FOLIA
HORTICULTURAE
Ann. 16/1, 2004, 39-45

Effect of chemical scarification on germination and state of health of carrot (*Daucus carota* L.) seeds

Tomasz W. Bralewski, Roman Hołubowicz, Dorota Szopińska

Department of Seed Science and Technology, Faculty of Horticulture
Agricultural University of Poznań
Baranowo, Szamotulska 22, 62-081 Przeźmierowo, Poland
e-mail: twbseed@interia.pl

Key words: hydrochloric acid, seed-borne fungi

ABSTRACT

Carrot seeds (*Daucus carota* L.) 'Jawa' were soaked for 12 hours at 20ºC in water and 0.5%, 1.0%, 1.5%, 2.0%, and 2.5% solutions of the hydrochloric acid (HCl). The seeds were then dried for 24 hours at 20ºC and tested for their germination capacity and seed state of health. Treating the seeds with 0.5% HCl increased their germination energy (57.0%) and capacity (63.3%) in comparison with non-treated seeds: 45.0% and 47.7%, respectively. The concentration of the HCl above 0.5% did not affect the germination capacity, but decreased the maximum germination and above 1.0% increased the percentage of dead seeds. All concentrations of HCl improved the state of health of the seeds.

INTRODUCTION

The carrot (*Daucus carota* L.) seeds reproduced in Poland have had in some years low germination. One of the reasons of this may be their contamination with pathogenic fungi (Duczmal and Tylkowska 1990). Methods to improve seed quality of this species include various activities: from traditional cultivation practices (Gray 1989) – to sophisticated physiological ones (Murray 1989, Strandberger and White 1989, Pill and Evans 1991, Biniek 1994, Yanmaz 1994, Dąbrowska and Kolasińska 1995, Khan et al. 1995, Tylkowska and Biniek 1996, Drew et al. 1997, Szafirowska and Janas 2000, Biniek 2001, Tylkowska and van der Bulk 2001). So far, little attention has been paid in this research to chemical scarification, despite a possibility to use it to improve seed quality of many other species (Geneve 1998). The main purpose of the carried out experiment was to find out the effect of the chemical scarification on the quality of carrot 'Jawa' seeds.

MATERIAL AND METHODS

The seeds of carrot (*Daucus carota* L.) 'Jawa' were soaked for 12 hours at 20ºC in the glass Petri dishes in the distilled water (the control) and water solutions of the hydrochloric acid (HCl) in concentrations: 0.5%, 1.0%, 1.5%, 2.0%, 2.5% (1 g of seeds per 20 ml per a dish). The experiment was done in 3 replications of 100 seeds each.

Then, without washing, the seeds were dried for 24 hours at 20ºC and their germination was checked. The germination test was done following the ISTA requirements (ISTA 1999). The tests included the energy, capacity, and time (T_{25} and T_{50}) of germination and total number of germinating seeds (maximum germination – during 14 days). The time of seed germination was calculated using the programme SeedCalculator 2.1 (Jalink and van der Schoor 1999).

Mycological analysis was performed on 400 seeds from each treatment by the deep-freezing blotter method. The seeds were placed on the blotter paper soaked with distilled water in 9 cm diameter Petri dishes, 20 seeds per dish, incubated for 3 days at 20°C in darkness, then transferred to -20°C for 24 hours and subsequently incubated at 20°C under alternating cycles of 12 hours in NUV light and 12 hours in darkness for 8 days. The fungi were identified on the basis of their growth and sporulation characteristics using a stereo- and compound microscope (ISTA 1987).

The received results were subjected to the statistical analysis of variance. The significant differences were pointed out on the basing of the Duncan's test at $p = 0.05$.

RESULTS AND DISCUSSION

The treatment of carrot seeds with the solutions of HCl had an effect on their quality (Table 1). The soaking of the seeds in the 0.5% HCl increased their energy (57.0%) and capacity (63.3%) of germination in comparison with the control seeds: 45.0% and 47.7%, respectively. The hydrochloric acid limited the number of the diseased seedlings. The concentration of HCl above 0.5% did not affect the percentage of germinating seeds and above 1.0% - increased the percentage of dead seeds. Soaking the seeds in 0.5% HCl speeded up their germination (Table 1). Irrespectively of the used HCl concentrations in the range from 1.0% to 2.5%, the compound did not significantly lower the germination capacity of the carrot seeds despite better state of health of the germinating seeds. The maximum seed germination though was lower than in the control seeds (Table 1).

