ZESZYTY PROBLEMOWE POSTĘPÓW NAUK ROLNICZYCH 2002 z. 481: 131–139

THE EFFECT OF PRESOWING SEED TREATMENT ON THE YIELD OF MARJORAM (*Origanum majorana* L.) SOWN DIRECTLY INTO THE OPEN FIELD

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Introduction

Marjoram, a Mediterranean perennial, is commonly grown as an annual in West and Central Europe, where its herb ranks among raw materials of a considerable and increasing demand. The most often used method of starting the crop on big plantations is a direct sowing into the open field [BOMME 1997]. A success of such cultivation requires a uniform and rapid field emergence which, due to the specific character of seed and sowing (slow to germinate, very small seeds sown without covering), is difficult to achieve under stressful conditions in spring [SUCHORSKA et al. 1997]. Physiological methods of presowing treatment improve distinctly the seed vigour under laboratory conditions and are also reported to be advantageous in agricultural practice, especially when germination and initial plant growth take place in adverse environmental conditions [PARERA, CANTLIFFE 1994].

As a result of presowing conditioning, the increase in microorganism infection of some vegetable seeds was observed [TYLKOWSKA, BINIEK 1996]. The application of chemical protectants against pathogens to conditioned seeds affected in different ways both emergence and further plant growth [KHAN et al. 1992; SZAFIROWSKA, KHAN 1995].

The aim of this study was to determine the effect of some presowing treatments and fungicide application on the vigour of seeds and seedlings, and the yield of marjoram herb collected from the cultivation started by direct sowing into the open field.

Material and methods

Marjoram seeds were soaked in the gibberellic acid (GA_3) solution at the concentration of 1000 mg·kg^{-1} for 24 hours, matriconditioned with solid substan-

ce Micro Cel E (MCE) at the seed : carrier : water ratio by weight of 12 : 4 : 16, at 15°C for 6 days, and osmoconditioned in the solution of polyethylene glycol of molecular weight 6000 (PEG) at the concentration 240 $g \cdot kg^{-1}$, at 15°C for 5 days. To the half of seeds of every treatment fungicide Penncozeb 80WP at the rate 3 $g \cdot kg^{-1}$ was added. Seed lots which were not treated (NT) and those not treated but dressed with fungicide (NT+F) were control combinations.

The initial capability of germination, laboratory tested [ISTA 1993], was 82%. To determine the effect of presowing treatments on the speed and capability of emergence and seedling vigour, seeds (8 × 100 seeds) were sown in peat-moss substrate and placed in the growing chamber MLR 350 at 15/10°C (day/night) with 5 hours per day of irradiation (4000 lux). The observations of the speed of emergence were carried out every second day, beginning with the appearance of first seedlings and ending when their final number settled (capability of emergence). The relative speed of emergence was calculated according to MAGUIRE [1962]. On the 40th day after sowing fresh and dry weight of a seedling and the content of DNA were determined. DNA was analyzed by the isolation method [ROGERS, BENDICH 1985] with the use of CTAB.

Control and treated seeds were subjected to phytopathological analysis. Incubation was carried out on PDA medium, at 20°C for 14 days, applying the irradiation NUV in alternating cycle 12/12h. Microorganisms were determined in germinating and not germinating seeds, number of fungi colonies being calculated per 100 seeds.

The yield and quality of marjoram herb were tested in two parallel field experiments conducted in Central Poland (Wilanów near Warszawa) on alluvial soil developed from a silty formation and in Southern Poland (Mydlniki near Kraków) on clay silt soil. They were established in a randomized block design with 4 replications. Seed was sown in the 2nd ten days of April and herb was collected twice: in the 3rd ten days of July and of September. The content of essential oil in herb was determined by steam-distillation in the apparatus of Deryng (FP V). The chemical composition of marjoram oil was analyzed by gas chromatography (Hewlett-Packard M-6890 with instrumentation). The results were statistically elaborated in ANOVA at $\alpha = 0.05$. Means differing significantly were marked with different letters.

Results and discussion

Phytopathological analysis (Table 1) showed a slight infestation of seeds (not numerous bacteria and only 8 species of fungi, mainly saprophytic ones). Both, soaking in GA_3 and osmo- and matriconditioning, did not cause an increase in marjoram seed infestation by microorganisms, that being the case noted previously with some vegetable seeds [TYLKOWSKA, BINIEK 1996]. The observations on seed and seedling vigour under controlled conditions evidenced the beneficial effect of every method of presowing treatment (Table 2). The best results were noted with matriconditioning and then with hormone permeation. The application of Penncozeb brought about no effect in general, only in the case of osmoconditioned seeds a decrease in speed and capability of emergence was observed. No improvement or even deterioration of the emergence of conditioned seeds of carrot, tomato, and pepper after fungicide application was proved by KHAN et al. [1992].

