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# Effect of laser priming on canola yield and its components under salt stress

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A b s t r a c t. The effect of laser priming at different irradiation times on canola yield and its components under saline conditions were investigated. The results showed that laser priming had a positive effect on yield and its components and caused yield increase under saline conditions. Increase in salt levels had a negative and significant effect on seed yield, number of seeds per pod, number of pod per plant, pod length and plant height. The results showed that 45-min laser priming had the strongest effect on yield and yield components and reduced significantly the adverse effects of salinity. By contrast, laser radiation applied for 60 and 75 min, resulted in a dramatic decrease in yield and its components. Correlation coefficients between the attributes showed that canola yield had a positive and significant correlation with plant height, number of seeds, pod per main branch and lateral branches, length of pod and number of lateral branches. Effects of laser and salinity were significant on lateral branch pod length but not on main branch pods.

K e y w o r d s: canola, laser irradiation, salt stress, yield, yield components

## INTRODUCTION

Salinity is known to adversely affect productivity of most crops worldwide (Ashraf, 2009) because their biomass and seed yield are significantly suppressed by this abiotic stress (Munns and Tester, 2008). Globally, more than 770 000 km$^2$ of lands are salt-affected by secondary salinization: 20% of irrigated land and about 2% of dry land agricultural land (Yildirim *et al*., 2006). In Asia, after pervious USSR, China, India and Pakistan the largest amount of saline soils belong to Iran (Szabolc, 1989). Canola represents its highest yield in proper and desirable soil conditions. However its growth, yield and oil yield can be reduced significantly by environmental stresses such as drought, salinity, water logging *etc*. Therefore, canola yield may reduce under saline soils (Ashraf and Mc Neilly, 2004).

Among the various methods of priming it seems that there is little information about physical methods. But in recent years, interest in the use of physical methods of plant growing stimulation has increased (Carbonell *et al.*, 2000; Dinoev, 2006; Hernandez *et al*., 2010; Vasilevski, 2003). Also in recent years the use of laser radiation in biology and agriculture extended widely and rapidly. Hernandez *et al.* (2006) reported that laser radiation increased the emergence speed and percentage, dry mass of seedlings and, ultimately, significantly increased the yield of laser radiated seeds. In the case of physical treatment the energy introduced in the cell creates conditions for molecular transformations and, as a result, the necessary substances are provided for the cell (Aladjadjiyan, 2007).

The purpose of this experiment was to study different laser intensities for priming canola seeds as well as to measure how different densities of laser radiation affect canola yield and performance under salt stress conditions.

## MATERIALS AND METHODS

The experiment was conducted as factorial in the complete randomized blocks design with three replications, in the greenhouse University Agricultural Faculty of Zanjan. Canola seeds, cv. RGS300, were irradiated by using a 532 nm diode laser with 2.5 W power, with 5 irradiation times (15, 30, 45, 60 and 75 min), plus a control treatment without irradiation, and three salt levels including 0, 0.5, and 1 g NaCl kg$^{-1}$ soil (which equal 3.24, 5.92, and 7.4 dS m$^{-1}$, respectively). Prior to laser priming canola seeds were placed in distilled water for 12 h, then swelled seeds were subjected to ND-YAG laser radiation with mentioned

