THE INFLUENCE OF DESICCATION FOLLOWING PRETREATMENT ON GERMINATION OF LETTUCE SEEDS

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Abstract

Seeds of certain lettuce cultivars need a pretreatment to obtain full germination up to an upper temperature limit of at least 28-30 °C. Seed handling requires desiccation of the pretreated seeds. However, desiccation often results again in a reduction of the upper temperature limit. This reduction was limited if the relative humidity during desiccation was increased. Neither the rate of drying, nor the temperature during drying significantly influenced the reduction of the upper temperature limit. It is concluded that the determining factor is the seed moisture content which remains after desiccation. Drying to a moisture content of 9% instead of the usual, lower values prevents almost any reduction of the upper temperature limit. These seeds could be stored for at least 18 weeks at 2 °C without any effect on the upper temperature limit.

1. Introduction

The germination of seeds of several lettuce (*Lactuca sativa* L.) cultivars is inhibited by temperatures exceeding 20 to 24 °C. This thermoinhibition is a strong hindrance to the cultivation of lettuce both in glasshouses and in the field. Osmotic pretreatment of the seeds has been shown to be an effective method to raise the upper temperature limit (Guedes and Cantliffe, 1980). Following pretreatment seeds have to be dried back to permit seed handling and storage. However, drying back the seeds often causes a partial loss of the beneficial effects of the pretreatment (Heydecker and Coolbear, 1977). The present contribution describes some preliminary results on the influence of the relative humidity during the drying period on the effectiveness of the pretreatment.

2. Materials and Methods

Commercial seed lots of lettuce cv. Musette were used. Triplicates of 50 seeds were pretreated in 5 cm Petri dishes on one layer of filter paper (Schleicher & Schüll No. 595) moistened with 1.5 ml distilled water. Pretreatment occurred either during 16 to 20 h at 15 °C or 72 h at 2 °C. Temperatures were realized in cooled incubators (Gallenkamp, Crawley, U.K.) (T ± 1 °C). After pretreatment the seeds were surface-dried in a Büchner funnel and transferred to a fresh filter paper in a second Petri dish. Thereafter in some treatments seeds were moistened with 1.5 ml distilled water and set to germinate at a range of temperatures. In other treatments seeds were dried back prior to germination. To dry seeds back at controlled relative humidity a drying equipment was developed based on the principle that saturated salt solutions are in equilibrium with a known relative humidity (Fig. 1). Surface-dried seeds in Petri dishes were placed in the hygrostat until the moisture content of the seeds was in equilibrium with the relative humidity of the atmosphere. This hygrostat was used in all experiments except for the test of the influence of the temperature on the drying process, which was performed in climate cabinets.

The moisture content of the seeds was determined by weighing (± 0.1 mg) about 200 mg seeds in little vials before and after oven drying at 130 °C during 1.5 h. The relative humidities above the salt solutions were measured with a Rotronic Hygroshop GT-L (± 2% r.h.) (Rotronic AG, Zürich, Switzerland).

3. Results and discussion

Without a pretreatment lettuce seeds cv. Musette did not germinate for 100% above a temperature of 20 °C (Fig. 2). A pretreatment during 20 h at 15 °C increased the limit to 28 °C. Drying back at 13% relative humidity, above saturated LiCl, caused a dramatic decrease to 22 °C, whereas at 88% relative humidity, above saturated Na_2CO_3, the beneficial effect of the pretreatment was maintained. Drying above saturated $Ca(NO_3)_2$, which resulted in 50% relative humidity, took an intermediate position. The different relative humidities of the atmosphere in the hygrostat strongly influenced the moisture content which was left in the seeds (Table 1). Drying to a moisture content of 4.2% in 13% relative humidity did not cause an irreversible change in the seeds, since the reduction of the upper

temperature limit could be reversed by a renewed treatment at 15 °C (data not shown). Thus, the drying did not cause real damage to the seeds as occurred, for instance, if seeds that had been treated longer than 20 h in water at 15 °C, were dried back. The seedlings of those seeds developed abnormal roots, most obvious because the seeds had entered the elongation phase, making them more vulnerable to desiccation.

