Effect of hydration treatments on seed parameters of different lettuce (*Lactuca sativa* L.) seed lots

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ABSTRACT: The influence of hydration treatments on seed parameters of lettuce seed lots with different initial quality was investigated. Nine seed lots were treated by prehydration (for 3, 6, 12 and 24 hours) and by osmopriming in polyethy-lene glycol 6000 solution (for 24, 72 and 144 hours) with osmotic potential –1.5 MPa. The result of hydration treatment depends on seed lot attributes. The germination percentage is not a sufficient criterion for determination of seed suitability for hydration treatment. A possible complementary parameter can be the mean time of germination (MTG) with high correlation between untreated and treated seed lots. The effect of hydration also depends on the hydration method and time of treatment. The osmopriming is a more suitable method for lettuce seed than prehydration. Generally, a shorter time of hydration (till 6 hours at prehydration and till 72 hours at priming) proved more effective on the parameters of lettuce seed lots after treatment.

Keywords: lettuce; seed; treatment; prehydration; osmotic priming; germination

Research on new seed treatment methods reflects seed producers' efforts to satisfy seed users' enhanced requirements for seed quality. Hydration treatments are presented in literature as a possibility of improvement of seed parameters, especially of an increase in germination percentage, faster and more uniform emergence and germination under a broader range of environmental conditions (COPELAND, MCDONALD 1995). Some seed companies already use these methods as a special seed treatment in practice.

The principle of hydration treatments is based on the fact that it is possible to hydrate seeds in some ways at a moisture level sufficient to initiate the early events of germination but not sufficient to permit radicle protrusion.

Methods of hydration can be divided into two groups depending on whether water uptake is uncontrolled (prehydration) or controlled (osmotic priming, solid matrix priming) (TAYLOR et al. 1998).

Water uptake during prehydration is governed only by the affinity of the seed tissue for water. Seeds are imbibed on moistened blotters or soaked in water. Because water is not limited, seeds can eventually germinate assuming that they are viable, not dormant, and optimal conditions are provided. Therefore, in uncontrolled systems the process must be arrested at a specific time to prevent radicle protrusion.

In controlled hydration the amount of water available for seeds is restricted or the water potential of hydration medium can be regulated. During osmotic priming seeds are imbibed in an osmotic solution of e.g. KNO_3, K_3PO_4, glycerol, mannitol, polyethylene glycol – PEG. The solid matrix priming employs a mixture of solid carrier (vermiculite, Celite, Mikro-Cel) with water as a hydration medium.

After hydration, seeds are dried to enable normal handling, storage and planting. But drying can reduce the advantages gained by hydration. Various methods of drying are used: open drying on filter paper in ambient air or oven drying in ambient or forced air.

In the last years various hydration methods were tested (KHAN et al. 1992; TARQUIS, BRADFORD 1992), use of different substances was compared (PÉREZ-GARCÍA et al. 1995; MAUROMICALE, CAVALLARO 1997) and the effect of hydration treatments on subsequent germinability and vigour of treated seeds was investigated, often in environments with high temperatures (VALDES, BRADFORD 1987) or in other unfavourable conditions (SUZUKI et al. 1993; OZBINGOL et al. 1998).

These experiments were usually carried out with one or two seed samples and seed quality was often ignored. Although it is generally known that seed lots can significantly differ in seed quality, the effect of seed quality on the asset of hydration treatments is seldom taken into consideration. The aim of this experiment was to evaluate the effect of hydration treatments on seed parameters of lettuce seed lots with different initial quality.

MATERIAL AND METHODS

Seeds

Seeds of lettuce (*Lactuca sativa* L.), often used as a model plant, were employed in this study. Nine lots of

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Table 1. Hydration methods

Hydration method	Time of treatment (hours)
Prehydration (simple imbibition)	3, 6, 12 and 24
Osmopriming (imbibition in lower water potential of osmotic medium)	24, 72 and 144

standard seed (cultivars Smaragd "S", Podřipan and Jupiter) intended for commercial use, with different declared initial seed germination rates (82–99%) were tested in two stages (lots 1–4 in 1997 and lots 5–9 in 1998).

Hydration methods

Seed lots were treated by two hydration methods: prehydration and osmotic priming, each method with different time of treatment (Table 1).

