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SEEDLINGS MORPHOLOGY OF CONFECTIONERY SUNFLOWER AT DIFFERENT pH OF WATER SOLUTION

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SUMMARY

In this study the confectionery sunflower seed was tested to germination at different pH media, from 3.5 to 8.5. The experiment was set up at room temperature (22°C) and at 24 h dark conditions for 10 days. The mean germination rate was 76%. The highest germination rate was 86% at pH 3.5, whereas the lowest was 68% at pH 5.5. The ANOVA resulted with very significant influence of pH on sunflower seedlings root, stem and total length ($p < 0.001$). The total length of seedlings was the shortest at acid media (9.2 cm at 3.5) and the longest at alkaline media (12.5 cm at pH 8.5). Regression equations showed that increment of stem or root length and total length have a positive trendline at all pH levels. It was found that the alkaline water solution has a positive influence on protein sunflower seedlings development, but it would be valuable to found how the seeds would germinate at the field conditions.

Key words: confectionery sunflower, pH, root, stem, seedlings

INTRODUCTION

Sunflower (*Helianthus annuus* L.) seeds contains about 20% of protein and the protein contents of the oil press cakes and meals ranging from 30 to 50% (Žilić et al., 2010). Processing of confectionery sunflower seeds enables the production of protein flour (isolates and concentrates) for human consumption. It is most commonly used as a valuable component in production of special breads, biscuits and other products. In the last decades there have been sunflower hybrids with increased protein content. Next to high energy values of oil and protein, the core of sunflower is very rich in minerals and vitamins. Sunflower is not only an oil and protein plant, but also an important

honey plant. Genetic variability of different cultivars within a sunflower species offers a valuable tool for breeding work (Luan et al., 2014; Ma et al. 2016; Markulj – Kulundžić et al., 2016). Confectionery sunflower due to the increase in protein content is intended primarily for cattle, dairy cows, pigs, sheep and goats, rabbits, poultry and birds. The total content of essential amino acids according to Nenova and Drumeva (2012) was within 31.06% - 32.33%.

The optimal sowing date is around mid-April. Sunflower grain, which doesn't have to be fried and can partially replace soy in livestock nutrition. In mixtures with cereals and corn whole grain or ground can be used.

Zengin and Kirbag (2007) at 7-day old sunflower seedlings found that total protein content in seedlings decreased, by 15%, 27.5% and 37.5% with increasing of Cu concentrations (0.4, 0.5 and 0.6 mM CuCl₂), compared to the control seedlings, respectively.

Environmental factors such as temperature, light, pH, soil moisture are all known to affect seed germination. Önemli (2004) stated that in recent years, insufficient seed germination and seedling emergence in sunflower production areas is a major problem, especially along with poor climatic conditions. Soil acidity has become a major yield-limiting factor in cropping systems (Antunović et al. 2014; Bukvić et al., 2015; Kovačević et al., 2017; Buranji et al. 2019; Iljkić et al. 2019). Acidity problem is common for most agricultural soils due to intensive monocropping. According to Sutradhar et al. (2014), sunflower has been produced traditionally on soils with nearly neutral pH (6.5 to 7.5). Thus, with the integration of sunflower into the rotation system, liming acidic soils may now need to be considered within the farmer's management practices.

The aim of this study was to test the germination rate and seedlings morphology of confectionery sunflower at different level of pH water solutions (3.5 to 8.5).

MATERIAL AND METHODS

The study was set up in the Laboratory of plant analysis at the Faculty of Agrobiotechnical Sciences Osijek, Republic of Croatia. The germination test of different pH media was set up at room temperature (22°C) and at 24 h dark conditions. The germination test was done according to the International Seed Testing Association – ISTA (ISTA, 2006). There were six different pH levels of water solution tested: 3.5, 4.5, 5.5, 6.5, 7.5 and 8.5. The granulated NaCl was used for the tested water solutions of different molarity. There was 55 ml of water solution added on the filter paper (Munktell, 580 x 580 mm, 80 g/qm) before sowing. The seeds were sown on the wet filter paper (within the filter paper) in 4 replications. Filter paper was then rolled, marked and put into clean plastic bag. Every replication consisted of 100 seeds. After 10 days, the total germination rate (%) was determined by counting the seeds which had germinated. Then, 20 seedlings per replication were chosen randomly in order to measure the length of the seedlings root, stem and total seedlings length (cm).

The results were transformed into Microsoft Office Excel programme and the statistical analysis was done using SAS Enterprise Guide 7.1. The grouping means was done by the Fisher LSD method at 95% confidence.

RESULTS AND DISCUSSION

The seedlings germinated differently among the pH levels. Thus, the mean germination rate of seeds was 76% (Figure 1). The germination rate varied from 68% at pH 5.5 up to 86% at pH 3.5.