Guedes and Cantliffe (1980) compared the effect of drying in air at 21 °C with a more rapid oven drying at 32 °C of pretreated lettuce seeds. In three different cultivars they observed a stronger reduction of germination after oven drying. In the present study temperatures in the range from 10 to 30 °C did not change the influence of relative humidity during desiccation (Table 2). In this experiment the seeds were pretreated for 3 d at 2 °C and the relative humidity was established in climate cabinets. Nevertheless it was found again that low relative humidity during drying reduced germination at 30 °C, whereas drying at high relative humidity kept the effect of the pretreatment intact.

The influence of the rate of drying was investigated by opening or closing the Petri dishes during the drying of the seeds at a relative humidity of 13% (Table 3). After 3 h in a closed Petri dish the germination at 28 °C was hardly reduced, whereas 3 h in an open dish caused a strong reduction. If the drying process took 7 h divided into 3 h of slow drying and 4 h of fast drying, the influence on the germination at 28 °C was similar to fast drying only.

It is concluded that neither the drying rate nor the drying temperature determines the effect on the germination process. The determining factor is obviously the moisture content which is left when the seeds are in equilibrium with the surrounding atmosphere in the hygrostat. It can also be seen in the studies of Guedes and Cantliffe (1980) with lettuce seeds and of Brocklehurst and Dearman (1983) with seeds of onion, carrot and celery that lower germination after drying correlates with lower moisture content.

A disadvantage of moisture contents higher than 5 to 6% is that the survival capacity of the seeds is strongly reduced (Villiers, 1973, Ibrahim and Roberts, 1983). We stored pretreated seeds after drying to a moisture content of 9% in glass vials (3000 seeds in 8 ml) at 24 °C or 2 °C. At 24 °C the upper temperature limit decreased within a few weeks, most probably preceeding seed death. Storage at 2 °C kept the germination

at 28 ^{o}C unchanged during at least 18 weeks (Table 4).

References

Brocklehurst, P.A., and Dearman, J., 1983. Interactions between seed priming treatments and nine seed lots of carrots, celery and onion. I. Laboratory germination. Ann. Appl. Biol. 102: 577-584.

Guedes, A.C., and Cantliffe, D.J., 1980. Germination of lettuce seeds at high temperature after seed priming. J. Amer. Soc. Hort. Sci. 105: 777-781.

Heydecker, W., and Coolbear, D., 1977. Seed treatments for improved performance - survey and attempted prognosis. Seed Sci. and Technol. 5: 353-425.

Ibrahim, A.E., and Roberts, E.J., 1983. Viability of lettuce seeds. I. Survival in hermetic storage. J. Exp. Bot. 34: 620-630.

Villiers, T.A., 1973. Ageing and longevity of seeds under field conditions. In: Seed ecology. Ed. W. Heydecker. Butterworths London: 265-288.

Figure 1 - Scheme of the hygrostat. The hygrostat consists of a plastic container (65 x 45 x 40 cm), filled with 2.5 l saturated salt solution. The Petri dishes with seeds were placed on top of a perforated and inverted tray. The air in the hygrostat was moved, by means of a fan, through a plastic pipe with small holes just above the salt solution. See for relative humidities above the different salt solutions Table 1.

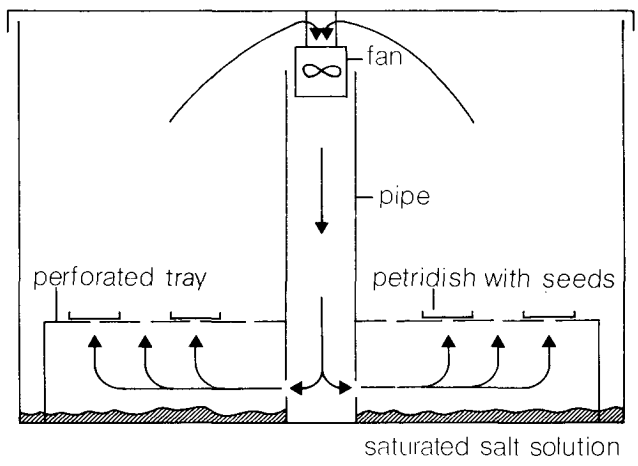

Figure 2 - The effect of pretreatment on the germination of lettuce seeds cv. Musette at different temperatures. The seeds were not pretreated (●) or pretreated during 16 h at 15 °C in water, without (o) or with an additional 24 h in the hygrostat in equilibrium with relative humidities of 88% (Δ), 50% (□) or 13% (◇). Vertical bars indicate S.D.

