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EFFECT OF THE APPLICATION METHODS OF NATURAL PLANT EXTRACTS ON EMERGENCE OF BEETS

Summary

The experiment presented in this article consisted in determination of the impact of the method of application of green plant extracts on germination of fodder beet (Beta vulgaris L.*) 'Rekord' variety, sugar beet (Beta vulgaris L.) 'Szach' variety, and red beet (Beta vulgaris L. var. conditiva Alef.) 'Czerwona Kula' variety seeds in soil. Earlier in vivo laboratory tests allowed for identification of plant extracts with the strongest germination stimulating effect and contamination reduction on seeds selected for the experiment. This included the infusions of Juniperus communis fruits in the case of fodder beet, Hyssopus officinalis herb in the case of sugar beet, and Artemisia absinthium herb in the case of red beet. In the paper mean time, uniformity and rate of germination were determined for all plants in two combinations. The first combination consisted of seeds pre-treated with the aforementioned plant extracts and sown into non-treated soil while the second combination consisted of non-treated seeds sown into the soil that had been locally pre-treated with plant extracts. The control group consisted of non-treated seeds sown into non-treated soil. As demonstrated, in-soil germination capacity of root crop seeds was better when the plant extracts were applied into the soil rather than onto the seeds themselves. The largest differences in the dynamics of germination depending on the method of herb brews application were observed in the case of red beet seeds.*
***Key words**: beets, aqueous extracts, application method, crop emergence*

OCENA WPŁYWU METOD APLIKACJI NATURALNYCH WYCIĄGÓW ROŚLINNYCH NA WSCHODY BURAKÓW

Streszczenie

Przedstawione w publikacji doświadczenie polegało na określeniu wpływu, jaki ma sposób aplikacji zapraw przygotowanych z roślin zielonych na wschody buraka pastewnego (Beta vulgarisL.) odmiany 'Rekord', buraka cukrowego (Beta vulgaris L.*) odmiany 'Szach', buraka ćwikłowego (Beta vulgaris L. var. Conditiva Alef.) odmiany 'Czerwona Kula' w glebie. We wcześniejszych badaniach laboratoryjnych in vivo wyłoniono wyciągi z roślin, które najsilniej stymulowały kiełkowanie wybranych do badania nasion oraz ograniczały ich zasiedlenie przez drobnoustroje. W przypadku buraka pastewnego był to napar z owoców Juniperus communis, buraka cukrowego napar z ziela Hyssopus officinalis, a buraka ćwikłowego napar z ziela Artemisia absinthium. W doświadczeniu przedstawionym w artykule określono średni czas, równomierność oraz szybkość wschodów roślin w glebie w dwóch kombinacjach. Pierwszą stanowiły nasiona zaprawiane w/w wyciągami i wysiane do gleby, natomiast drugą nasiona niezaprawione wysiane do gleby, w której uprzednio punktowo zaaplikowano wyciągi wodne. Próbą kontrolną były nasiona niezaprawiane wysiane do gleba bez zapraw. Wykazano, że w warunkach glebowych na zdolność kiełkowania nasion buraków zdecydowanie lepiej działało aplikowanie wyciągów do gleby, a nie na nasiona. Największe różnice w dynamice wschodów w zależności od metody aplikacji naparów roślinnych odnotowano dla buraka ćwikłowego.*
***Słowa kluczowe**: buraki, wodne wyciągi, sposób aplikacji, wschody roślin*

1. Introduction

The increasing acreage of ecological cultivation farms results in reduction of the excessive use of chemicals and triggers interest in biological methods for the protection of harvest and the quality of seeds [5].

Due to the presence of pathogens in both the seeds and the soil, pre-sowing treatment of seeds becomes a necessity as non-treated seeds germinate poorly and the infected seedlings are subject to impaired development or wither away. This results in a reduced number of plants in the vegetation period, low crop stand during the harvest and low harvest yields of reduced-quality crops. It should also be mentioned that ecological agriculture precludes the use of chemical coatings that are of widespread use in conventional agriculture and thus the search is ongoing for alternative, non-chemical methods for pre-sowing treatment of seeds based on natural antifungal, antibacterial or antiviral substances contained in herbs or essential oils [9, 11, 12].

The objective of the presented experiments was to determine the efficacy and the method of application of green plant extracts for the pre-treatment of seeds. Therefore, the impact of pre-sowing measures on the rate and uniformity of in-soil germination of fodder beet, sugar beet, and red beet was examined.

