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INFLUENCE OF SUGAR BEET SEED PRIMING METHOD ON GERMINATION UNDER WATER SHORTAGE CONDITIONS AND ROOT SYSTEM DEVELOPMENT

Summary

Sugar beet seeds var. Melodia were primed on germination using three different methods: 24 h in water, 21+3 h in water (seeds were dried between 2 cycles) and 24 h in solution of UG MAX – commercially used bacterial treatment. Control combination were non-treated sugar beet seeds. Germination ability, speed and uniformity were examined in different water content in germination medium: 15%, 25% and 65% respectively. The highest differences were observed in 25% moisture of blotting paper. All methods of seed treatment improved germination speed and ability, especially measured after 4 days of germination. After 14 days differences were not significant. Method of priming in water for 24 hours appeared to be most effective in improving germination course under conditions of water shortage. Root systems of seedlings obtained from primed seeds were analyzed with special scanner EPSON Scan LA 2400 and computer programs WinRHIZO and XLRhizo. Results showed that seedlings obtained from seeds primed for 24 h in water produced the most advanced root system. Their seedlings formed thicker roots then others. Volume of their root system was also bigger. There was no influence of this method of priming on a total root length.
***Key words**: sugar beet, seed priming, drought, water shortage, root system*

WPŁYW METODY POBUDZANIA NASION BURAKA CUKROWEGO NA KIEŁKOWANIE W WARUNKACH NIEDOBORU WODY I ROZWÓJ SYSTEMU KORZENIOWEGO

Streszczenie

Nasiona buraka cukrowego odmiany Melodia zostały pobudzone do kiełkowania trzema różnymi metodami: 24 h w wodzie, 21 +3 h w wodzie (nasiona zostały wysuszone pomiędzy cyklami pobudzania) oraz 24 h w roztworze preparatu bakteryjnego UG MAX. Kombinację kontrolną stanowiły surowe, niepobudzane nasiona. Zdolność, szybkość i równomierność kiełkowania zostały ocenione w różnych warunkach wilgotności podłoża – 15, 25 i 65% zawartości wody. Największe różnice między kombinacjami zaobserwowano w warunkach wilgotności bibuły 25% pełnej pojemności wodnej. Wszystkie zastosowane metody poprawiły zdolność i szybkość kiełkowania po 4 dniach. Po 14 dniach kiełkowania różnice były nieistotne. Metoda pobudzania nasion w wodzie przez 24 h była najbardziej efektywna w warunkach niedoboru wody. System korzeniowy siewek uzyskanych z nasion pobudzanych 3 metodami oraz nasion kontrolnych i analizowany był przy użyciu skanera EPSON Scan LA 2400 i programów komputerowych WinRHIZO i XLRhizo. Wyniki wskazują, że siewki z nasion pobudzanych przez 24 h w wodzie wytworzyły grubsze korzenie o większej sumarycznej objętości niż pozostałe kombinacje. Metoda pobudzania nasion nie wpłynęła na długość korzeni.
***Słowa kluczowe**: burak cukrowy, pobudzanie nasion, susza, niedobór wody, system korzeniowy*

1. Introduction

Drought affects the most physiological processes, and decreases the plant productivity. Estimates of potential sugar beet yield losses in Europe, due to insufficient water resources, are between 5 to 30% [6]. The solution can lie in breeding of varieties that are tolerant to water stress, based upon morphological, physiological, biochemical and molecular criteria. Appropriate criteria may be identified by detailed study of the water stress on this crop and its drought tolerance [1].

The other solution can lie in pre-sowing seed treatment, which accelerates the early stages of germination and makes young plants more resistant to abiotic stresses. Seed priming can be one of such treatments [7].

During priming treatment there is solute accumulation in embryo and during dehydration the level of solutes in the embryo is maintained so during the reimbibiton, potential gradient causes faster germination. A lot of factors affect the results of priming, among them: temperature, duration, light, aeration, dehydratation, storage [2].

