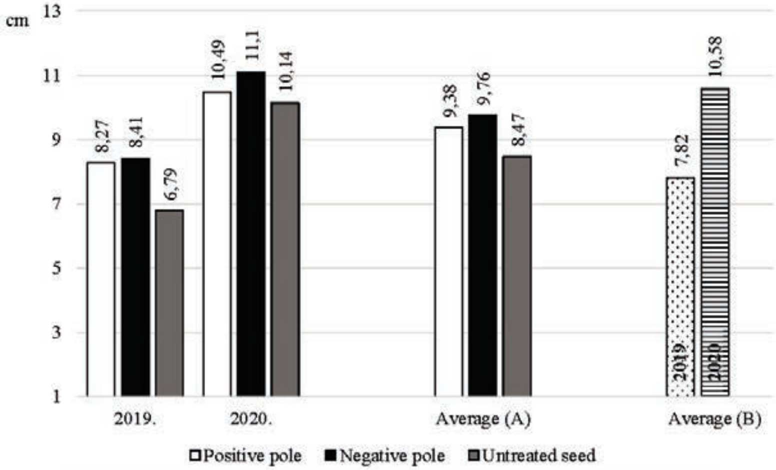
*A – untreated and seed treated with magnetic field (for both years); *B – seed age (by years)

Fig. 3 Influence of magnetic pole and seed age on seedling stem length (cm)

Grafikon 3. Utjecaj magnetnog pola i starosti sjemena na dužinu stabljike klijanaca (cm)

On average, as regards seed age, magnetic poles had no significant effect on seedling root length (Figure 4). However, a statistically significant effect of seed age and interaction of magnetic pole and age ($p<0.05$) was observed. In all treatments and ages, the average root length of the seedlings was 9.20 cm. On average, pea seed of 2020 had 2.76 cm longer seedling roots compared to an older seed.

In general, the exposure to the negative magnetic pole resulted in higher values of root length than the exposure to the positive pole. These differences in seedling root length were more pronounced in the older seeds. The negative pole of the magnet increased root length by 1.62 cm compared to untreated seed and the positive pole by 1.48 cm. When comparing untreated and magnetically treated seed of different age, the differences were greatest in untreated seed (3.35 cm) and least in the positive pole (2.22 cm).



LSD 0.05	A	B	AB
	n.s.	0.59	0.53

*A – untreated and seed treated with magnetic field (for both years); *B – seed age (by years)

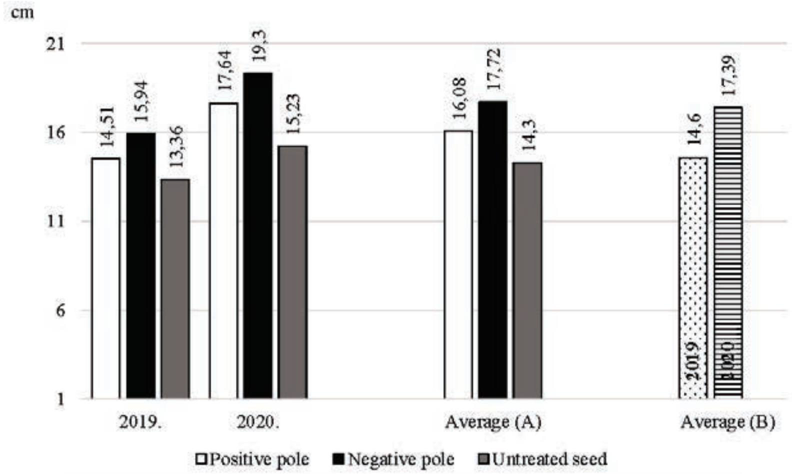
Fig. 4 Influence of magnetic pole and seed age on seedling root length (cm)

Grafikon 4. Utjecaj magnetnog pola i starosti sjemena na dužinu korijena klijanaca (cm)

The total seedling length was significantly affected by magnetic pole treatment, seed age and their interactions ($p<0.05$) (Figure 5). The average total seedling length in all treatments was 16.00 cm. On average of seed age, the negative pole increased total seedling length (3.42 cm) to a greater extent than the positive pole (1.78 cm), but the difference between the poles was not statistically significant.