Table 1. Effect of soaking carrot 'Jawa' seeds in different solutions of hydrochloric acid (HCl) on their germination

Parameter	Control	Water	0.5% HCl	1.0% HCl	1.5% HCl	2.0% HCl	2.5% HCl
Energy of germination (%)	45.0 a*	48.0 ab	57.0 b	46.7 ab	42.3 a	39.3 a	38.0 a
Normal seedlings - germination capacity (%)	47.7 a	51.3 a	63.3 b	50.7 a	45.3 a	43.0 a	42.3 a
Deformed seedlings (%)	1.0 a	0.7 a	0.7 a	2.7 a	2.0 a	1.3 a	1.3 a
Diseased seedlings (%)	22.0 c	15.0 b	0.7 a	0.3 a	0.0 a	0.0 a	0.0 a
Dead seeds (%)	10.0 a	12.7 ab	12.0 ab	15.0 a-c	19.0 bc	19.3 bc	21.3 c
Healthy ungerminated seeds (%)	19.3 a	20.3 ab	23.3 a-c	31.3 a-c	33.7 a-c	36.5 c	35.0 bc
T_{25} (days)	2.7 b	2.4 ab	2.3 a	2.2 a	2.4 ab	2.6 ab	2.4 ab
T_{50} (days)	3.3 b	3.0 ab	3.0 ab	2.7 a	3.1 ab	3.0 ab	3.1 ab
Maximum germination (%)	70.7 b	71.0 b	64.7 b	54.3 a	47.7 a	45.0 a	44.0 a

* Means in the rows followed by the same letter are not significantly different at p = 0.05 level according to the Duncan's range test

T_{25} – time to 25% of the maximum germination
T_{50} – time to 50% of the maximum germination

In the literature, one can find contradictory information concerning the effectiveness of the seed chemical scarification. Some authors have found no positive effect of it on seed quality (Jha and Sinha 1989, Love et al. 1994, Saba et al. 1997), whereas the others have received positive results using it (Maguire et al. 1993, Masuda and Konishi 1993). Soaking of seeds of some species in HCl to speed up their germination and even their field establishment was recommended

already in the 19th century (Anonymous 1880). The presence of chlorine in water taken by seeds may speed up their germination (Hryniewiecki 1952).

In the tested seed sample the following fungi were identified: *Alternaria alternata* (Fr.) Keissler, *Alternaria dauci* (Kűhn) Groves & Skolko, *Alternaria radicina* Meier, Drechsler & Eddy, *Bipolaris sorokiniana* (Sacc.) Shoem., *Cladosporium* spp., *Epicoccum purpurescens* Ehrenb. & Schlecht., *Fusarium* spp., *Penicillium* spp., *Phoma* sp., *Stemphylium consortiale* (Thűm.) Groves & Skolko and some non-sporulating species (Table 2).

Table 2. Effect of soaking carrot 'Jawa' seeds in different solutions of hydrochloric acid (HCl) on their infestation by fungi

Fungi	Colonised seeds (%)						
	Control	Water	0.5% HCl	1.0% HCl	1.5% HCl	2.0% HCl	2.5% HCl
Alternaria alternata	32.0 c*	29.2 c	1.7 ab	1.5 ab	0.2 a	0.5 a	3.7 b
Alternaria dauci	1.0 a	0.2 a	0.5 a	0.0 a	0.2 a	0.0 a	0.0 a
Alternaria radicina	34.0 c	19.7 b	0.2 a	0.0 a	0.0 a	0.0 a	0.2 a
Bipolaris sorokiniana	0.5 a	0.7 a	0.2 a	0.0 a	0.2 a	0.0 a	0.0 a
Cladosporium spp.	1.2 a	0.7 a	0.5 a	1.0 a	1.0 a	0.7 a	0.5 a
Epicoccum purpurescens	0.2 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
Fusarium spp.	0.5 ab	1.5 b	0.2 a	0.5 ab	0.0 a	0.5 ab	0.0 a
Penicillium spp.	1.5 a	0.2 a	0.7 a	1.5 a	3.2 a	0.2 a	2.7 a
Phoma sp.	0.0 a	0.2 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
Stemphylium consortiale	0.2 ab	0.7 b	0.0 a	0.0 a	0.2 ab	0.2 ab	0.0 a
Non-sporulating	9.7 b	5.5 b	0.2 a	0.2 a	0.2 a	1.0 a	1.0 a
Seeds free from fungi	29.0 a	47.5 b	95.5 c	95.2 c	94.7 c	96.7 c	92.0 c