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durations. Then they were dried at room temperature for 48 h. Potting soil was prepared at 6-3-1 ratio including cultivated soil, fine sand and dung, respectively. Given amount of salts was added to soils and then electrical conductivity of samples was measured. The seeds were planted in plastic pots with 25 cm diameter and 30 cm height in July 2009. The seeding depth was 2-3 cm and each of the pots contained 15 kg soil. 15 seeds were planted in each pot after making them salted, and after the establishment of seedlings four plants were kept in every pot. Three cavities with 0.5 cm in diameter were made at the bottom of the pots as drains, and some gravel was cast at their bottoms in some cm height. The pots were filled in such a way that there was 5 cm space between the soil level and the mouth of each pot. When the plants attained physiological maturity, the numbers of pods on both the main and secondary branches as well as the numbers of secondary branches on each plant were counted separately. Then their mean values were calculated as the numbers of pods on both the main and secondary branches and as the numbers of secondary branches per plant. The length of pods was measured on both main and secondary branches separately by a ruler. After that the length of pods on the main and secondary branches was calculated as their mean. In order to count the number of seeds per pod, their mean in terms of the number of seeds on a pod was calculated when seeds separated from the pod and all the seeds sampled were counted. The height of the main and secondary branches on plants was also measured. Then their mean was calculated as the height of the main and secondary branches and, in order to calculate seed yield as seed yield of each plant, the whole seeds on the plants were weighed at 0.0001 accuracy after harvesting and picking them from the pods of each plant. The resulting data were analyzed statistically by MSTAT-C and SPSS software and finally, means (averages) were compared by using Duncan multiple range test.

## RESULTS AND DISCUSSION

Interaction effects of salinity and laser on the plant height of main branch were significant (Table 1). The highest height on non-saline treatment involved the seeds which were irradiated by laser for 45 min. The lowest height involved the seeds which were irradiated by laser for 75 min and grew at the highest level of salinity. In general, with increasing salinity the plant height was decreased (Fig. 1).

The height of plants had a positive and significant correlation with seed yield per plant, number of pods on lateral branches, number of seeds per pod and thousand seeds mass (Table 2). That is, decreasing of plant height is one of the factors that may cause undesirable effect on dry matter accumulation. It seems that laser priming of seeds would cause an increase in plant height under normal and saline conditions and ultimately they could have a higher yield. The length and number of lateral branches decreased significantly while salt levels increased. The least length and number of lateral branches belong to the treatments that have higher salt level (1 g NaCl $kg^{-1}$ soil) and were laser irradiation was applied for 60 and 75 min. Indeed these treatments have no lateral branches at higher salt levels. Nevertheless, while the seeds of these salt treatments were irradiated for 45 min, the numbers of lateral branches increased. In this experiment the number of lateral branches had a positive and significant correlation with canola yield (Table 2) (R = 0.924).

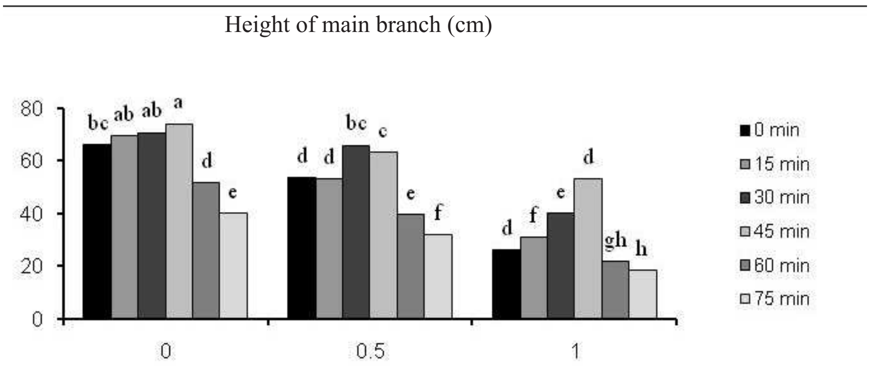
With increasing number of lateral branches, the number of pods and seeds per plant increased, which resulted in higher yielding. The interaction effect of salinity and laser priming for these characters were significant (Table 1). The highest number of pods on the main branch and lateral branches resulted from laser irradiation for 45 min and without any addition of salt, and the least number of pods on the main branch and lateral branches resulted from laser irradiation for 75 min and 1 g NaCl $kg^{-1}$ soil level. Laser priming improved the number of pods on the main branch and lateral branches.