2. Material and methods

Sugar beet seeds var. Melodia from Kutnowska Hodowla Buraka Cukrowego were prepared in 3 different ways: 1) primed in germination boxes in water for 24 h, then air dried, 2) primed for 21 h in water, then dried and primed again for 3 h, then dried again, 3) primed for 24 h in UG Max solution (P.P.H.U. BOGDAN – bio product containing micro and macroelements combined with bacteria), then air dried. Raw, not primed seeds were a control combination.

Four seed lots (in 3 replication each) were examined in germination ability test in different water content in germination medium: 15%, 25% and 65% in temperature 21ºC. For 14 days the number of germinated seeds were counted and seedlings were removed from germination boxes. Germination ability after 4 and 14 days, mean time of germination after 4 and 14 days (Pieper's coefficient) and uniformity of germination were calculated.

Pieper's coefficient was counted using a formula:

$$Pieper's\ coefficient = \frac{\Sigma(d_n\ x\ a_n)}{\Sigma a_n},$$

where:
d_n– number of the day of germination (emergence),
a_n – number of seeds germinated/seedlings emerged on this day [9].

Pieper's coefficient expresses the average number of days from sowing to the moment of germination. Low value is connected with fast germination and high seed vigor. The longer the time from sowing to germination, the higher is its value [6].

Results were subject to statistical univariate and two-factor variance analysis with ANOVA program.

In the second part of the experiment sugar beet seeds prepared in the same way were placed in the paper rolls (roll test) in water, for 10 days to obtain seedlings. Air temperature was 21ºC. There were 15 seeds used per one roll, 3 replication for each combination.

After 10 days of germination, seedlings were removed carefully from the rolls and then scanned with EPSON Scan LA2400, special equipment used for root system projection. The results from the scanner were then analyzed using special computer program WinRHIZO.

3. Results

After 4 days of germination in 15% water content germination ability was very low (average 3%) (tab. 1). Only seeds primed in water for 24 h germinated in more than 8%. Seeds primed for 21+3 h didn't germinate. In 25% water content in germination medium only primed seeds reached germination ability higher than 40%. Germination ability of control seeds was only 29%. In optimum water conditions, germination of all seed combinations was above 92% and didn't differ statistically.

After 14 days of germination the results of germination ability in 15% of water didn't change (tab. 2). In 25% water content germination ability of all seed combinations was similar, (mean value 45.8%), only control seeds were germinating a little worse (42%). In 65% of water there were no significant differences.

On average, significant differences were observed only after 4 days of germination (fig. 1). Priming in water for 24h was the only method which improved germination ability of seeds.

Mean time of germination (germination speed) after 4 days depended on the water content in germination medium and the method of seed treatment (tab. 3). All used methods shortened time of seed germination. Only in 15% of water in germination medium all seeds germinated on 4th day.

Similar results were observed after 14 days of germination (tab. 4). All used methods improved speed of germination. This influence wasn't observed in 15% water content where all seeds germinated on 4th day.

Uniformity of germination depended on the water content in germination medium and the method of seed treatment (tab. 5). In general treated seeds germinated more evenly than control ones. The differences were the highest in optimum water content (65%).

Regardless the water conditions, all used methods of seed treatment improved germination speed and uniformity comparing to raw, control seeds. Priming in water for 24 h was the most effective method.

Table 1. Germination ability (%) after 4 days of germination, depending on a method of seed treatment and water content in germination medium
Tab. 1. Zdolność kiełkowania (%) po 4 dniach kiełkowania w zależności od metody pobudzania nasion i zawartości wody w podłożu

	Method of seed treatment					
Moisture [%]	Control	Water 24 h	Water 21+3 h	UG MAX	Mean value	LSD α=0.05
15	2.0	8.7	0.0	1.3	3.0	4.24
25	29.0	46.7	40.7	44.0	40.1	
65	93.3	95.7	95.7	92.7	94.3	
mean value	41.4	50.3	45.4	46.0		
LSD α=0.05	5.38					