Table 1; Tabela 1

Infestation of marjoram seeds by microorganisms as depending on presowing treatment (%)

Zasiedlenie nasion majeranku przez mikroorganizmy w zależności od uszlachetniania (%)

Microorganism; Mikroorganizm	Presowing seed treatment* Sposób uszlachetniania nasion*			
	NT	GA_3	MCE	PEG
Alternaria alternata (FR.) KEISSLER	0.5	–	0.5	0.5
Aspergillus spp.	3.0	2.5	0.5	3.0
Botrytis cinerea PERS. EX FR.	–	–	0.5	–
Cephalosporium sp.	–	–	–	1.0
Cladosporium herbarum (PERS.) LINK EX FR.	0.5	–	–	1.0
Mucor spp.	1.5	1.0	0.5	1.0
Penicillium spp.	2.5	2.0	1.0	–
Stemphylium botryosum WALLR.	–	0.5	–	–
Mycelium; Grzybnia niezarodnikująca	1.0	2.0	5.0	1.5
Bacterial infection; Bakterie	3.0	–	0.5	1.0
Total fungus infection; Porażenie grzybowe ogółem	9.0	8.0	8.0	8.0
Total infection; Porażenie ogółem	12.0	8.0	8.5	9.0

* NT – control; kontrola
GA_3 – soaking in GA_3 solution; moczenie w roztworze GA_3
MCE – matriconditioning; matrykondycjonowanie
PEG – osmoconditioning; osmokondycjonowanie

Table 2; Tabela 2

Effect of presowing treatment on vigour of seeds and seedlings of marjoram
Wpływ przedsiewnego traktowania na wigor nasion i siewek majeranku ogrodowego

Presowing seed treatment* Przedsiewne traktowanie nasion*	Speed of emergence, number of seedlings·day^{-1} Szybkość wschodów, liczba siewek·dzień$^{-1}$	Emergence capability Zdolność wschodów (%)	Fresh matter of a seedling Świeża masa siewki (g)	Weight of air-dried seedling Masa siewki powietrznie suchej (mg)	DNA content in seedling leaf tissue, mg·g^{-1} FM Zawartość DNA w tkankach liści siewki, mg·g^{-1} św.m.
NT	12.9 b**	38.2 a	0.13 a	25 a	302.2 a
GA_3	15.4 d	62.2 d	0.28 c	52 bc	385.2 c
MCE	18.6 f	76.8 e	0.36 d	89 d	440.8 d
PEG	14.2 c	56.4 c	0.24 b	58 bc	357.5 b
NT + F	12.9 b	48.6 b	0.14 a	28 a	308.2 a
GA_3 + F	14.5 cd	62.0 d	0.27 c	50 b	380.3 c
MCE + F	17.6 e	75.0 e	0.35 d	82 d	433.8 d
PEG + F	9.8 a	40.0 a	0.27 c	65 c	351.8 b
$LSD_{0.05}$; $NIR_{0.05}$	1.0	4.4	0.02	13	7.8

* NT, GA_3, MCE, PEG – explanations see Table 1; objaśnienia jak w tab. 1
F – fungicide application; stosowanie zaprawiania fungicydem
** – values indicated with the same letter are not significantly different; wartości oznaczone tymi samymi literami nie różnią się istotnie

Table 3; Tabela 3

Yield of dry marjoram herb (dt·ha^{-1}) depending on tested methods of presowing seed treatment
Plon suchego ziela majeranku (dt·ha^{-1}) zależnie od zastosowanych metod przedsiewnego traktowania nasion

