Effect of Presowing Seed Treatment and Fungicide Application on the Yield of Marjoram (*Origanum majorana* L.) Grown by Setting-Out Transplants in the Open Field

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Keywords: Gibberellic acid, polyethylene glycol, solid substance MicroCel-E, seedling vigour, herb, essential oil

Abstract

Marjoram seeds were soaked in Gibrescol solution (GA_3), matriconditioned with MicroCel-E (MCE), and osmoconditioned in polyethylene glycol solution (PEG). The treated seeds and control ones were either dressed with fungicide or sown without it. In order to investigate the effect of the applied treatments on the marjoram herb yield, content and composition of essential oil and oil yield, field experiments were conducted in two regions of Poland (Warsaw and Krakow). Transplants were grown in the greenhouse. Each tested method of presowing treatment increased the seed vigour and the highest improvement was noted with MCE and followed by PEG and GA_3, respectively. Fungicide application did not cause positive effects. That was also confirmed with the results of field experiments where fungicide applying either showed no significant differences (Krakow) or even decreased the yield of marjoram herb and oil (Warsaw). The advantageous effect of presowing seed conditioning and treating with GA_3 on the marjoram yield was observed in both experimental locations, eventhough its degree was different. Tested methods of seed treatment did not change marjoram oil composition considerably.

INTRODUCTION

The unsatisfactory efficiency in the production of herbal raw materials is attributed to a low level of agrotechnical methods (Jambor and Reuter, 1997). A high quality yield of marjoram (*Origanum majorana* L.) is easily obtained by a proper plant growth, which begins with seed germination. The marjoram emergence is, from its nature, uneven and long lasting. Physiological presowing treatments were proved to enhance seed vigour and in many crops to increase also yield and its quality (Parera and Cantliffe, 1994; Dąbrowska and Suchorska, 1999). The combination of presowing conditioning and hormone applying with fungicide protection may contribute either to an improvement or to a deterioration of plant growth and development (Khan et al., 1992; Szafirowska and Khan, 1995). The aim of this study was to determine the effect of presowing seed soaking in GA_3 solution, matriconditioning, osmoconditioning, and protecting with fungicide on the yield of marjoram crop in the open field cultivation started with transplants.

MATERIALS AND METHODS

Marjoram seeds with 82 % initial germination capability (ISTA, 1993) were treated as follows. GA_3 – soaking in gibberellic acid solution (1000 ppm, 24 hrs), MCE – matriconditioning with MicroCel-E (the weight ratio of seed:carrier:water = 3:1:4, 6 days, 15°C, in light), PEG – osmoconditioning in the solution of polyethylene glycol PEG6000 (240 g kg^{-1}, 5 days, 15°C, in light). Non-treated seeds were used as a control. The seeds from each treatment were dressed with mancozeb (Penncozeb 80WP, 3 g kg^{-1}) or not

Proc. IS on Sust. Use Of Plant Biodiv.
Eds. E. Düzyaman &Y.Tüzel
Acta Hort. 598, ISHS 2003

treated with fungicide. To measure parameters of seed and seedling vigour, the seeds were sown in peat-moss substrate in the growing chamber MLR 350 at 15/10°C (day/night) and 5 hrs of irradiation (4000 lux) per day. Emerging seedlings were counted every second day until their number ceased to increase (emergence capability), the relative speed of emergence being calculated according to Maguire (1962). Seedling weight and DNA content were determined on the 40th day after sowing.

Field experiments were conducted on alluvial soil with silt formation in Wilanów near Warsaw (Central Poland) and on clayed silt soil in Mydlniki near Krakow (Southern Poland). They were established in a randomised block design with 4 replications. Sowing took place in a glasshouse where transplants were raised for 8 weeks to be set out in the open field in the first 10 days of June. Marjoram herb was harvested twice (in the 3rd ten days of July and of September). Essential oil content was determined after steam-distillation of air-dried marketable herb. Analyses of oil composition based on gas chromatography (Hewlett-Packard M-6890 with instrumentation). Results were subjected to ANOVA at α=0.05. Means marked with different letters differed significantly.

RESULTS AND DISCUSSION

The highest improvement of seed and seedling vigour tested under controlled conditions (Table 1) was noted in MCE and followed by GA_3 and PEG, respectively. Fungicide application, in turn, did not show any positive effects. This might results from a very low seed infection by microorganisms (below 10 %) with only 8 fungus species, mainly saprophytic and not numerous bacteria. In addition, the applied treatments did not increase seed infection (data not shown).