LSD A/B = 9.32, LSD B/A = 8.47

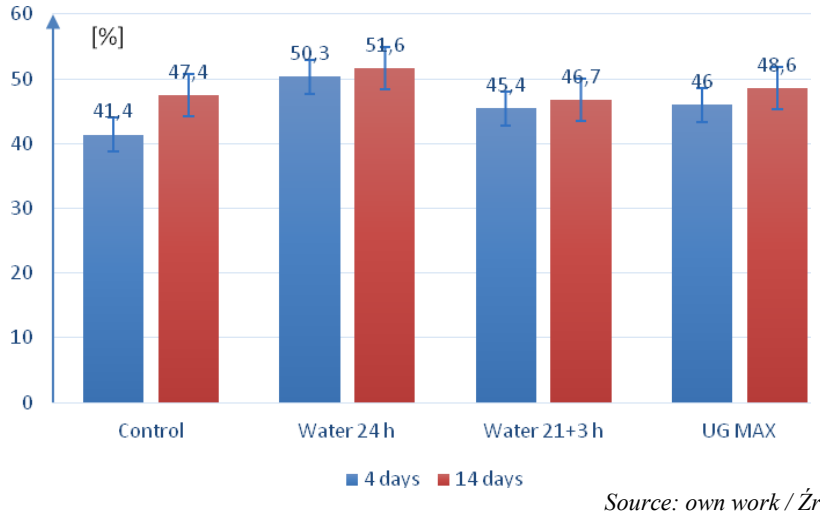
Source: own work / Źródło: opracowanie własne

Table 2. Germination ability (%) after 14 days of germination, depending on a method of seed treatment and water content in germination medium
Tab. 2. Zdolność kiełkowania (%) po 14 dniach kiełkowania w zależności od metody pobudzania nasion i zawartości wody w podłożu

	Method of seed treatment					
Moisture [%]	Control	Water 24 h	Water 21+3 h	UG MAX	Mean value	LSD α=0.05
15	2.0	8.7	0.0	1.3	3.0	5.13
25	42.0	49.3	42.7	49.0	45.8	
65	98.3	96.7	97.3	95.3	96.9	
mean value	47.4	51.6	46.7	48.6		
LSD α=0.05	6.51					

LSD A/B = 11.28, LSD B/A = 10.25

Source: own work / Źródło: opracowanie własne



Source: own work / Źródło: opracowanie własne

Fig. 1. Germination ability (%) of sugar beet seeds after 4 and 14 days of germination depending on a method of seed treatment
Rys. 1. Zdolność kiełkowania (%) nasion buraka cukrowego po 4 i 14 dniach kiełkowania w zależności od metody pobudzania nasion

Table 3. Germination speed (Pieper's Coefficient – days) after 4 days of germination depending on a method of seed treatment and water content in germination medium
Tab. 3. Szybkość kiełkowanie (współczynnik Piepera) po 4 dniach kiełkowania w zależności od metody pobudzania nasion i zawartości wody w podłożu

	Method of seed treatment					
Moisture [%]	control	Water 24 h	Water 21+3 h	UG MAX	mean value	LSD α=0.05
15	4.00	4.00	-	4.00	4.00	0.04
25	3.81	3.09	3.32	3.29	3.29	
65	3.24	2.38	2.46	2.72	2.72	
mean value	3.68	3.16	3.26	3.34		
LSD α=0.05	0.05					

LSD A/B = 0.09, LSD B/A = 0.08

Source: own work / Źródło: opracowanie własne

Table 4. Germination speed (Pieper's Coefficient – days) after 14 days of germination depending on a method of seed treatment and water content in germination medium
Tab. 4. Szybkość kiełkowania (współczynnik Piepera) po 14 dniach kiełkowania w zależności od metody pobudzania nasion i zawartości wody w podłożu

	Method of seed treatment					
Moisture [%]	control	Water 24 h	Water 21+3 h	UG MAX	mean value	LSD α=0.05
15	4.00	4.00	-	4.00	4.00	0.08
25	4.34	3.22	3.42	3.48	3.48	
65	3.35	2.42	2.55	2.80	2.80	
mean value	3.90	3.21	3.32	3.43		
LSD α=0.05	0.10					