**T a b l e 1.** Analysis of variance for yield and yield components of canola primed with laser under salinity conditions

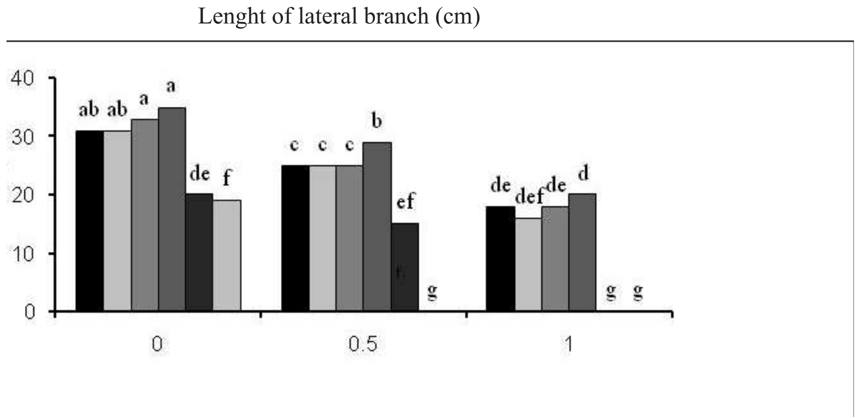
| Source of variation | DF | Mean of squares: Plant height | Length of lateral branch | Number of lateral branch | Number of pod on main branch | Number of pod on lateral branch | Number of seeds per pod | Pod length on main branch | Pod length on lateral branch | Seed yield per plant |
|---|---|---|---|---|---|---|---|---|---|---|
| Replications | 2 | 16.074* | 1.352 ns | 0.130 ns | 0.396** | 6.463* | 29.825* | 0.921** | 0.141** | 0.056 ns |
| Laser | 5 | 1449.352** | 199.007** | 4.996** | 3682.389** | 27.630** | 106.830** | 4.113** | 34.125** | 21.987** |
| Salinity | 2 | 4256.074** | 496.130** | 21.907** | 1877.778** | 81.130** | 623.907** | 9.144** | 37.361** | 8.565** |
| Salinity x Laser | 10 | 64.116** | 9.752** | 0.396** | 1549/611** | 5.130** | 12.552 ns | 0.115 ns | 9.847** | 1.062** |
| Error | 34 | 4.623 | 2.920 | 0.110 | 40.196 | 1.267 | 6.734 | 0.116 | 0.88 | 0.165 |
| CV(0/0) | - | 4.44 | 10.14 | 18.47 | 30.05 | 18.99 | 23.20 | 10.41 | 15.96 | 13.45 |

*, **significant at 0.05 and 0.01%, respectively. ns – non-significant.