Prehydration was carried out in distilled water, without aeration, at a temperature 20°C. Osmopriming was done in PEG 6,000 solution at 20°C, with osmotic potential –1.5 MPa, prepared by MICHEL and KAUFMANN (1973). The PEG solution was aerated with ambient air. After both hydration methods were terminated, seeds were dehydrated on filter paper in two steps: at first free water was quickly drained off and then seeds were let on filter paper in the open for 24 hours at a temperature 22°C and RH 42%.

Seed germination percentage and mean time of germination (MTG) of all treated samples and untreated control were determined.

Lots evaluation

Germination test – was evaluated at 20°C, in plastic boxes on filter paper (crepe, 120 g/m^2), with underlying sand saturated with 60% of water, in four replications of 100 seeds each. Germination was counted in 24 hours intervals. Radicle protrusion of 3 mm was scored as germination.

Mean time of germination (MTG) – was calculated from daily germination values by the equation of NICHOLS and HEYDECKER (1968):

$$\frac{\sum n_d d}{\sum n_d} \qquad (1)$$

where: n_d – number of seeds that germinated on the day (d),
d – serial number of the day.

Statistical analysis

Experimental data were analysed by a statistical packet SAS, version 6.12. Analysis of variance was used to evaluate the effect of hydration treatment and seed lots, exactly SAS GLM (General Linear Model) procedure. The means were compared by Tukey's test. The mean values of treated samples were related by correlation analysis to the mean values of untreated samples.

RESULTS AND DISCUSSION

Changes in seed values after hydration treatment

Seed values of untreated seed (control) and treated samples are shown in Tables 2 and 3.

Prehydration had no positive effect on an increase in germination percentage or on MTG reduction on average of all evaluated seed lots. On the contrary, germination percentage with prolonged prehydration time decreased and MTG had an increasing tendency relative to the longer time of prehydration. Seed treatment by priming for 24 and 72 hours had positive statistically significant effects on a decrease in MTG (on average) compared with MTG of untreated lots. Germination percentage after priming decreased, most of all in the variant with longest time of treatment.

Table 2. Germination of seed lots after hydration treatment (%)

Treatment	Time of treatment (h)	Seed lots 1	2	3	4	5	6	7	8	9	Average
Control	0	93.5 a	96.0 a	95.5 a	95.0 a	97.5 a	96.0 a	85.0 bc	80.8 a	88.8 a	92.0 a
Prehydration	3	61.8 cd	97.8 a	93.0 a	91.8 a	98.0 a	92.5 ab	92.5 ab	83.0 a	87.5 a	88.6 b
Prehydration	6	62.3 cd	97.8 a	96.0 a	92.3 a	96.3 a	93.0 ab	95.0 ab	79.0 a	92.3 a	89.0 b
Prehydration	12	54.0 d	96.8 a	81.3 b	90.3 a	96.3 a	94.5 a	80.5 c	83.8 a	89.8 a	85.2 c
Prehydration	24	61.8 d	94.0 ab	74.3 b	71.3 c	92.8 a	86.8 b	76.8 c	85.8 a	86.5 a	81.1 d
Priming	24	68.3 bc	95.5 a	94.5 a	59.5 d	94.8 a	86.5 a	96.5 a	85.8 a	91.3 a	86.9 bc
Priming	72	74.8 b	87.0 b	94.5 a	81.0 b	96.0 a	93.8 a	93.5 ab	83.3 a	88.5 a	88.0 b
Priming	144	59.3 cd	90.8 ab	91.8 a	25.8 e	96.5 a	93.8 a	82.0 c	86.0 a	86.5 a	79.1 d
LSD		10.0	7.5	8.1	8.2	7.7	6.6	9.7	12.4	10.5	2.8
F-test		33.6	5.8	21.5	183.7	1.0	4.5	12.2	0.9	0.9	43.6
Significance level		< 0.01	< 0.01	< 0.01	< 0.01	0.46	< 0.01	< 0.01	0.52	0.52	< 0.01

LSD – least significant difference

Values in columns marked with the same letter are insignificantly different on significance level $\alpha = 0.05$

Table 3. Mean time of germination of seed lots after hydration treatment (days)