LSD A/B = 0.17, LSD B/A = 0.15

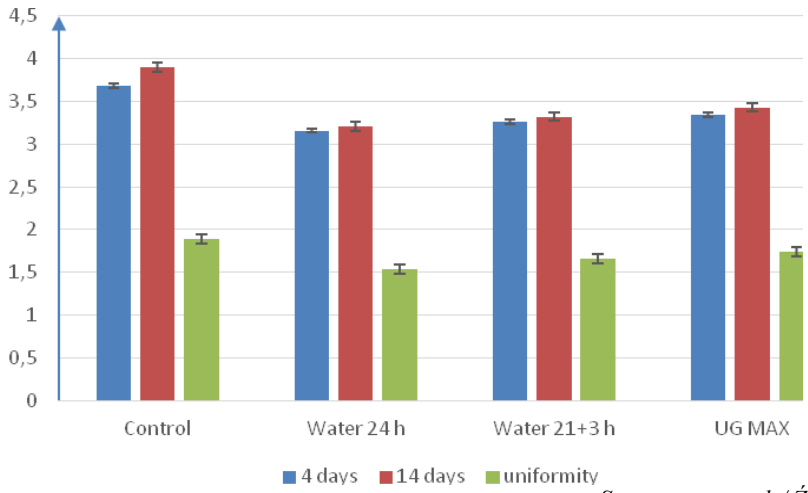
Source: own work / Źródło: opracowanie własne

Table 5. Germination uniformity (Pieper's Coefficient – days) after 14 days of germination depending on a method of seed treatment and water content in germination medium
Tab. 5. Równomierność kiełkowania (współczynnik Piepera) po 14 dniach kiełkowania w zależności od metody pobudzania nasion i zawartości wody w podłożu

	Method of seed treatment					
Moisture [%]	control	Water 24 h	Water 21+3 h	UG MAX	mean value	LSD α=0.05
15	1.0	1.0	-	1.0	1.0	0.09
25	2.3	2.2	2.4	2.4	2.35	
65	2.3	1.4	1.5	1.8	1.77	
mean value	1.89	1.54	1.66	1.74		
LSD α=0.05	0.11					

LSD A/B = 0.19, LSD B/A = 0.17

Source: own work / Źródło: opracowanie własne



Source: own work / Źródło: opracowanie własne

Fig. 2. Germination speed (Pieper's Coefficient – days) after 4 and 14 days and germination uniformity of sugar beet seeds depending on a method of seed treatment
Rys. 2. Szybkość kiełkowania (współczynnik Piepera) po 4 i 14 dniach kiełkowania oraz równomierność kiełkowania w zależności od metody pobudzania nasion

Results of root image analysis is shown in figures 3-6. Results were not significant statically due to high variation, except for root volume. Results show that priming in water for 24 hours resulted in higher root volume and diameter, although it didn't increase root length. Seedlings from seeds primed for 21+3 h produced the longest roots.

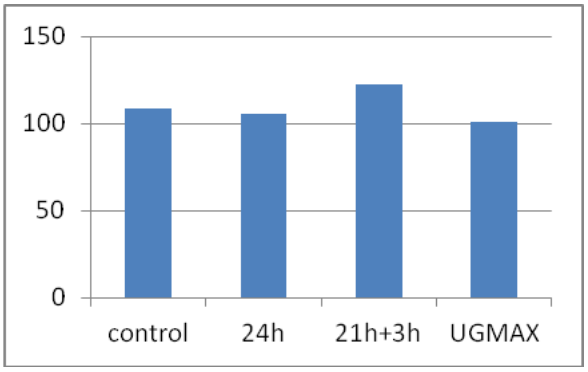


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Fig. 3. Total root length (cm), LSD=341.5, α=0.01
Rys. 3. Sumaryczna długość korzeni (cm), LSD=341,5, α=0,01