* Means in the rows followed by the same letter are not significantly different at p = 0.05 level according to the Duncan's range test

The most numerous fungi were *A. alternata* and *A. radicina*, detected respectively in 32.0% and 34.0% of the untreated with the acid seeds. The soaking of the seeds in water reduced slightly the level of *A. alternata* infection (29.2%) and significantly – the level of *A. radicina* infection (19.7%). A considerable decrease in the seed infestation with those fungi was observed after the HCl treatment. After this treatment, the percentage of seeds free from the fungi ranged from 92.0% to 96.7%. Statistically, all concentrations of the HCl solution were equally effective though. The other of the identified fungi occurred at low levels (0.2-1.5%) and the HCl seed treatment had no significant effect on their incidence.

Generally, the low percentage of infected seeds, observed after the HCl soaking, pointed out that the majority of the fungi were seed surface contaminants. Probably their incidence was reduced by the hydrochloric acid. Chlorine

compounds, such as a sodium hypochlorite are commonly used in seed health testing for the pretreatment procedures (ISTA 1999).

The carried-out seed scarification with the solution of HCl improved both germination capacity and state of health of the tested carrot seeds. Similar results were received by Hermansen et al. (1999) who treated the carrot seeds with hot water. Other researchers, however, when priming carrot seeds, found decrease in their state of health (Janas et al. 2000) correlated with the improvement of their germination energy (Tylkowska and van der Bulk 2001).

CONCLUSION

1. There is a possibility of improving germination and state of health of carrot seeds by soaking them in the hydrochloric acid.
2. In the concentration 0.5%, HCl improved both germination energy, capacity and state of health of the tested seeds.
3. In the range of 1.0% to 2.5%, HCl did not reduce the seed germination capacity but improved their state of health, decreasing, however, the maximum germination.

REFERENCES

ANONYMOUS, 1880. Przygotowanie do siewu trudno wschodzących nasion. Ogrodnik Polski 4: 100-101.

BINIEK A., 1994. The influence of osmoconditioning in polyethylene glycol (PEG 6000) on the germination and emergence of carrot and parsley seeds. Acta Hort. 371: 77-81.

BINIEK A., 2001. Influence of fungicide treatment and osmoconditioning with polyethylene glycol on germination of graded carrot seeds. Veg. Crops Res. Bull. 55: 115-120.

DĄBROWSKA B., KOLASIŃSKA K., 1995. Wstępne badania wartości uszlachetnionego materiału siewnego marchwi i pietruszki. Biul. IHAR 193: 121-133.

DREW R.L., HANDS L.J., GRAY D., 1997. Relating the effects of priming to germination of unprimed seeds. Seed Sci. Technol. 25: 537-548.

DUCZMAL K.W., TYLKOWSKA K., 1990. Badania nad kiełkowaniem nasion marchwi II. Możliwości poprawienia zdolności kiełkowania. Biul. IHAR 176: 93-98.

GENEVE R.L., 1998. Seed dormancy in commercial vegetable and flower species. Seed Tech. 20: 236-250.

GRAY D., 1989. Improving the quality of horticultural seeds. Profess. Hort. 3: 117-123.

HERMANSEN A., BRODAL G., BALVOLL G., 1999. Hot water treatments of carrot seeds: effects on seed-borne fungi, germination, emergence and yield. Seed Sci. Technol. 27: 599-613.

HRYNIEWIECKI B., 1952. Owoce i nasiona. PWN, Warszawa: 89.

ISTA, 1987. Handbook on Seed Health Testing. Section 2. Working Sheet No 5. Zürich, Switzerland.