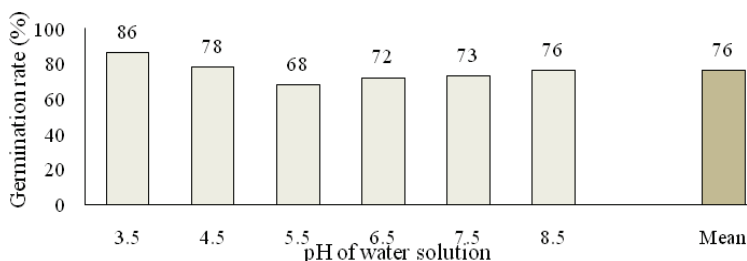


Figure 1 Total germination rate (%) on the 10th day of confectionery sunflower with regard to pH of water solution

Slika 1.: Ukupna klijavost (%) proteinskog suncokreta nakon 10 dana ovisno o pH vrijednosti vodene otopine

The pH of water solution had a very significant influence ($p < 0.001$) on confectionery sunflower seedlings morphological parameters (Table 1).

Table 1 The one-way analysis of variance of confectionery sunflower morphological parameters

Tablica 1.: Jednosmjerna analiza varijance morfoloških pokazatelja klijanaca proteinskog suncokreta

	DF	F – value	P – value
Root length	5	14.14	0.000
Stem length	5	7.86	0.000
Total length	5	14.74	0.000

Even though in acid media seeds had higher germination rate, the developed seedlings were smallest (Table 2). Mean root length was 4.3 cm (Table 2). The seedlings in alkaline media of pH 8.5 had the longest root (5.3 cm) and the shortest root was developed at pH 3.5 (3.4 cm). Stem length had the similar trend. The mean stem length was 6.8 cm, while the seedlings at pH 8.5 (7.2 cm) had the longest stem, and the

seedlings had pH 3.5 (5.8 cm) shortest stem. Thus the total length of seedlings was also the shortest at acid media (9.2 cm) and the longest at alkaline media (12.5 cm).

Table 2 Morphological characteristic of confectionery sunflower seedlings at different pH of water solution

Tablica 2.: Morfološki pokazatelji klijanaca proteinskog suncokreta ovisno o pH vrijednosti vodene otopine

pH	Root length (cm)	Stem length (cm)	Total length (cm)
3.5	3.4 ^c	5.8 ^c	9.2 ^d
4.5	3.8 ^{bc}	6.8 ^{ab}	10.6 ^c
5.5	4.0 ^b	7.1 ^a	11.1 ^{bc}
6.5	4.1 ^b	6.3 ^{bc}	10.4 ^c
7.5	5.0 ^a	6.5 ^b	11.5 ^b
8.5	5.3 ^a	7.2 ^a	12.5 ^a
Mean	4.3	6.8	10.9

Means that do not share a letter within a column are significantly different at $p < 0.05$

From the regression equations it can be seen that increment of stem length and total length (Figure 2) and root length and total length (Figure 3) have a positive trendline at all pH levels. On average at all pH levels, for 1 centimetre elongation of total length, the stem length increased from 0.38 cm (pH 4.5) to 0.62 cm (pH 8.5).

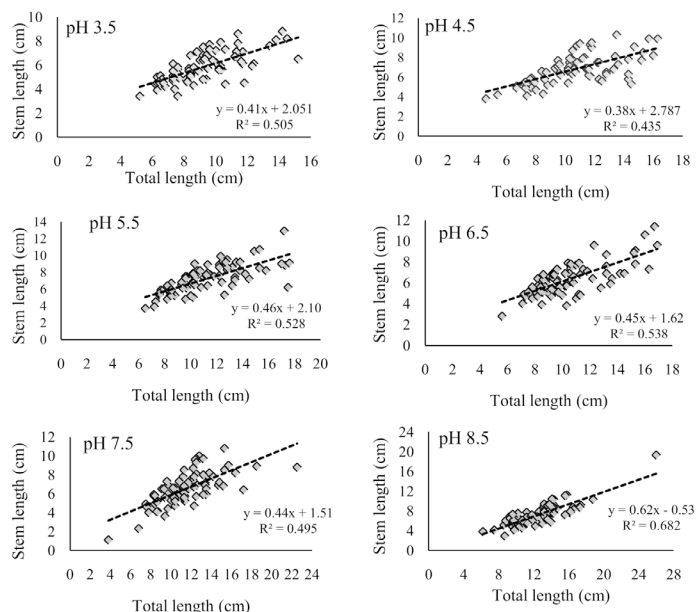


Figure 2 Scatter plot diagrams of confectionery sunflower seedlings stem and total length
Slika 2.: Dijagram rasipanja dužine stablike i ukupne dužine klijanaca proteinskog suncokreta