The degree of advantageous effect of applied seed treatments on marjoram yield was different in the two experimental locations (Tabs. 2 and 3). In Warsaw the highest yield of herb and oil as well as oil content were noted with GA_3 and followed by MCE and PEG, the highest increase in comparison with control reached up to 68 %. In Kraków the differences were considerably low and the highest herb yield was observed after seed matriconditioning. That is confirmed its significant effect on seedling vigour evidenced under controlled conditions. Parera and Cantliffe (1994) reported that beneficial effects of presowing priming on seedling development are not always similar with respect to plant yield and quality. This could explain the different plant response to seed treatment in the two locations of present observations. In the case of fungicide protection the results of field experiments were more consistent with those proved under controlled conditions (Tabs. 1-3). Khan et al. (1992) found no improvement or even deterioration in emergence of conditioned seeds of some vegetables after fungicide application. Also in the present work the fungicide applying either decreased the yield of marjoram herb and oil (Warsaw) or showed no significant differences (Krakow). The quality and quantity of marjoram oil compounds was not affected considerably by the applied seed treatments (Table 4). The share of leading compounds remained within limits characteristic for *Origanum majorana* L (Suchorska-Tropiło et al., 2000).

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Tables

Table 1. Effect of presowing treatment on the vigour of marjoram seeds and seedlings.

Seed treatment*	Control		GA_3		MCE		PEG	
Fungicide dressing**	–	+	–	+	–	+	–	+
Speed of emergence (seedlings day^{-1})	12.9 b	12.9 b	15.4 d	14.5 cd	18.6 f	17.6 e	14.2 c	9.8 a
Emergence capability (%)	38.2 a	48.6 b	62.2 d	62.0 d	76.8 e	75.0 e	56.4 c	40.0 a
Fresh weight of a seedling (g)	0.13 a	0.14 a	0.28 c	0.27 c	0.36 d	0.35 d	0.24 b	0.27 c
Weight of a seedling after air-drying (mg)	25 a	28 a	52 bc	50 b	89 d	82 d	58 bc	65 c
DNA content in seedling leaf tissue (mg g^{-1} f.w.)	302 a	308 a	385 c	380 c	441 d	434 d	357 b	352 b

* GA_3, MCE, PEG – soaking in GA_3 solution, matriconditioning, osmoconditioning, respectively

** fungicide seed dressing before sowing: – not applied, + applied

Table 2. Effect of presownig seed treatment and fungicide application on the yield of dry marketable herb of marjoram in the growing started with transplants in two locations in 2000 (dt ha^{-1}).

Location of field experiments	Presowing seed treatment*	1st harvest			2nd harvest			Total yield		
		Fungicide application**			Fungicide application**			Fungicide application**		
		–	+	Mean	–	+	Mean	–	+	Mean
Krakow Mydlniki	Control	3.60 a	4.10 b	3.85 A	13.30 bcd	12.13 a	12.72 A	16.90	16.23	16.57 A
	GA_3	4.27 b	4.13 b	4.20 B	12.33 ab	13.23 bcd	12.78 A	16.60	17.37	16.98 AB
	MCE	4.23 b	4.30 b	4.27 B	13.43 cd	13.53 d	13.48 B	17.67	17.83	17.75 B
	PEG	4.30 b	4.07 b	4.18 B	12.17 a	12.53 abc	12.35 A	16.47	16.60	16.53 A
	mean	4.10	4.15		12.81	12.85		16.90	17.00	
Warsaw Wilanów	Control	3.18	4.00	3.59	17.56	15.46	16.51 A	20.74	19.46	20.10 A
	GA_3	3.87	4.70	4.29	23.94	18.77	21.55 C	27.81	23.48	25.64 C
	MCE	4.19	4.21	4.20	19.97	17.84	18.91 B	24.17	22.05	23.11 B
	PEG	4.09	3.81	3.95	20.12	17.63	18.87 B	24.22	21.43	22.83 B
	mean	3.83	4.18		20.40 B	17.43 A		24.23 B	21.61 A	

* GA_3, MCE, PEG – soaking in GA_3 solution, matriconditioning, osmoconditioning, respectively

** fungicide seed dressing before sowing: – not applied, + applied

Table 3. Effect of presownig seed treatment and fungicide application on the content of essential oil in dry marketable herb and total oil yield (growing of marjoram started with transplants in two locations in 2000).

Location of field experiments	Presownig seed treatment*	Content of essential oil (ml 100 g^{-1})						Essential oil yield (l ha^{-1})		
		1st harvest			2nd harvest					
		Fungicide application**			Fungicide application**			Fungicide application**		
		–	+	mean	–	+	mean	–	+	mean
Kraków Mydlniki	Control	2.15	2.02	2.08	2.52 bc	2.53 bc	2.53	41.14 bc	38.90 ab	40.02
	GA_3	2.18	2.07	2.13	2.61 c	2.37 ab	2.49	41.37 bc	39.76 abc	40.56
	MCE	2.15	2.12	2.13	2.47 abc	2.30 a	2.38	42.18 c	40.20 abc	41.19
	PEG	2.08	2.18	2.13	2.33 ab	2.58 c	2.46	37.31 a	41.23 bc	39.27
	mean	2.14	2.09		2.48	2.45		40.49	40.02	
Warszawa Wilanów	Control	1.92	1.88	1.90 A	2.12	2.20	2.16 A	43.18 a	41.44 a	42.31 A
	GA_3	2.23	2.25	2.24 C	2.67	2.54	2.60 C	72.42 e	58.22 d	65.32 C
	MCE	2.13	2.18	2.16 B	2.37	2.44	2.40 B	56.18 d	52.67 bc	54.42 B
	PEG	2.15	2.20	2.17 BC	2.35	2.40	2.37 B	56.06 cd	50.63 b	53.34 B
	mean	2.11	2.13		2.37	2.39		56.96 B	50.74 A	