Localization of growing Lokalizacja uprawy	Presowing seed treatment* Przedsiewne traktowanie nasion*	Harvest I; Pokos I			Harvest II; Pokos II			Total yield; Plon ogółem		
		fungicide application**; stosowanie zaprawiania chemicznego**								
		–	+	mean; średnio	–	+	mean; średnio	–	+	mean średnio
Kraków Mydlniki	NT	13.6 bc	13.9 bc	13.8 A	14.9	17.1	16.0	28.5 ab	31.0 bc	29.8 A
	GA_3	13.9 bc	11.1 ab	12.5 A	16.0	14.4	15.2	29.9 bc	25.5 a	27.7 A
	MCE	15.2 c	18.8 d	17.0 B	17.1	16.8	17.0	32.3 bcd	35.6 d	34.0 B
	PEG	16.2 cd	10.5 a	13.3 A	17.2	14.7	15.9	33.5 cd	25.1 a	29.3 A
	mean; średnio	14.7	13.6	–	16.3	15.7	–	31.1	29.3	–
Warszawa Wilanów	NT	7.9	8.4	8.1 A	16.4	16.5	16.5 A	24.3	24.9	24.6 A
	GA_3	10.1	10.3	10.2 B	31.0	30.4	30.7 D	41.1	40.7	40.9 C
	MCE	12.6	12.4	12.5 C	27.3	26.8	27.1 C	39.9	39.1	39.5 C
	PEG	10.9	10.7	10.8 B	18.2	20.2	19.2 B	29.0	30.8	29.9 B
	mean; średnio	10.4	10.4	–	23.2	23.5	–	33.6	33.9	–

* NT, GA_3, MCE, PEG – explanations see Table 1; objaśnienia jak w tab. 1

** – fungicide seed dressing before sowing: (–) not applied, (+) Penncozeb 80 WP (3 g·kg^{-1}); zaprawianie nasion bezpośrednio przed siewem: (–) nie stosowano, (+) zaprawiano preparatem Penncozeb 80 WP (3 g·kg^{-1})

Table 4; Tabela 4

Effect of marjoram seed treatment on the essential oil content in air-dried marketable herb from two harvests and total oil yield
Wpływ przedsiewnego traktowania nasion na zawartość olejku eterycznego w suchym zielu otartym majeranku i ogólną wydajność olejku

Localization of growing Lokalizacja uprawy	Presowing seed treatment* Przedsiewne traktowanie nasion*	Oil content; Zawartość olejku (ml·100 g^{-1})						Total oil yield; Ogólna wydajność olejku (dm^3·ha^{-1})		
		harvest I; pokos I			harvest II; pokos II					
		fungicide application** stosowanie zaprawiania chemicznego**								
		–	+	mean; średnio	–	+	mean; średnio	–	+	mean; średnio
Kraków Mydlniki	NT	2.22	2.12	2.17	2.37 ab	2.35 ab	2.36	40.1 bc	37.4 b	38.7 B
	GA_3	2.20	2.08	2.14	2.58 c	2.30 a	2.44	40.8 bc	30.5 a	35.7 A
	MCE	2.15	2.22	2.18	2.32 a	2.47 abc	2.39	40.4 bc	46.8 d	43.6 C
	PEG	2.38	2.13	2.26	2.39 ab	2.50 bc	2.45	43.1 c	33.0 a	38.0 AB
	mean; średnio	2.24 B	2.14 A	–	2.41	2.40	–	41.1 B	36.9 A	–
Warszawa Wilanów	NT	1.90 ab	1.83 a	1.87 A	2.10	1.93	2.02 A	27.2	24.9	26.0 A
	GA_3	2.23 d	2.23 d	2.23 C	2.42	2.45	2.43 C	50.1	47.3	48.7 C
	MCE	1.98 b	2.15 cd	2.07 B	2.20	2.27	2.23 B	43.9	46.8	45.4 C
	PEG	1.90 ab	2.12 c	2.01 B	2.18	2.27	2.23 B	34.6	39.8	37.2 B
	mean; średnio	2.00 A	2.08 B	–	2.23	2.23	–	39.0	39.7	–

* – NT, GA_3, MCE, PEG – explanations see Table 1; objaśnienia jak w tab. 1

** – fungicide seed dressing before sowing: (–) not applied, + Penncozeb 80 WP (3 g·kg^{-1}); zaprawianie nasion bezpośrednio przed siewem: (–) nie stosowano, (+) zaprawiano preparatem Penncozeb 80 WP (3 g·kg^{-1})

Table 5; Tabela 5

Effect of seed treatment on the content of identified compounds in marjoram essential oil (%)
Wpływ traktowania nasion na udział zidentyfikowanych związków w olejku eterycznym majeranku (%)