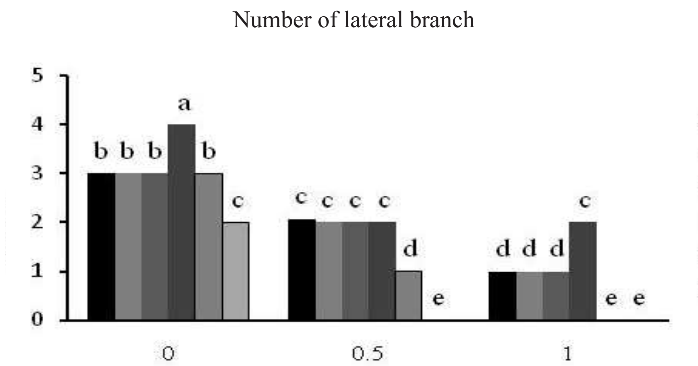
A




B




C




D

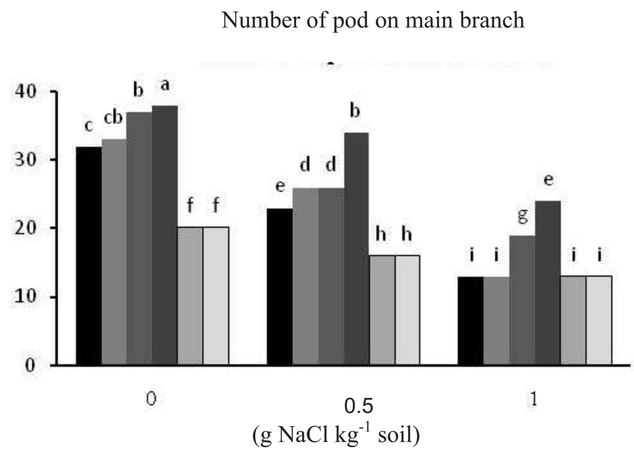
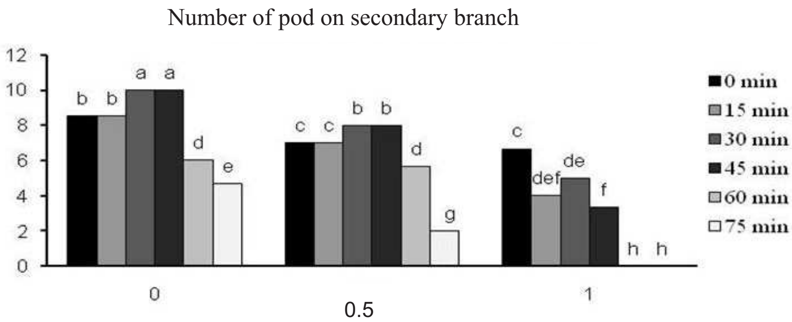
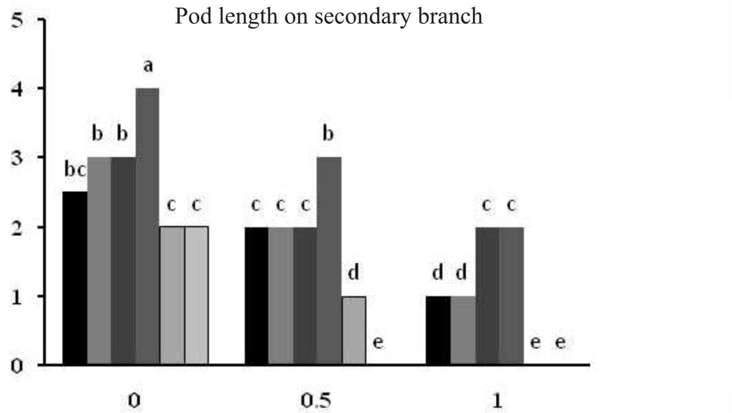



**Fig. 1.** The effect of laser priming and salinity on the chosen properties of canola (A-G); a-i – the same letters are not significantly different at P<0.05.