* GA_3, MCE, PEG – soaking in GA_3 solution, matriconditioning, osmoconditioning, respectively
** fungicide seed dressing before sowing: – not applied, + applied

Table 4. Effect of seed treatment on the content of identified compounds in marjoram essential oil (%).

Compound	Seed treatment*															
	Control				GA_3				MCE				PEG			
	Without fungicide		With fungicide		Without fungicide		With fungicide		Without fungicide		With fungicide		Without fungicide		With fungicide	
	I**	II**	I	II	I	II	I	II	I	II	I	II	I	II	I	II
α-thujene	0.50	0.44	0.38	0.40	0.41	0.44	0.41	0.36	0.40	0.37	0.40	0.38	0.50	0.39	0.46	0.41
α-pinene	0.85	0.72	0.66	0.74	0.63	0.70	0.66	0.61	0.65	0.67	0.64	0.62	0.78	0.63	0.54	0.60
camphene	-	-	-	-	-	-	-	-	-	-	0.02	-	-	-	0.01	0.02
β-pinene	0.37	0.36	0.30	0.30	0.30	0.33	0.32	0.28	0.30	0.31	0.30	0.29	0.35	0.30	0.30	0.29
sabinene	7.84	7.32	6.25	6.47	6.47	6.87	6.66	6.25	6.52	6.61	6.30	6.38	7.48	6.38	6.20	5.91
β-mircene	1.54	1.43	1.28	1.17	1.24	1.29	1.33	1.10	1.29	1.24	1.24	1.09	1.31	1.12	1.25	1.24
α-terpinene	7.38	6.70	6.28	5.77	5.73	6.55	6.35	5.18	5.97	5.75	6.04	5.48	6.56	5.58	5.91	6.18
limonene	1.38	1.34	1.21	1.18	1.15	1.21	1.24	1.10	1.15	1.22	1.11	1.14	1.18	1.10	1.11	1.15
cineole	1.92	2.35	1.88	2.02	1.55	2.14	1.88	1.61	1.61	2.09	1.57	1.91	1.84	1.69	1.51	1.53
γ-terpinene	12.01	10.76	10.34	9.14	9.47	10.18	10.29	8.26	9.87	9.00	10.11	8.98	10.55	8.96	9.89	10.45
p-cymene	0.60	0.48	0.59	0.44	0.64	0.32	0.64	0.40	0.45	0.38	0.57	0.35	0.60	0.40	0.55	0.78
o-cymene	2.63	2.40	2.37	2.05	2.18	2.21	2.30	1.88	2.22	2.07	2.28	1.95	2.37	2.05	2.22	2.35
trans sabinene hydrate	6.22	7.02	4.93	5.90	5.11	5.75	5.00	5.86	5.21	6.07	5.13	6.05	5.29	6.02	4.94	4.54
linalol	22.80	22.49	26.19	30.92	35.33	24.21	30.75	37.20	33.57	32.84	31.30	35.06	31.78	34.17	33.59	24.73
linalyl acetate	-	-	4.68	-	-	5.92	-	-	-	-	-	-	-	-	-	5.40
β-cariophylene	1.28	1.51	1.92	2.51	2.08	2.19	1.89	2.62	1.98	2.40	2.09	2.57	1.87	2.43	2.10	1.95
terpinene-4-ol	26.06	23.35	23.49	19.71	20.92	21.01	22.96	17.71	21.64	18.73	22.94	17.29	18.62	19.17	22.28	25.10
α-humulene	0.29	0.28	0.27	0.20	0.25	0.22	0.27	0.21	0.21	0.22	0.22	0.19	0.22	0.22	0.21	0.22
α-terpineol	3.35	3.61	3.04	2.82	2.98	2.91	3.17	2.97	3.11	2.79	3.23	3.02	2.82	2.95	3.09	3.20
borneol	0.04	2.22	1.45	1.84	1.49	1.76	1.48	2.00	1.42	1.85	1.50	1.94	2.25	2.02	1.53	1.34
geranyl acetate	0.11	-	0.15	-	0.11	-	0.12	-	0.11	-	0.14	-	0.05	-	0.15	0.35
geraniol	0.17	0.14	0.17	-	0.13	0.05	0.16	0.05	0.13	-	0.19	-	0.04	0.14	0.22	-
thymol	-	0.05	-	-	-	-	-	-	-	-	0.04	0.05	-	-	0.04	-

* as in Table 2

** I, II - herb from 1st and 2nd harvest, respectively