Compound Związek	Seed treatment*; Traktowanie nasion*															
	NT				GA_3				MCE				PEG			
	without fungicide; bez zaprawiania		with fungicide; z zapra-wianiem		without fungicide; bez zaprawiania		with fungicide; z zaprawianiem		without fungicide; bez zaprawiania		with fungicide; z zaprawianiem		without fungicide; bez zaprawiania		with fungicide; z zaprawianiem	
	I**	II**	I	II	I	II	I	II	I	II	I	II	I	II	I	II
α-thujene; α-tujen	0.43	0.40	0.45	0.40	0.45	0.39	0.44	0.42	0.41	0.41	0.39	0.39	0.46	0.39	0.71	0.38
α-pinene; α-pinen	0.65	0.60	0.68	0.58	0.66	0.62	0.72	0.56	0.65	0.55	0.65	0.53	0.63	0.57	0.64	0.56
camphene; kamfen	0.04	0.04	–	–	0.04	–	–	–	0.04	–	–	–	–	–	0.08	–
β-pinene; β-pinen	0.31	0.31	0.33	0.31	0.33	0.29	0.31	0.31	0.31	0.29	0.31	0.30	0.33	0.31	0.33	0.29
sabinene; sabinen	6.41	5.93	6.72	5.97	6.40	5.84	6.55	5.93	6.37	5.85	6.25	5.83	6.46	5.99	6.00	5.92
β-mircene; β-mircen	1.38	1.10	1.34	1.10	1.37	1.09	1.24	1.12	1.36	1.07	1.31	1.15	1.38	1.17	1.37	1.15
α-terpinene; α-terpinen	6.15	5.40	6.67	5.58	6.30	5.71	6.59	5.93	6.27	5.44	6.66	5.80	6.38	5.84	6.22	5.32
limonene; limonen	1.25	1.09	1.22	1.09	1.26	1.07	1.19	1.09	1.22	1.09	1.17	1.16	1.21	1.17	1.29	1.12
cineole; cyneol	1.74	1.75	1.61	1.79	1.70	1.58	1.65	1.67	1.75	1.75	1.58	1.95	1.58	2.01	1.65	1.93
γ-terpinene; γ-terpinen	10.08	8.79	11.06	9.06	10.37	9.45	11.00	9.63	10.26	8.89	11.27	9.37	10.56	9.42	10.76	8.47
p-cymene; p-cymen	0.56	0.43	0.67	0.38	0.47	0.47	0.51	0.40	0.55	0.29	0.61	0.38	0.44	0.42	0.68	0.39
o-cymene; o-cymen	2.26	1.96	2.47	2.04	2.22	2.08	2.37	2.12	2.25	1.96	2.52	2.09	2.33	2.13	2.33	1.92
trans sabinene hydrate; hydrat trans-sabinenu	4.97	5.79	4.68	5.77	4.98	5.67	4.83	5.47	4.86	5.65	4.52	5.28	4.85	5.52	4.22	5.68
linalol; linalol	32.08	36.10	23.62	35.26	30.90	33.62	29.46	34.72	25.86	37.08	27.79	35.54	26.06	34.45	18.22	36.40
linalyl acetate; octan linalilu	–	–	5.58	–	–	–	–	–	5.17	–	–	–	5.20	–	12.65	–
β-cariophylene; β-kariofilen	1.88	2.16	1.88	2.22	1.92	2.17	1.79	2.21	1.91	2.33	1.77	2.11	1.99	2.16	1.87	2.53
terpinene-4-ol; terpinen-4-ol	22.26	19.60	24.49	20.23	23.17	20.71	25.11	21.07	23.43	19.30	25.88	20.75	23.05	20.70	23.20	20.23
α-humulene; α-humulen	0.23	0.19	0.28	0.23	0.28	0.20	0.25	0.21	0.27	0.18	0.26	0.21	0.23	0.20	0.21	0.23
α-terpineol; α-terpineol	3.17	2.92	3.05	2.90	3.03	3.04	3.16	2.90	3.03	2.86	3.18	2.88	3.03	2.87	2.93	2.90
borneol; borneol	1.35	1.90	1.27	1.90	1.38	1.92	1.23	1.86	1.33	2.06	1.20	1.91	1.43	1.99	1.20	1.90
geranyl acetate; octan geranylu	0.12	0.08	0.08	0.08	0.15	0.07	–	–	0.13	0.06	0.11	0.04	0.12	0.07	0.26	0.08
geraniol; geraniol	0.16	0.10	0.12	0.10	0.19	0.12	0.08	0.10	0.16	0.11	0.14	0.09	0.16	0.10	0.37	0.10
thymol; tymol	0.02	–	–	–	0.08	–	–	–	–	–	–	–	–	–	0.11	–

* – NT, GA_3, MCE, PEG – explanations see Table 1; objaśnienia jak w tab. 1
** – I, II – herb from 1st and 2nd harvest, respectively; ziele odpowiednio z pierwszego i z drugiego pokosu