2. Materials and methods

Earlier *in vivo* laboratory tests allowed for identification of plant extracts with the strongest germination stimulating effect on seeds selected for the experiment.

Non-treated seeds (as obtained from the Seed Center and, in the case, of sugar beet, from a beet farm in Kutno) were used in the experiment. The study were carried out in 2015.

Brew (hot method) prepared as follows – 5 g of dried plant poured of 250 ml of boiling water and left covered for 30 minutes, after cooling the extract was filtered [3].

Germination capacity and health of the seeds were assessed in line with the International Seed Testing Association (ISTA) guidelines: Chapter 5, Chapter 7 [7]. The controls consisted of non-treated seeds. Variables of importance at both deadlines included the numbers of normally germinating seeds, abnormally germinating seeds, non-germinating seeds, and contaminated seeds with bacteria and fungi [7].

Following varieties were used: fodder beet (*Beta vulgaris* L.) of 'Rekord' variety, sugar beet (*Beta vulgaris* L.) of 'Szach' variety, and red beet (*Beta vulgaris* L. var. *conditiva*Alef.) of 'Czerwona kula' variety.

The study involved the use of plant extracts identified as having the highest seed germination stimulating in the assessment of viability and health of root crop seeds. These included:

- Common juniper (*Juniperus communis*) fruit infusion – fodder beet seeds
- Hyssop (*Hyssopus officinalis*) herb infusion – sugar beet seeds
- Absinthe wormwood (*Artemisia absinthium*) herb infusion – red beet seeds.

Assessment of direct-soil germination following the treatment with aqueous extracts

The tests were carried out using a light soil with moisture content of 85%, pH of 6.0, phosphorus content of 0,00263 g/100g of soil, potassium content of 0,0013 g/100g of soil and magnesium content of 0,0096 g/100g of soil free of chemical fertilizers or herbicides.

The test was carried out in laboratory conditions. Experiments were carried out in 40 plastic Seed bed containers 50 mm in diameter and 50 mm in depth. Forty seeds of selected crops were planted into each soil-filled container at the depth of 1.5 cm (the seeds sown immediately after application brew into soils). Containers with seeds were placed in a chamber containing 400 ml of water that was uniformly soaked up into each flower pot to achieve uniform soil moisture of 80% in each flower pot. The ambient temperature of 18°C was maintained throughout the experiment.

Two combinations were used to compare the efficacy of water infusions on the seedlings as follows:

- the sowing material was prepared by soaking the plants for 24 hours in aqueous extracts; subsequently, the seeds were dried in air and sown into the soil;
- soil application of plant extract before sowing seeds.

The experiment was conducted in quadruplicate for each combination, with non-treated seeds sown into the non-treated soil used as the control group. The germinating plants were counted each day.

The assessment of mean time, uniformity and rate of *in-soil* germination of beet seed crops after pre-treatment with aqueous extracts of various plants.

Between post-sowing Day 1 and Day 15, the seedlings were systematically counted with identification of newly emerging seedlings performed so as to determine the mean germination capacity and the course of plant germination. The temporal profile of germination was used for calculation of the mean time for germination of a single plant and expressed by Pieper's (1) index (the day of appearance of the first seedlings taken as Day 1) and the Maguire's rate of germination (2) [2]. Formulas 1-2 were adapted and adjusted to the investigations of the rate emergence of plants.

$$\text{Rate of Pieper's} = \Sigma(dn \cdot an)/\Sigma an \quad (1)$$

dn –means the day of the east plant
an – the number of seeds germinated at given intervals of time
n_i – the number of seeds germinated at given intervals of time

$$\text{Rate of Maguire's} = \Sigma(ni/ti) \quad (2)$$

n_i – the number of seeds germinated at given intervals of time
t_i – time seed germination

Statistical analyses: the results were processed statistically by the analysis of variance with single class (P = 95%). If significant differences were detected, the lowest significant difference $LSD_{0.05}$ was calculated (0.05=Tukey's confidence interval value).

3. Results and discussions

The plant extracts identified as having the highest seed germination stimulating in the assessment of viability and health of root crop seeds while reducing the infection by fungal pathogens [3] are listed in Table 1.