On average, the 2020 magnetic pole developed significantly longer seedlings (by 2.79 cm) in all treatments. The negative magnetic pole increased seedling length to a greater extent, by 2.58 cm in the older seed and by 4.07 cm in the 2020 seed compared to the untreated seed.

An increase in stem length, as well as total seedling length under the influence of the magnetic field, has been reported in other studies in pea (Grewal and Maheshwari, 2011) as well as in other plants (Dayal and Singh, 1986; Selim, et al. 2011). Carbonell et al. (2011) obtained an increase in pea stem length by 35% and 32% and total seedling length by 37% and 35% under the effect of 24 hours of seed exposure to steady-state magnetic field strength of 125 mT and 250 mT, respectively.



LSD 0.05	A	B	AB
	1.67	1.30	0.77

*A – untreated and seed treated with magnetic field (for both years) ; *B – seed age (by years)

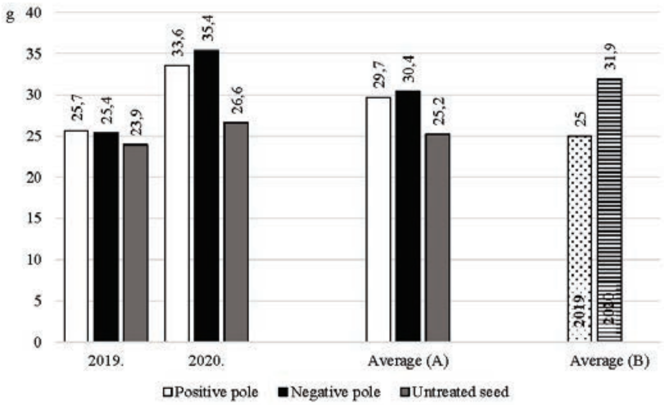
Fig. 5 Influence of magnetic pole and seed age on the total length of seedlings (cm)

Grafikon 5. Utjecaj magnetnog pola i starosti sjemena na ukupnu dužinu klijanaca (cm)

Statistically significant differences (p<0.05) were also found for the mass of field pea seedlings under the influence of magnetic poles and seed age, as well as their interaction. Similarly, Iqbal et al. (2012) reported the increase in length, dry and fresh mass of stem and roots of seedlings due to pretreatment of pea seed with a magnetic field of different intensity and exposure.

The average seedling weight in all treatments was 28.43 g. On average, in both seed ages, both pole magnets significantly increased seedling weight in comparison to the control, but there was no statistically significant difference between positive and negative pole magnets. The older seed had significantly lower values, averaging 6.9 g in both pole magnet treatments and untreated seed. For the 2019 seed, differences in total seedling weight were not significant. However, for 2020 seed, the seedling weight of untreated seed was significantly lower than the weight of seedlings treated with both magnetic poles. On average, in both seed ages, untreated seed obtained lower seedling weight in comparison to negative pole treatment than positive pole.

Based on the results of research on the treatment of pea seed with a magnetic field before sowing, Podleśny et al. (2021) conclude that the use of a magnetic field stimulates biochemical processes, increases the concentration of amylolytic enzymes, and affects the increase in phytohormones the content in seed and seedlings.



LSD 0.05	A	B	AB
	4.42	2.69	2.2

*A – untreated and seed treated with magnetic field (for both years); *B – seed age (by years)

Fig. 6 Influence of magnetic pole and seed age on seedling weight (g)

Grafikon 6. Utjecaj magnetnog pola i starosti sjemena na masu klijanaca (g)

CONCLUSION

Based on the results of our study influence of magnetic poles on field pea seed and seedling traits, it can be concluded that on average, for both seed ages, the magnetic poles significantly influence stem length, total length, and seedlings weight.

On average, significant differences were found between the magnet treatments and the control for all the traits studied except seedling stem length.

A significant interaction was found between magnetic pole treatment and seed age for all the traits studied.

Considering the research results obtained, as well as the results of other research on treatments of pea and other crops seed with a magnetic field, it can be concluded that this method of pre-sowing seed preparation has a positive effect, although it is necessary to find the optimal exposure time and magnetic field strength for a particular crop.

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