An Effective Post-sown Priming Method to Improve Emergence from Lettuce Seeds at High Temperature

Ken Takahata[1], Yoko Mine[1], Atsukiyo Karimata[1], and Hiroyuki Miura[1,2]

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Summary. **A study was conducted to improve the seedling emergence rate of lettuce (*Lactuca sativa*) seeds at high temperatures using a convenient postsown priming method. Seeding mixtures adjusted to 35%, 45%, or 55% moisture content were sown with lettuce 'Patriot' in cell trays. Postsown priming was performed at 20 °C for 1 day and at 30 °C for 3 or 5 days. After the treatment, trays were moved to an emergence room kept at 32.5 °C, a temperature assumed to be typical of non-air-conditioned rooms in nurseries. Emergence of nonprimed controls was 9% to 16% after 2 days in the emergence room and was 59% to 75% on day 6. In contrast, seedling emergences on day 2 were 95%, 76%, and 78% to 79% in 55% moisture at 20 °C for 1 day, 55% moisture at 30 °C for 3 days, and 45% to 55% moisture at 30 °C for 5 days, respectively. Therefore, the treatment with 55% moisture at 20 °C for 1 day appeared most effective; however, post-sown priming with 55% moisture at 30 °C for 3 days or 45% to 55% moisture at 30 °C for 5 days may be more practical due to lower temperature-control costs.**

Cell trays for raising vegetable seedlings on a large scale have become increasingly popular because of their low cost; however, the method yields poor emergence rates due to the high temperatures when lettuce seeds are sown in the summer. Inhibition of lettuce seed germination under high temperatures was reported by Gray (1975) who found that germination rates substantially decreased over 22 °C. Therefore, growth chambers which allow to adjust the internal temperature to the optimum temperature are very effective, but high purchase, maintenance, and operating costs limit their use in many agricultural nurseries.

In seed priming, small amounts of water are supplied to seeds so that the water can be taken up through osmotic or matric forces, leading to an activation of numerous seed enzymes. There have been many reports that seed priming before sowing improves the uniformity and rates of lettuce emergence at high ambient temperatures (Cantliffe et al., 1981; Guedes and Cantliffe, 1980; Khan et al., 1990; Taylor et al., 1988); however, seed priming has not been widely applied in Japan since it requires advanced technical expertise, and the costs of seed processing by commercial firms are high.

We suppose that priming can be used very efficiently in nurseries where seeds can be sown immediately after the priming step. Miura et al. (1997, 2001) attempted to develop an easy and practicable post-sown procedure for priming malabar spinach (*Basella alba*) and parsley (*Petroselinum crispum*) seeds, which are not cultivated much in Japan because of low emergence rates.

The present study was conducted to determine the most effective method for post-sown priming of lettuce, one of the very important vegetable crops that are produced in relatively large quantities in Japan.

Materials and methods

The design of the experiments is shown in Fig. 1. A seeding mixture (Yosaku N-150; Chisso Asahi Fertilizer Co., Tokyo) formulated for raising vegetable seedlings in cell trays was adjusted to 35%, 45%, or 55% moisture content (moisture weight per moist substrate weight) and was evenly distributed into 128-hole cell trays (Landmark Plastic Corp., Akron, OH) divided into four sections. One 'Patriot' lettuce seed (Nitto Nosan Seed Co., Yokohama, Japan) was sown 5 mm deep in each cell. 'Patriot' is a crisphead lettuce type that is sown in the summer in major producing regions. The trays were placed in plastic containers (32 cm long, 22 cm wide, 11 cm high) covered with lids for moisture retention and were kept in a thermostatic room (LH·200; Nippon Medical & Chemical Instruments Co., Osaka, Japan) at 20 °C for 1 d (Expt. 1), at 30 °C for 3 d (Expt. 2), or at 30 °C for 5 d (Expt. 3). After the treatment, the sectioned trays were watered and transferred to an emergence room [LH·200; light period = 12 h per day, mean photosynthetic photon flux (*PPF*) = 74 $\mu mol \cdot m^{-2} \cdot s^{-1}$] kept at 32.5 °C. The number of seedlings that had emerged more than about 1 mm was checked daily between 0900 to 1000 HR, and the fresh weight of the aboveground parts (hypocotyl + epicotyl + cotyledons + leaves) was determined on day 6.

Control groups were set up by sowing nontreated seeds on the days when the post-sown priming was completed for the treated groups and the trays were transferred to the emergence room. Three sectioned trays were used for each of the treated and control groups.