The results of flower-pot experiments (Table 2) markedly differed from the results of laboratory tests involving the use of germination dishes (Table 1). Despite high germination capacity being observed, no significant differences were observed compared to the control experiment. Similar conclusions were arrived at by Horoszkiewicz-Janka and Jajor [6] who assessed the effects of seed treatment on the health of barley, wheat, and rape plants at the early stages of the development. The authors also observed high germination capacities and energies in laboratory tests that were subsequently reduced in flower-pot experiments.

The relationship between germination capacity and the seed and/or soil treatment method is presented in Table 2. All tested seeds were characterized by high germination capacity values. In the case of sugar beet, 100% germination capacity was observed in all tested combinations. In the case of red beet, the lowest germination capacities were observed for seeds (88%) and application to soil (96%) with absinthe wormwood herb extract.

Table 1. Plant extracts that have extremely stimulated germination of beet seeds in vivo (% relative to control)
Tab. 1. Wyciągi roślinne, które w najwyższym stopniu stymulowały kiełkowanie nasion buraków w badaniach in vivo (% w stosunku do kontroli)

Tested seed	Plant species	Form extract	E1 %	Z1 %	Z5 %
Fodder beet	Fruits *Juniperus communis*	brew	+35.21	+46.38	-61.54
Sugar beet	Herb *Hyssopus officinalis*	brew	+32.07	+23.49	-76.19
Beetroot	Herb *Artemisia absinthium*	brew	+28.08	+15.27	-40.00

E1 – *germination energy*, Z1 – *capacity of germination*, Z5 – *microbial contamination*

Source: own work / Źródło: opracowanie własne

Table 2. The ability, uniformity and speed of emergence of root crops, depending on the method of sowing seeds into the soil
Tab. 2. Zdolność, równomierność i szybkość wschodów roślin okopowych w zależności od sposobu siewu nasion do gleby

	Fodder beet			Sugar beet			Beetroot		
	seed	soil	control	seed	soil	control	seed	soil	control
The ability of emergence %	98	100	100	100	100	100	88	96	100
$LSD_{0.05}$ - $NIR_{0.05}$	Statistically insignificant			Statistically insignificant			5.81		
The ability of emergence% relative to control	seed	soil		seed	soil		seed	soil	
	-2%	0%		0%	0%		-12.00%	-4.00%	
Rate of Pieper's [days]	5.49	5.57	5.37	5.55	5.22	5.08	5.76	5.33	5.81
$LSD_{0.05}$ - $NIR_{0.05}$	0.47			0.45			0.57		
Rate of Pieper's uniformity of emergence [days]	2.49	2.51	1.37	1.55	2.22	2.08	2.76	2.33	1.81
$NIR_{0.05} - LSD_{0.05}$	0.34			0.89			0.65		
Rate of Maguiere's	22.71	23.11	23.22	22.76	24.35	25.23	19.48	31.75	27.90
$LSD_{0.05}$ - $NIR_{0.05}$	3.06			2.57			9.47		

Source: own work / Źródło: opracowanie własne

Both the discussed method of herb brew application led to a 4-12% reduction in germination capacity as compared to control experiments. Similar results were obtained by Orzeszko-Rywka, Rochalska and Chamczyńska [8] who analyzed the applicability of plant oils for the treatment of seeds of selected crops. The authors concluded that pre-treatment of seeds using most oils markedly reduced the germination capacities and increased germination times of all seeds.

Based on the germination vs. time pattern, the mean germination time of an individual plant, expressed by the Pieper's index, was determined [2]. The low value of the Pieper's index suggests high vigor and rapid germination of seeds. The longer the duration of germination, the higher the Pieper's index values [2] In our study, we demonstrated significant differences in germination rates and uniformities for beet seeds subjected to different methods of germination environment modification. In the case of fodder beet, the values of the Pieper's index were as follows: 5.49 days for seeds and 5.57 for the soil pre-treated with common juniper fruit infusion. The lowest value was observed in the control experiments. The tests conducted using the seeds of sugar beet and red beet revealed lower mean germination times following pre-sowing treatment of soil with the infusions from hyssop and absinthe wormwood herbs, respectively. Similar observations were made by Rochalska et al. [10] who studied the potential for stimulation of germination of red beet seeds of chamomile and salvia infusions. After 14 days of the experiment, best germination rates as expressed by the Pieper's index were obtained for the seeds pre-treated with water or 30% salvia infusion.