Treatment	Time of treatment (h)	Seed lots 1	2	3	4	5	6	7	8	9	Average
Control	0	5.12 bc	2.66 de	2.72 c	2.99 bc	2.01 e	2.03 c	2.70 d	3.78 a	2.57 bc	2.96 e
Prehydration	3	5.42 b	3.16 c	3.38 b	3.67 a	2.24 cde	2.14 c	4.31 b	3.86 a	2.44 bc	3.40 c
Prehydration	6	6.02 a	3.50 b	3.32 b	3.56 a	2.47 c	3.45 a	4.59 ab	3.84 a	2.63 b	3.71 b
Prehydration	12	6.17 a	3.75 ab	4.22 a	3.69 a	3.08 b	2.68 b	3.60 c	3.88 a	2.56 bc	3.74 b
Prehydration	24	6.25 a	3.97 a	4.17 a	3.57 a	3.92 a	2.59 b	4.18 b	4.36 a	3.36 a	4.04 a
Priming	24	4.59 d	2.50 e	3.10 b	3.13 b	2.20 de	1.95 c	2.01 e	2.88 b	2.17 c	2.73 f
Priming	72	4.72 cd	2.80 d	2.25 d	2.62 c	2.00 e	1.95 c	2.67 d	2.58 b	2.28 bc	2.65 f
Priming	144	5.10 bc	2.77 d	2.32 d	3.69 a	2.35 cd	2.09 c	5.04 a	3.07 b	2.71 b	3.24 d
LSD		0.50	0.26	0.32	0.42	0.25	0.29	0.56	0.66	0.45	0.13
F-test		36.86	96.07	124.5	19.76	155.1	73.01	80.63	18.68	14.17	267.85
Significance level		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

LSD – least significant difference
Values in columns marked with the same letter are insignificantly different on significance level $\alpha = 0.05$

These equivocal results are in contrast with the results of other authors who in their experiments reported either improvement of germination percentage (MAUROMICALE, CAVALLARO 1995) or MTG reduction after prehydration (TARQUIS, BRADFORD 1992). The MTG reduction after priming corresponds with the results by DREW and DEARMAN (1993) or by PÉREZ-GARCÍA et al. (1995).

But nine seed lots with different initial quality were evaluated in this experiment. If we examine our results of hydration in detail, i.e. in individual lots, we can find seed lots with improved germination (lot 7) or lots with MTG after prehydration on a similar level (insignificant difference) in comparison with untreated seed (lots 8 and 9).

A very important result of this experiment is the diverse responses of different seed lots to hydration treatment. The "negation" of average results makes us consider hydration treatments as not generally applicable technology for seed treatment, but as selective technology applicable only to concrete seed lots, for quality improvement of good seed lots.

The tested lettuce seed lots can be divided on the basis of responses after hydration treatment into three groups:

1. Lots with statistically significant reduction of MTG and with germination on the same or higher level than in untreated seed (lots 3, 7 and 8).
2. Lots with MTG and germination after hydration on the same level (insignificant difference) as in untreated seed (lots 2, 5, 6 and 9).
3. Lots with increased MTG or with reduced germination (significant difference) in comparison with untreated seed (lots 1 and 4).

Seed producers are interested in seed lots from the first group, which proves a requisite effect after hydration, i.e. reduction of MTG while germination is retained minimally on the initial level before hydration.

Seed lots from the second group retained similar parameters after hydration in comparison with seeds before hydration, but the expected effect of MTG reduction was not produced. Hydration treatment had no effect on the seed quality of lots from the second group.

Lots from the third group, whose germination considerably decreased after hydration, are not suitable for hydration treatments.

Correlation analysis

High correlation coefficients (above 0.80) were determined between MTG of untreated lots and MTG of treated samples (Table 4). A high correlation (above 0.80) with MTG of untreated lots was also observed in some values of germination after prehydration for 3, 6 and 12 hours and after priming lasting 72 hours. Correlation coefficients between germination of untreated seed and seed parameters of treated seed lots are very low.

The high correlation coefficients correspond with the results reported by DREW et al. (1997), who also determined a high correlation between MTG of untreated seeds and MTG of seeds treated by priming.