In the two localizations of field experiment the yield of marjoram herb and essential oil was the highest with the crop from seeds subjected to matriconditioning (Tables 3 and 4). This could confirm the advantageous effect of this treatment on seed and seedling vigour also under field conditions. On the other hand, in the similar investigation conducted in 1998 and 1999 [SUCHORSKA-TROPIŁO et al. 2000] the yield of marjoram crop from seeds soaked in GA_3 was higher than that from matriconditioned ones. In the present work, in the experiment in Wilanów, seed soaking in GA_3 gave the results as good as matriconditioning, while in Mydlniki only due to seed matriconditioning the yield was significantly higher than that from the other combinations. The effect of fungicide application on the yield of marjoram herb and oil became apparent only in the cultivation in Mydlniki, being disadvantageous in the case of osmoconditioning and soaking in GA_3, but beneficial in that of matriconditioning. The effect of presowing seed treatments on an essential oil content was various, depending also on a crop localization. A significant positive effect of tested methods, soaking in GA_3 in particular, was observed with the herb from both harvests of the marjoram crop in Wilanów (Table 4). The changes in essential oil composition resulted mainly from a harvest term but the tested methods of seed treatments did not affect considerably the quality and quantity of oil chemical compounds (Table 5).

Conclusions

The infestation of marjoram seeds by microorganisms was slight and did not increase following the tested methods of presowing treatment.

Seed matriconditioning contributed to the best results with respect to the vigour of seeds and seedlings and the yield of marjoram herb and essential oil.

The effect of fungicide application on the yield and quality of marjoram herb differed, depending on the method of presowing seed treatment and localization of experiments.

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Key words: GA_3, matriconditioning, osmoconditioning, chemical protection, seed vigour, herb yield, essential oil

Summary

The aim of this study was to investigate the effect of presowing conditioning, hormone permeation, and fungicide application on the vigour of seeds and seedlings as well as the yield of marjoram herb collected from the cultivation started by direct sowing into the open field. The methods of presowing seed treatment were as follows: soaking in GA_3, matriconditioning with solid substance MicroCel-E, osmoconditioning in the solution of polyethylene glycol PEG 6000. Seeds of every combination were either dressed with Penncozeb or sown without fungicide. The yield and quality of marjoram herb were tested in the field experiments conducted in the region of Central and Southern Poland.

The phytopathological analysis of seeds showed their low infestation by microorganisms, this not increasing following the seed conditioning and soaking in GA_3 solution. The measurements of seedling vigour under controlled conditions proved the positive effect of every tested method of presowing seed treatment. Irrespective of localization, the yields of marjoram herb and essential oil were the highest with the crop from matriconditioned seeds. The effect of seed osmoconditioning and soaking in GA_3 solution as well as fungicide application depended on the localization of marjoram growing.

WPŁYW ZABIEGÓW PRZEDSIEWNEGO TRAKTOWANIA NASION NA PLONOWANIE MAJERANKU OGRODOWEGO (*Origanum majorana* L.) UPRAWIANEGO Z SIEWU WPROST NA POLE

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Słowa kluczowe: GA_3, matrykondycjonowanie, osmokondycjonowanie, zaprawianie chemiczne, wigor nasion, plon ziela, olejek eteryczny

Streszczenie

Celem pracy było zbadanie wpływu zabiegów przedsiewnego uszlachetniania nasion oraz ich zaprawiania chemicznego na wigor nasion i siewek oraz plon ziela majeranku ogrodowego w uprawie z siewu wprost na pole. Metody uszlachetniania nasion obejmowały: moczenie w roztworze giberelliny, matrykondycjonowanie substancją stałą MicroCel-E i osmokondycjonowanie w roztworze glikolu polietylenowego PEG 6000. Tak przygotowane nasiona oraz kontrolne były zarówno zaprawione chemicznie (Penncozeb 80WP) bezpośrednio przed siewem, jak i wysiewane bez stosowania fungicydu. Plon i jakość ziela majeranku były badane w dwu równolegle prowadzonych doświadczeniach polowych w rejonie Polski Centralnej i Południowej.

Analiza fitopatologiczna wykazała niewielkie zasiedlenie nasion przez mikroorganizmy oraz brak jego wzrostu wskutek zastosowanych metod uszlachetniania. Obserwacje wigoru siewek prowadzone w warunkach kontrolowanych wskazywały na korzystny wpływ każdej z metod przedsiewnego uszlachetniania. Niezależnie od lokalizacji doświadczenia (Warszawa, Kraków) plon ziela majeranku i olejku eterycznego były najwyższe w uprawie z nasion matrykondycjonowanych. Wpływ pozostałych metod uszlachetniania oraz stosowania fungicydu zależał od miejsca uprawy.

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