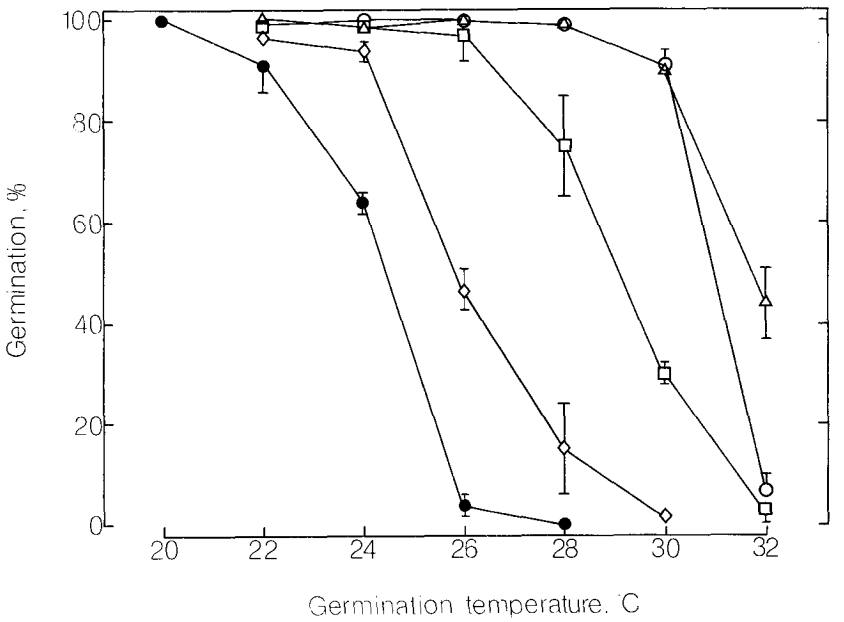

Table 1 - The effect of saturated solutions of different salts on the relative humidity of the atmosphere in the hygrostat and the moisture content of lettuce seeds cv. Musette after 24 h of equilibration; the seeds had been pretreated during 16 h at 15 °C.

saturated salt solution	Na_2CO_3	NaCl	$Ca(NO_3)_2$	$CaCl_2$	LiCl
relative humidity	88	73	50	32	13
moisture content	13.0	8.8	6.8	6.0	4.2

Table 2 - The influence of temperature and relative humidity during drying of lettuce seeds cv. Musette in climate cabinets on germination at 30 °C; the seeds had been pretreated during 72 h at 2 °C.

	Germination, % ± S.D.		
	relative humidity, %		
temperature (°C)	30	60	90
10°	1 ± 1	57 ± 12	92 ± 0
20°	11 ± 6	70 ± 16	99 ± 1
30°	1 ± 1	73 ± 12	91 ± 3

Table 3 - The effect of drying in open and/or closed Petri dishes in the hygrostat above saturated LiCl (13% relative humidity) on the germination at 28 °C of lettuce seeds cv. Musette; the seeds had been pretreated during 16 h at 15 °C.

Drying time (h)		Germination	moisture
Petri dishes		% ± S.D.	content
closed	open		(%)
3	0	81 ± 8	37
3	4	12 ± 7	6
0	3	11 ± 3	7

Table 4 - The influence of storage at 2 °C in closed glass vials (3000 seeds in 8 ml) on germination of lettuce seeds cv. Musette at 28 °C and at 30 °C; the seeds had been pretreated during 16 h at 15 °C and had been dried back at 75% relative humidity to a moisture content of 9%.

	Germination, %			
Germination temperature	Storage (weeks)			
(°C)	1	4	8	18
28°	97 ± 2	98 ± 2	99 ± 1	98 ± 0
30°	85 ± 9	73 ± 5	92 ± 2	77 ± 5