Results

Emergence on day 1 in Expt. 1 reached 87% in the 55% moisture group, followed by the 45% moisture group at 60%, the 35% moisture group at 40%, and the control group at 0% emergence (Fig. 2). The average number of days to emergence (Table 1) was lowest (1.11 d) in the 55% moisture group, which also had the highest weight of the aboveground parts with the low coefficient of variation (CV).

Units

To convert U.S. to SI, multiply by	U.S unit	SI unit	To convert SI to U.S., multiply by
2.54	inch(es)	cm	0.3937
25.4	inch(es)	mm	0.0394
28,350	oz	mg	3.5274×10^{-5}
(°F – 32) ÷ 1.8	°F	°C	(1.8 × °C) + 32

[1]Department of Agriculture, Tokyo University of Agriculture, Atsugi, 243-0034, Japan

[2]Corresponding author. E-mail miurahvg@nodai.ac.jp.

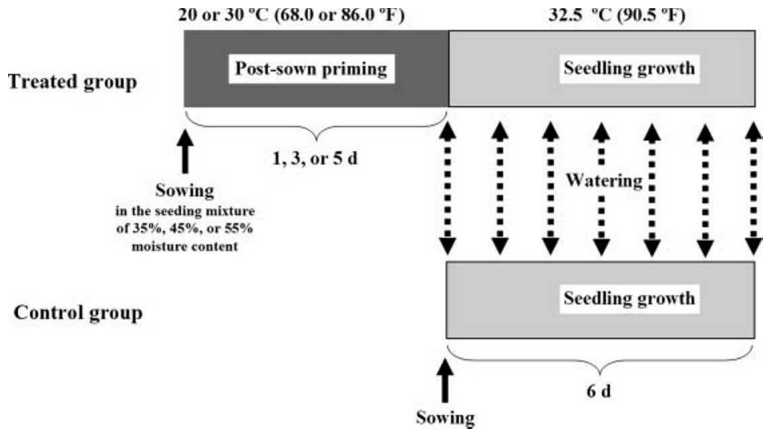

Fig. 1. Procedure of post-sown priming with the seeding mixture followed by seedling growth.

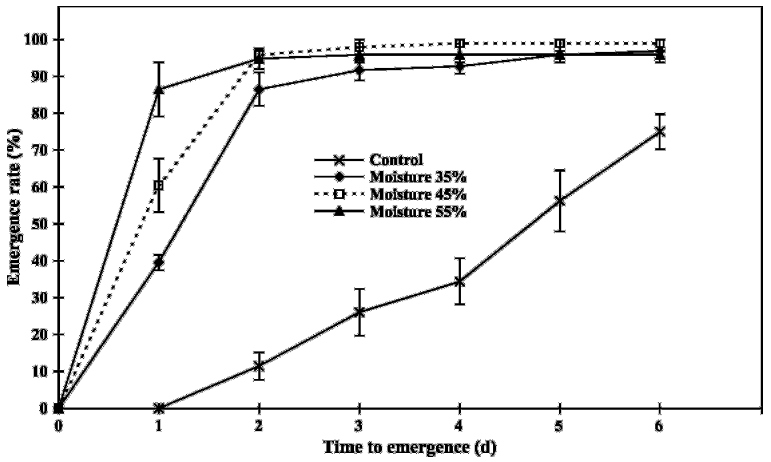

Fig. 2. Effects of post-sown priming with different moisture contents of the seeding mixture at 20 °C (68.0 °F) for 1 d on lettuce emergence at 32.5 °C (90.50 °F) in Expt. 1. Vertical bar = SE.

Table 1. Effect of post-sown priming of lettuce on time to emergence and the fresh weight of the aboveground seedling parts.

Treatment	Mean time to emergence (d)	Fresh wt of aboveground seedling parts	
		Fresh wt (mg)[z]	Coefficient of variation (%)
Expt. 1 [20 °C (68.0 °F) for 1 d]			
Control	4.31 a[y]	13.6 c	48.9
35% seeding mixture moisture	1.81 b	25.5 b	25.1
45% seeding mixture moisture	1.44 bc	26.0 b	22.5
55% seeding mixture moisture	1.11 c	28.9 a	22.6
Expt. 2 [30 °C (86.0 °F) for 3 d]			
Control	4.14 a	14.3 c	44.5
35% seeding mixture moisture	3.44 b	19.8 b	45.9
45% seeding mixture moisture	2.37 c	23.3 a	22.8
55% seeding mixture moisture	2.05 c	24.9 a	18.6
Expt. 3 (30 °C for 5 d]			
Control	3.88 a	18.1 c	50.8
35% seeding mixture moisture	2.88 b	21.2 b	40.3
45% seeding mixture moisture	2.16 c	24.2 a	20.6
55% seeding mixture moisture	2.08 c	25.7 a	14.7

[z]1 mg = 3.5274×10^{-5} oz.
[y]Mean separation by Duncan's multiple range test at $P \leqq 0.05$.