E




F




G

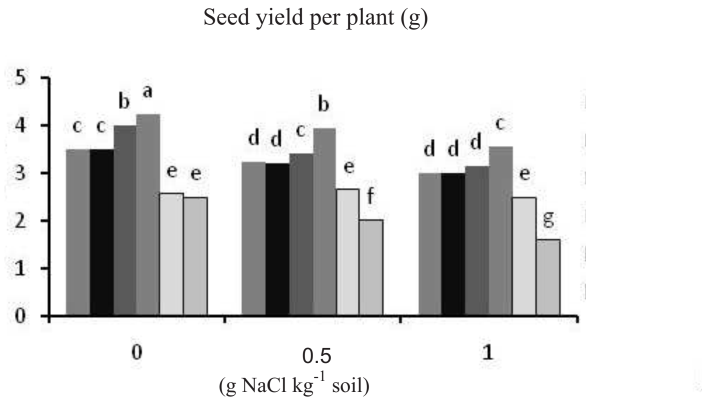



**Fig. 1.** Continuation.

The number of pods on the main branch and on the lateral branches had a positive and significant correlation with canola yield (R = 0.732 and R = 0.517, respectively). The number of seeds per pod decreased while salt levels increased. But, laser irradiation for 45 min increased the number of seeds per pod. In the cases mentioned above, again the lowest number of seeds belonged to treatments with higher salinity (1g NaCl $kg^{-1}$ soil) and laser irradiation of 75 min (Figs 2, 3). Interaction effects of salinity and laser on this attribute were not significant. In these treatments the length of pods was lower and the number of seeds on these pods also decreased. The number of seeds per pod on the main branch and lateral branches had a positive and significant correlation with the length of main and lateral pods, number of pods and the length of branch (Table 2). It seems that decrease of the seeds number per pod is a major factor for decreasing pod size among others resulting from salt stress. Considering the positive and significant correlation between the length of pods on the main and lateral branches and the seeds number per pod (R = 0.769 and 0.743, respectively) shows that the decreasing of the length of pod resulting from salt stress could be one reason for decrease of the seeds number. The seeds laser irradiated for 45 min produced plants with the highest pod length on the main branch and lateral branches, and in this respect they were significantly different from the other treatments. Interaction effects of laser and salinity on pod length were significant on the lateral branches but not on the main branch pods. Pod length on the main branch decreased with increasing salinity level. Laser priming of seeds, especially in the case of seeds irradiated for 45 min, resulted in increasing pod length. The lowest pod length was observed in treatments with the highest level of salinity and laser irradiation of 75 min. That was the case with pod length of lateral branches. That is, pod length of lateral branches decreased while the salinity level increased. The lowest pod length was on lateral branches

**T a b l e 2.** Correlation coefficient attributes of canola under salt and laser priming

| Seed yield per plant | Number of lateral branch | Pod length on lateral branch | Pod length on main branch | Number of seeds per pod | Number of pod on lateral branch | Number of pod on main branch | Length of lateral branch | Plant height |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1 | 0.904** |
| | | | | | | 1 | 0.369** | 0.362** |
| | | | | | 1 | 0.184 | 0.633* | 0.656** |
| | | | | 1 | 0.739** | 0.365** | 0.844** | 0.365** |
| | | | 1 | 0.769** | 0.524** | 0.421** | 0.828** | 0.846** |
| | | 1 | 0.905** | 0.743* | 0.530** | 0.412* | 0.814* | 0.863** |
| | 1 | 0.812** | 0.743** | 0.860** | 0.612** | 0.355* | 0.841* | 0.822* |
| 1 | 0.924** | 0.781** | 0.841** | 0.851** | 0.732** | 0.517** | 0.541** | 0.960** |

Explanations as in Table 1.

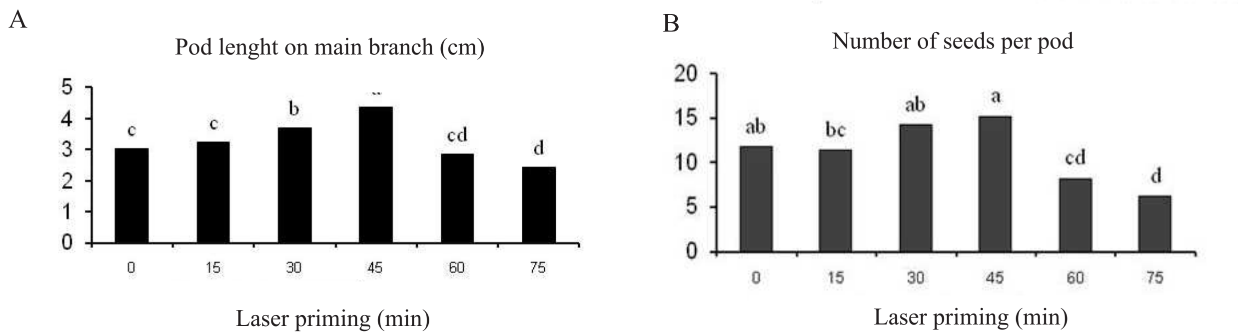



**Fig. 2.** The effect of laser priming on: A – pod length on the main branch, B – number of seeds per pod. Explanations as in Fig. 1.