Comparison of used hydration methods

Prehydration is a simple method of hydration treatment. It does not require any special technical equipment and owing to the use of distilled water as a hydration medium it is probably the cheapest hydration method. Similarly, FUJIKURA et al. (1993) presented prehydration as a simple and inexpensive method of seed hydration.

But as it is evident from experimental results, the effect of prehydration on MTG reduction is questionable. The shorter time of prehydration (3 and 6 hours) is more effective than the longer one, but MTG of all seed lots (except lot 9) increased after treatment (in lots 1, 5, 6 and 8 statistically insignificantly). TARQUIS and BRADFORD (1992) admittedly demonstrated MTG reduction in lettuce seeds, but their experiment was conducted with one seed lot only.

Osmotic priming is a more exacting method. A solution of osmotic substance whose price can be high is used for hydration. In the case of PEG this method also demands

Table 4. Correlation coefficients between seed values of untreated and treated seed

Parameter	Germination Untreated control	MTG Untreated control
Germination		
Prehydration 3 hours	0.28	–0.92
Prehydration 6 hours	0.35	–0.94
Prehydration 12 hours	0.21	–0.89
Prehydration 24 hours	0.01	–0.71
Priming 24 hours	–0.02	–0.62
Priming 72 hours	0.23	–0.86
Priming 144 hours	–0.06	–0.45
MTG		
Prehydration 3 hours	–0.31	0.90
Prehydration 6 hours	–0.19	0.85
Prehydration 12 hours	0.01	0.90
Prehydration 24 hours	–0.15	0.88
Priming 24 hours	0.05	0.88
Priming 72 hours	–0.06	0.92
Priming 144 hours	–0.30	0.71

Parameters are arranged in an ascending order by the time of treatment, upper value is correlation coefficient, lower value represents significance level

an equipment for aeration of hydration solution. Owing to these two requirements osmotic priming is a more expensive method in comparison with prehydration. The effect of priming is admittedly higher (MTG after treatment decreased significantly in four of the nine seed lots), especially in shorter treatments (24 and 72 hours).

The result of lettuce seed hydration treatment depends on the quality of treated seed lot. Seed lots with similar (high) germination ability determined in a standard way can respond to hydration treatment differently. Thus germination percentage is not a sufficient criterion to determine the seed suitability for hydration treatment. On the basis of a high correlation between MTG of untreated seeds and MTG of treated seed lots MTG appears to be a possible complementary parameter.

The resultant effect of hydration also depends on the used method and time of treatment. The osmotic priming is a more suitable hydration method in comparison with prehydration, although it is methodically, technically and financially more exacting than prehydration. Optimal time of osmotic priming for lettuce seed in this experiment was 72 hours in the solution of PEG with osmotic potential –1.5 MPa. A shorter time of hydration (till 6 hours in prehydration and till 72 hours in priming) seems to have a higher effect on the seed parameters of lettuce seed lots after treatment.

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Vliv hydratačních úprav na semenářské parametry partií salátu (*Lactuca sativa* L.)

ABSTRAKT: V experimentu byl zjišťován vliv hydratačních úprav na semenářské parametry partií osiva salátu s rozdílnou počáteční kvalitou. Devět vzorků osiva bylo upraveno prehydratací (expozice 3, 6, 12 a 24 hodin) a osmotickým primingem v roztoku polyethylenglykolu 6000 (expozice 24, 72 a 144 hodin) s osmotickým potenciálem –1,5 MPa. Výsledek hydratační úpravy závisí na parametrech osiva. Klíčivost osiva není postačujícím kritériem pro určení vhodnosti osiva pro hydratační úpravu. Možným doplňujícím parametrem by mohla být střední doba klíčení (MTG), která má vysokou korelaci se střední dobou klíčení upraveného osiva. Efekt hydratace také záleží na použité metodě hydratace a na délce jejího trvání. Osmotický priming je pro salát vhodnější hydratační metodou než prehydratace. Obecně je možné říci, že kratší doby trvání hydratace (do 6 hodin u rehydratace a do 72 hodin u primingu) měly na semenářské parametry osiva salátu po úpravách větší vliv.

Klíčová slova: salát; osivo; úprava; prehydratace; osmotický priming; klíčení

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