ISTA, 1999. International Rules for Seed Testing. International Seed Testing Association, Seed Sci. Technol. 27, Supplement.

JALINK H., VAN DER SCHOOR R., 1999. SeedCalculator 2.1. License number: 100200122. Plant Res. Intl. Wageningen, the Netherlands.

JANAS R., HABDAS H., SZAFIROWSKA A., 2000. Health status and cytological changesin matriconditioned seeds. Phytopatol. Polonica 19: 117-125.

JHA B.N., SINHA R.P., 1989. Hard-seededness in *Vicia faba* L. FABIS 24: 37-38.

KHAN A.A., SZAFIROWSKA A., SATRIYAS I., PTASZNIK W., 1995. Presowing seed conditioning to improve stand establishment and yield of vegetables. J. Kor. Soc. Hort. Sci. 36: 438-451.

LOVE B., JOHNSON W.S., FERNANDEZ G.C.J., 1994. A germination study of purple sage. Hort. Tech. 4: 244-247.

MAGUIRE J.D., ANDERSON W.C., MARING E.S., 1993. Enhanced performance of cucumber seed by matriconditioning integrated with phosphoric acid and fungicide treatments. Proc. 4 th. Intl. Workshop on Seeds: Basic and Applied Aspects of Seed Biology, Angers, France, D. Côme, F. Corbineau. Paris, France; ASFIS 3: 1075-1080.

MASUDA M., KONISHI K., 1993. Improvement of high-temperature germination of spinach seeds with acid scarification and priming with polyethylene glycol 6000. J. Japan. Soc. Hort. Sci. 62: 419-424.

MURRAY G.A., 1989. Osmoconditioning carrot seed for improved emergence. HortSci. 24(4): 701.

PILL W.G., EVANS T.A., 1991. Seedling emergence and economic yield from osmotically primed or hydrated seeds of carrot (*Daucus carota* L.). J. Hort. Sci. 66: 67-74.

SABA, PUROHIT M., IQBAL M., SRIVASTAVA P.S., 1997. Seed germination studies on an important medicinal plant, *Silybum marianum* (Linn.). Hamdard Medicus 40: 31-33.

STRANDBERGER J.O., WHITE J.M., 1989. Response of carrot seeds to heat treatments. J. Amer. Soc. Hort. Sci. 114: 766-769.

SZAFIROWSKA A., JANAS R., 2000. Integrating matriconditioning and chemical seed treatment to improve carrot field emergence and yield. Veg. Crops Res. Bull. 53: 55-63.

TYLKOWSKA K., BINIEK A., 1996. Fungi and germination of carrot and parsley seeds under osmoconditioning and fungicide treatment. Phytopatol. Polonica 12: 51-61.

TYLKOWSKA K., VAN DER BULK R.W., 2001. Effects of osmo- and hydropriming on fungal infestation levels and germination of carrot (*Daucus carota* L.) seeds contaminated with *Alternaria* spp. Seed Sci. Technol. 29: 365-375.

YANMAZ R., 1994. Effects of pre-sowing PEG (polyethylene glycol) treatments on the germination and emergence rate and time of carrot seeds. Acta Hort. 362: 229-234.

WPŁYW SKARYFIKACJI CHEMICZNEJ NA KIEŁKOWANIE I ZDROWOTNOŚĆ NASION MARCHWI (*DAUCUS CAROTA* L.)

Streszczenie: Nasiona marchwi ‘Jawa’ moczono (12h/20ºC) w wodzie i 0,5%, 1,0%, 1,5%, 2,0% oraz 2,5% kwasie solnym (HCl), następnie suszono (24h/20ºC) i badano ich kiełkowanie oraz zdrowotność. Traktowanie nasion 0,5% HCl zwiększyło ich energię (57,0%), zdolność (63,3%) i szybkość kiełkowania (kontrola: 45,0% i 47,7%). Stężenia HCl powyżej 0,5% nie wpłynęły na zdolność kiełkowania, ale zmniejszyły maksymalne kiełkowanie, a powyżej 1,0% zwiększyły odsetek nasion martwych. Wszystkie stężenia HCl poprawiły zdrowotność nasion.

Received September 15, 2003; accepted May 13, 2004