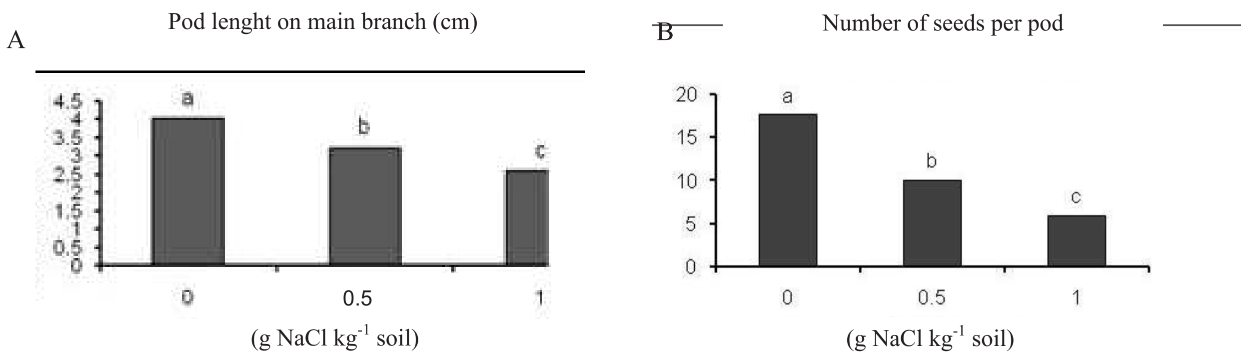



**Fig. 3.** The effect of salinity on: A – pod length on main branch, B – number of seeds per pod.

(zero) which involved treatments with highest level of salinity and laser irradiation for 75 min, because these treatments principally had no lateral branches. Pod length of the main branch and lateral branches has a positive and significant correlation with the height of branch, number of seeds, and number of pods (Table 2). Simple and interaction effects of salinity and LASAR priming on seed yield were significant ($p \leq 0.01$) (Table 1). Seed yield per plant showed that seeds laser irradiated for 45 and 30 min under non-saline conditions produced 4.25 and 4 g seeds per plant, respectively, and had the highest yield, whereas seeds laser irradiated for 75 min produced 2.5 g seeds per plant and had the lowest seed yield compared to the control treatment. Laser radiated seeds for 45 min had many important and relating attributes of seed yield, and the number of pods per plant, number of seeds per pod and other important agronomic characters were better than for the other studied treatments. Seed yield per plant decreased significantly with increasing salinity. Comparing seed yield between the salt treatments showed that the treatment with the highest salinity and with 75 min laser irradiation of seeds had the lowest seed yield per plant (1.59 g).

Plant height was modified to a much lower extent. Decrease in the plant height may be a result of osmosis damage, ion toxicity, and change in the balance of available nutrients in a saline environment. Rameeh *et al.* (2004) showed that plant height of lines and cultivars of canola were affected undesirably by soil salinity. Mahmood *et al.* (2003) found that the height of sesame plants decreased significantly at increasing salt levels. Ashraf and Sarvar (2002) reported that increasing salinity can result in a decrease of plant height in certain species of rapeseed. Also, Ashraf and McNeilly (2004) reported undesirable effect of salt stress on the growth of rapeseed. Kareem *et al.* (2009) reported that cell elongation causes an increase of plant height in plants treated with helium-neon laser compared to untreated ones, so the shoot internodes increase, which gives a chance for growing more branches as well as umbels.