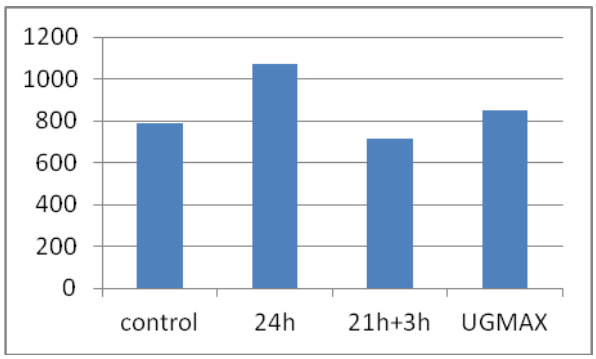

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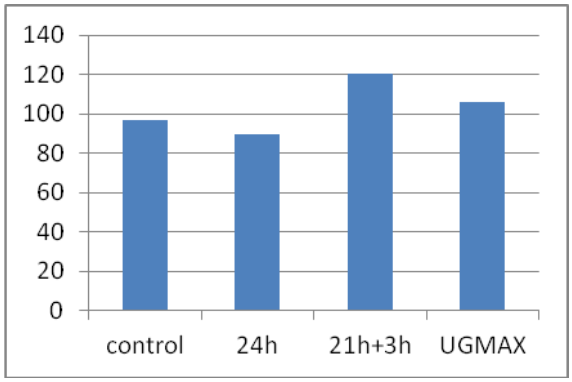
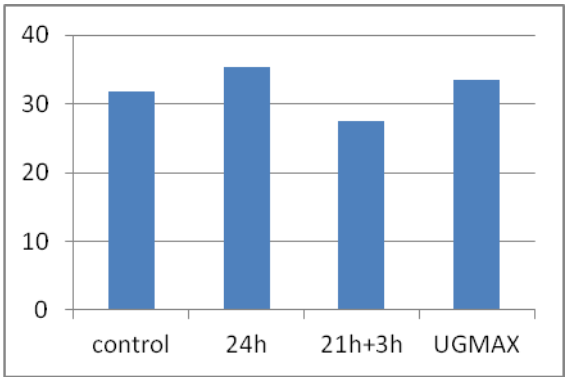
Fig. 4. Total root volume (cm^3), LSD=341.5, α=0.01
Rys. 4. Sumaryczna objętość korzeni (cm^3), LSD=341,5, α=0,01



Source: own work / Źródło: opracowanie własne

Fig. 5. Length/volume (cm/m^3)
Rys. 5. Długość/objętość korzeni (cm/m^3)



Source: own work / Źródło: opracowanie własne

Fig. 6. Average diameter (mm)
Rys. 6. Przeciętna średnica (mm)

4. Discussion

Seed priming is known as a method increasing tolerance to drought stress. However obtained results indicate that the efficiency of priming methods is different. Generally all used methods of seed treatment increased germination speed and spread and germination ability after short time (4 days). Early stages of sugar beet germination and field

emergence have strong effect on further development of a plant, susceptibility to plant diseases, growth rate and yielding [5]. Time of single plant emergence has a great influence on final root weight during the harvest. Plants emerging first produce the heaviest roots [4].

After 14 days differences in germination ability were not significant (average for 3 water contents in germination medium), only in 15 and 25% of water seeds primed for 24 h in water germinated significantly better than control ones. Other surveys also proved that primed sugar beet seeds germinate better in water shortage comparing to not primed ones [7]. Priming has favorable effect on course of germination. This effect is visible in different moisture conditions, especially shortage and excess of water in germination medium. [3]. In 15% of water seeds primed for 21, dried and then primed again for 3 h gave no seedlings at all. In the same conditions 2% of control seeds germinated and 9% of primed for 24 h ones.

Surprisingly seeds primed for 24 h in water didn't produce the longest roots, (unlike other primed seed combinations), but total root volume and diameter were higher than in case of other combinations. Otherwise, root length is correlated to drought tolerance and is used for sugar beet lines selection [8].

Adding UG MAX solution to the priming boxes decreased slightly priming effect comparing to pure water, but this method of seed treatment should be examined in the field because of other possible beneficial influence.

5. Conclusions

– All used methods of seed treatment increased germination speed and spread and germination ability after short time (4 days).

– Priming for 21+3 h made seeds susceptible to severe drought.

– Seed priming for 24 h in water improved significantly germination in conditions of water shortage.

– Priming for 24 h increased volume and diameter of roots, although didn't affect root length.

6. References

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