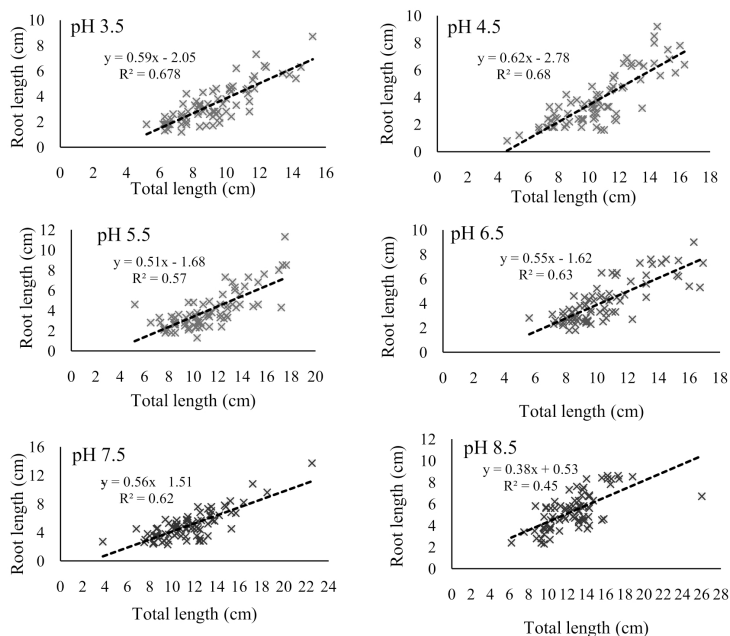


Figure 3 Scatter plot diagrams of confectionery sunflower seedlings root and total length
 Slika 3.: Dijagram rasipanja dužine korijena i ukupne dužine klijanaca proteinskog suncokreta

The protein content in the seeds of confectionery sunflower is between 17 and 21% (P o s p i š i l, 2013). R e u z e a u et al. (1992) try to identify a possible marker for germination capacity and to evaluate seed viability precociously after harvest and after natural ageing during storage of sunflower seed.

K a y a et al. (2006) tested sunflower seeds using different seed treatments (control, KNO_3 and hydropriming) in salt (NaCl) and drought conditions (PEG 6000) and a significant three-way interaction (seed treatment, solution and stress) was found ($P < 0.05$, 60 d.f.) for all investigated characteristic. The authors found that the mean germination rate was decreased with increasing NaCl level and PEG concentrations, but the lowest germination rate with hydropriming and PEG (25.3%), while the highest was with KNO_3 pre-treatment and is 100% at all salinity levels. Shoot length after 7 days was from 0.9 cm (hydropriming and PEG) up to 12.2 cm (only pre-treatment hydropriming).

Yerima et al. (2015) reported about the importance of substrate on germination of sunflower seeds. Authors found that seeds sown in sawdust substrate had the lowest germination rate (25%), while in sawdust-soil substrate the maximum germination rate was 75%, 9 days after sowing.

Önemli (2004) found the highest sunflower seedling emergence percentage (93.42%) in glasshouse experiments in which the optimum condition was provided for seed germination and seedling emergence. Autor found that in field conditions the

seedling emergence percentage in 2001 (69.87%) was lower than that in 2000 (76.13%), as total rainfall in 2001 was less than in 2000.

In a experiment, Sutradhar et al. (2014) tested sunflower germination at soil pH values ranging from 4.0 to 7.0. The authors found that the number of sunflower heads per plot at harvest was reduced in low pH treatments when compared to the plants number at emergence, which suggested that soil acidity had a strong negative impact on sunflower vegetative growth and yield.

CONCLUSION

In this study the different level of pH in confectionery sunflower seed was tested to germination and morphological characteristics of the seedlings. It was found that at low pH (3.5, 4.5) the seedlings were less developed than those in neutral and alkaline media. In the confectionery sunflower, the pH value also changed the germination rate, but it would be interesting to find out how the seeds would emerge in the field conditions at different levels of soil pH.

MORFOLOŠKE ZNAČAJKE KLIJANACA PROTEINSKOG SUNCOKRETA PRI RAZLIČITIM pH VRIJEDNOSTIMA VODENE OTOPINE

SAŽETAK

Cilj ovog istraživanja bio je utvrditi klijavost proteinskog tipa suncokreta na različitim pH vrijednostima (3,5 - 8,5). Eksperiment je postavljen na sobnoj temperaturi (22°C) i to u mraku 24 h kroz 10 dana. Ukupna klijavost proteinskog suncokreta bila je 76%. Najviša klijavost iznosila je 86% pri pH 3,5, dok je najniža bila 68% pri pH 5,5. ANOVA je rezultirala vrlo značajnim utjecajem pH na korijen, stabljiku i ukupnu duljinu klijanaca proteinskog tipa suncokreta ($p < 0,001$). Ukupna duljina klijanaca bila je najkraća u jako kiseloj sredini (9,2 cm kod pH 3,5), a najduža u alkalnoj sredini (12,5 cm kod pH 8,5). Jednadžba regresije pokazala je da priraštaj duljine stabljike ili korijena i ukupna duljina imaju pozitivan trend na svim pH razinama. Utvrđeno je da na razvoj klijanaca proteinskog suncokreta pozitivan utjecaj ima alkalna otopina.

Ključne riječi: proteinski suncokret, NaCl, temperatura, klijavost, klijanci

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