Increase in salt levels leads to a decrease in pod number. Lin *et al.* (2004) reported it is possible that decrease in the number of pods resulted from abscisic acid hormone, because increase in the amount of this hormone could bring pollen grain to death and therefore might decrease the number of inseminated flowers and pods. Considering the created stress, that resulted in early flowering and, on the other hand, shorter flowering period, and caused lower vegetative growth. Therefore the plant guaranteed its survival at the cost of decreasing the number of pods by storing less photosynthetic carbon in sections such as branch, root crown, and so on. Decrease in the number of pods under stress conditions may result from plant inability to create lateral branches because of salt stress intensity and its weakness, which could finally result in decreasing number and size of formed pods. The yield of canola depends on density, number of pods per plant, number of seeds per pod and mass of the seeds (Angadi *et al.*, 2003). Diepenbrock (2000) reported that in rapeseed the number of pods on plant is the most important part of its yield component. Furthermore, disruption in metabolism of carbohydrates because of increasing level of salt, resulting from a decrease of sugars concentration in leaves, could decrease the amount of available carbohydrates to send to storage organs. That could lead to increased abortion and, therefore, the number of formed seeds may decrease (Zadeh and Naeini, 2007).

Podleśny (2002) reported that plants grown from laser treated seeds in faba bean were characterised by a higher 1 000 seed mass, which was probably an effect of increased length of the pods, because the number of seeds per pod did not significantly change. Decrease of pods length may be due to salt effects on decreasing water absorption through the decrease of osmotic potential in soil solution and toxic effects of uptake ions, which then cause a decrease in cells division, elongation and cells differentiation or abortion of pollen and eggs, leading to a decrease of pod length while salinity increases. Higher relationship of seed yield with yield components on the one hand and decrease of these components because of salt stress on the other showed that yield decrease is reasonable. It seems that because the plants spent most of their growth period in saline conditions and the level of toxic ions such as $Na^+$ and $Cl^-$ increased in plant tissues such as leaves, so the reason for yield decrease is excessive ion accumulation in the plant tissues (Munns and Tester, 2008). Sana *et al.* (2003) reported that the number of pods per plant is the critical component of seed yield of canola and has an important role in seed yield.

Too long irradiation can cause considerable damage to the seed structures. In our research, in many of traits, laser irradiation lasting for over 45 min led to a decrease of the beneficial effects of laser priming. According to Podleśny and Podleśna (2004), irradiation of sowing materials had a positive influence on the seed yield of two varieties of white lupine and faba bean. The increase in yield was the result of an increased pod number of the individual plants; in the field experiment there was also a decrease in plant losses during the vegetative period; the 1 000 seed mass and the number of seeds per pod did not undergo any significant changes.

There are some reports showing that pretreatment of seeds by laser beams increased the quality and quantity of produced plants. According to Ćwintal *et al*. (2010), presowing stimulation of seeds with laser light caused a significant increase in the content of specific proteins, phosphorus and molybdenum in dry matter of the plants, and a decrease in the content of crude fibre. In our research, laser priming caused a reduction of undesirable effects of salinity and an increase in the yield and yield components of plants under both normal and stress conditions. But all treatments had no favourable effects on plants performance. Below and over a threshold level laser priming may not have a significant affect on plants performance or it may even have destructive effects. There was a higher positive correlation bet- ween height, number of seeds, number of pods on both main branch and lateral branches, length of pod and number of lateral branches in canola (Table 2).

## CONCLUSIONS

1.The experiment with canola seeds irradiation by laser radiation showed that this irradiation can be useful for improving rapeseed yield in salt stress conditions.

2. Results of the correlation coefficient showed that, among the studied attributes, the height of plant and the number of lateral branches had a very positive and significant correlation with the seed yield. Among the yield components, the number of pods on the secondary branch and the number of seeds had the highest relationship with the seed yield. Thus it seems that under the saline conditions the laser treatments caused an increase in the height of plant and in the number of lateral branches, along with the number of pods and seeds per plant, resulting in reduced decrease of yield.

3. It seems that among the laser treatments, seed treatment for 45 min had better effect than the other doses for increasing seed yield both in normal and stress conditions.

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