Germination uniformity was also different depending on the germination environment modification method. In the case of fodder beet, pre-treatment of soil and seeds led to similar Pieper's index values (numbers of days to germination). Low values were also observed for sugar beet seeds pre-treated with plant extracts. The best uniformity of germination of the red beet seeds was obtained in control experiments including non-treated seeds.

In addition, Maguire's germination rates were also determined in our study. High Maguire's rates reflect rapid germination of the tested seeds. In addition, due to the high sensitivity of Maguire's rate, it is considered a useful factor in the analysis of germination speeds [2]. The study revealed significant differences in germination speeds of the tested plants. The highest values were observed for sugar beet, fodder beet, and red beet alike in the experiments involving aplication to soils as well as in the control experiments. This is confirmed by the results obtained by Gleń-Karolczyk and Boligłowa [4] who assessed the efficacy of plant extract in the protection of plants against fungal diseases. The authors came to the conclusion that the method of application of plant extracts was important for germinating seeds. Direct soil application of the tested aqueous plant extracts was shown to be more beneficial.

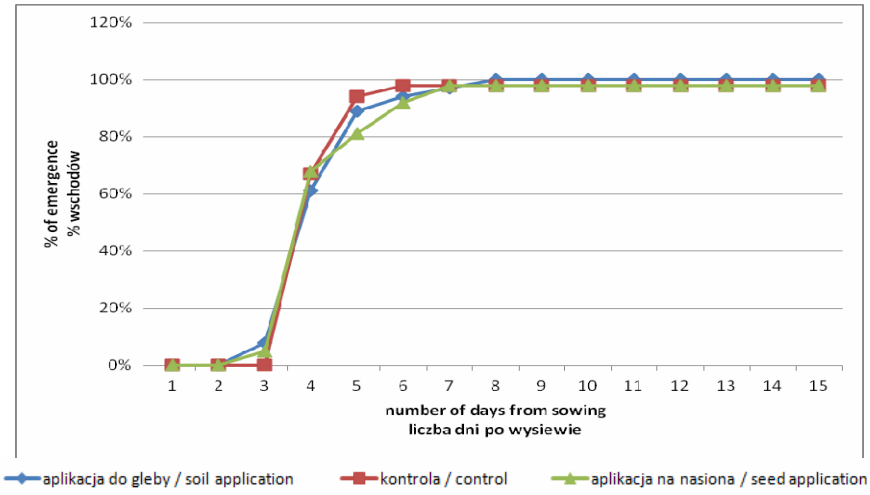
High differences were observed in the results of the studies of the dynamics of germination of fodder beet, sugar beet, and red beet seeds (Table 2). First germination of fodder beet seeds was observed 3 days after sowing. However, in the case of direct soil application of plant extracts, mean germination rates were higher by 3% as compared to the pre-sowing treatment of seeds. In the control experiments, the first seedlings were observed one day after the remaining two cases. As shown in the figure, pre-treatment of soil before the sowing of fodder beet seeds led to the overall germination capacity of more than 98%.

The experiments showed (Table 2) that pre-sowing treatment of fodder beet seeds led to a 2% decrease in germination capacity as compared to the controls. Similar germination capacities were observed in the experiments involving pre-treatment of seeds and the control experiments (Fig. 1).

In the case of red beet, the mean number of seedlings was 100%. High physiological activity of seeds was observed regardless of whether or not their growth environment was subjected to any modification. The only differences were observed in first germinations that occurred after 3 days in the case of control seeds and seeds sown into pre-treated soil. Germination capacity of 100% was achieved as early as after 7 days (Fig. 2).

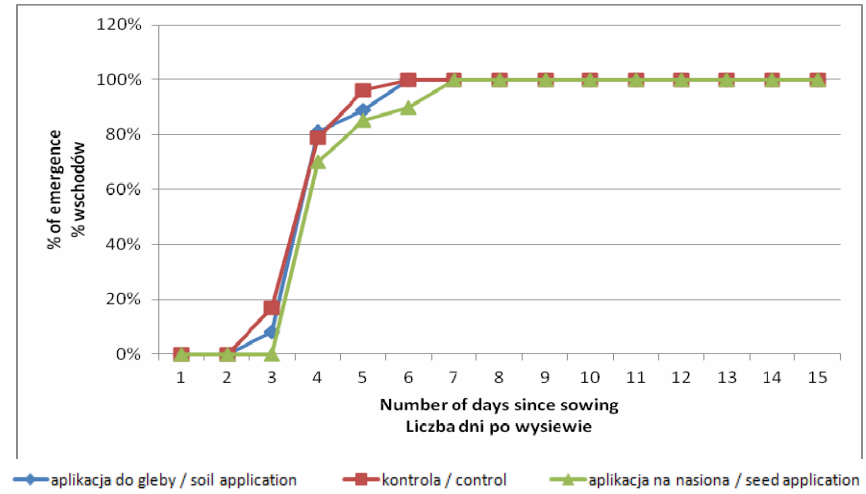
The studies on germination of sugar beet led to the conclusion that pre-treatment of either the seeds or the soil had no significant effect on the germination capacity of seeds.

The largest differences in the dynamics of germination were observed for red beet seeds (Fig. 3). The highest physiological activity was observed in the case of control seeds which was difficult to elucidate as the seeds were pre-treated with distilled water only. In addition, the soaking time was too short to allow possible initiation and development of metabolic processes. Similar observations were made by Borowski and Michałek [1] who studied the effects of seed conditioning on germination and growth of seedlings of celery and parsley. The authors also observed unexplained high activity of control seeds.



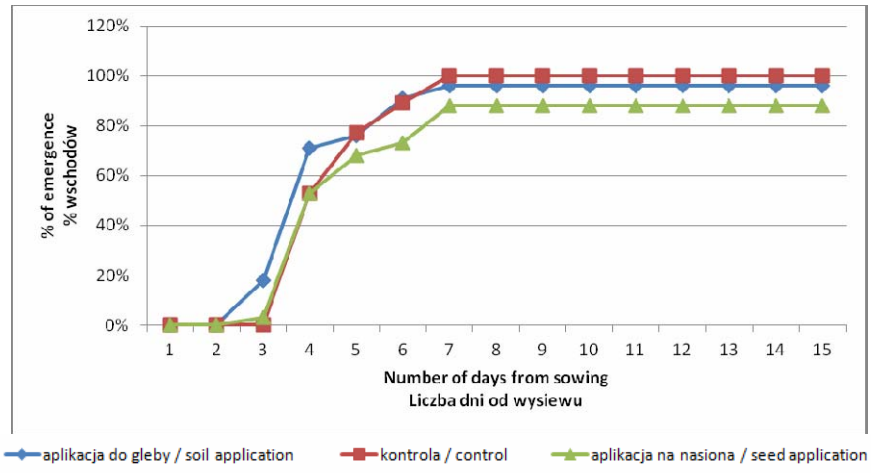
Source: own work / Źródło: opracowanie własne

Fig. 1. Dynamics of emergence of sugar beet depending on the method of application of herbal brew
Rys. 1. Dynamika wschodów buraka pastewnego w zależności od sposobu aplikacji naparów roślinnych



Source: own work / Źródło: opracowanie własne

Fig. 2. Dynamics of emergence of sugar beet depending on the method of application of herbal brew
Rys. 2. Dynamika wschodów buraka cukrowego w zależności od sposobu aplikacji naparów roślinnych



Source: own work / Źródło: opracowanie własne

Fig. 3. Dynamics of emergence of sugar beet depending on the method of application of herbal brew
Rys. 3. Dynamika wschodów buraka ćwikłowego w zależności od sposobu aplikacji naparów roślinnych

Notably, the red beet seeds were characterized by high average activity of germination (94%). First seedlings were observed as early as 3 days after sowing, with a higher number being observed in the experiments involving soils that had been pre-treated with plant extracts.

4. Conclusions

High germination capacities were observed for fodder and sugar beet seeds following direct soil application of tested plant extracts as well as in respective control experiments.

The most rapid germination were observed for red beet and sugar beet seeds following pre-sowing application of plant extracts into the soil.

Significantly the best uniformity of germination was observed for non – treated fodder beet, sugar beet, as well as red beet seeds.

The highest Maguire's rates were observed for sugar beet, fodder beet, and red beet alike in the experiments involving application to soil as well as in the non – treated seeds.

The largest differences in the dynamics of germination depending on the method of application of the plant extracts were observed in the case of red beet seeds.

The biggest differences in the dynamics of the emergence depending on the method of application of the herb brews for seeding recorded for beetroot.

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