In Expt. 2, emergence was 6% in the 55% moisture group on the day the trays were transferred to the emergence room (Fig. 3). Emergence had begun on day 2 in the other groups. On that day, emergence was 9% in the control, 31% at 35% moisture, 59% at 45% moisture, and 76% at 55% moisture. The 45% and 55% moisture groups required the shortest time to emergence and had the greatest aboveground fresh weight (Table 1), also with the small CV.

In Expt. 3, some seedlings emerged on day 0 in the 45% and 55% moisture groups, with 4% and 8% emerging, respectively (Fig. 4). On day 2, emergence was 16%, 56%, 79%, and 78% in the control, and 35%, 45%, and 55% moisture groups, respectively. The 55% and 45% moisture groups performed better with respect to time to emergence as well as the aboveground fresh weight and the low CV (Table 1).

A direct comparison of emergence in the 55% moisture group of Expt. 2 and the 45% and 55% moisture groups of Expt. 3 indicates that there is no significant difference.

Effects of a treatment of 30 °C/3 d/55% moisture on the emergence of four additional cultivars sown in the hot season in Japan were also assessed. On day 2, emergence rates of 'Exceed' (Nitto Nosan Seed Co.), 'Sunny Boy No.1' (Fujii Seed Co., Osaka, Japan), 'Cisco', and 'Berkeley' (Takii & Company, Kyoto, Japan) were 76%, 75%, 75%, and 87%, respectively, compared with 18%, 12%, 0%, and 14%, respectively, in the control.

Discussion

Gray (1975) examined germination rates of 22 lettuce cultivars in temperatures ranging from 5 °C to 33 °C and found that the optimal temperature for germination was between 15 °C and 22 °C. The germination rate above this range of temperatures was substantially deduced. Borthwick and Robbins (1928) and Thompson et al. (1979) reported similar findings. In the present study, emergence of 'Patriot' seeds was not synchronous in the control groups at 32.5 °C, which presumably is within the temperature range of noncooled growth rooms during the hot season.

Guedes and Cantliffe (1980), Cantliffe et al. (1981), Taylor et al.

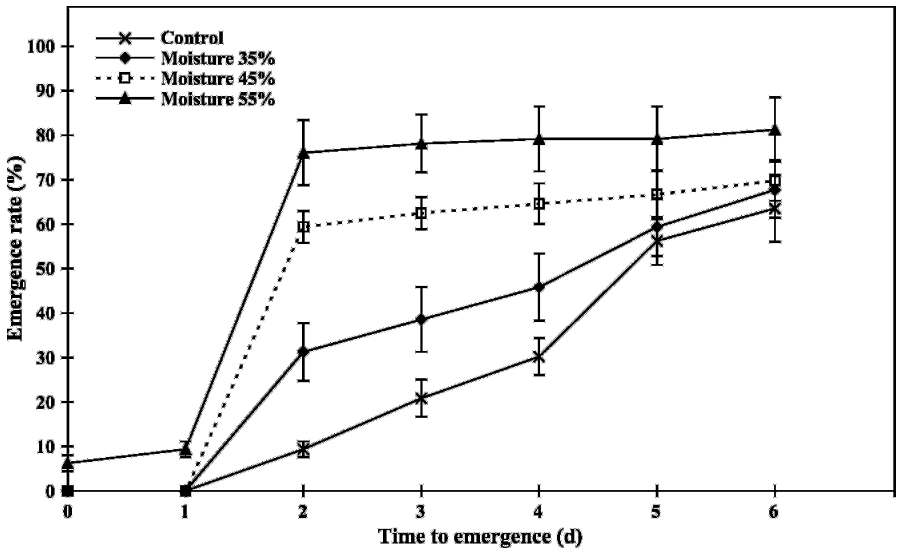

Fig. 3. Effects of post-sown priming with different moisture contents of the seeding mixture at 30 °C (86.0 °F) for 3 d on lettuce emergence at 32.5 °C (90.50 °F) in Expt. 2. Vertical bar = SE.

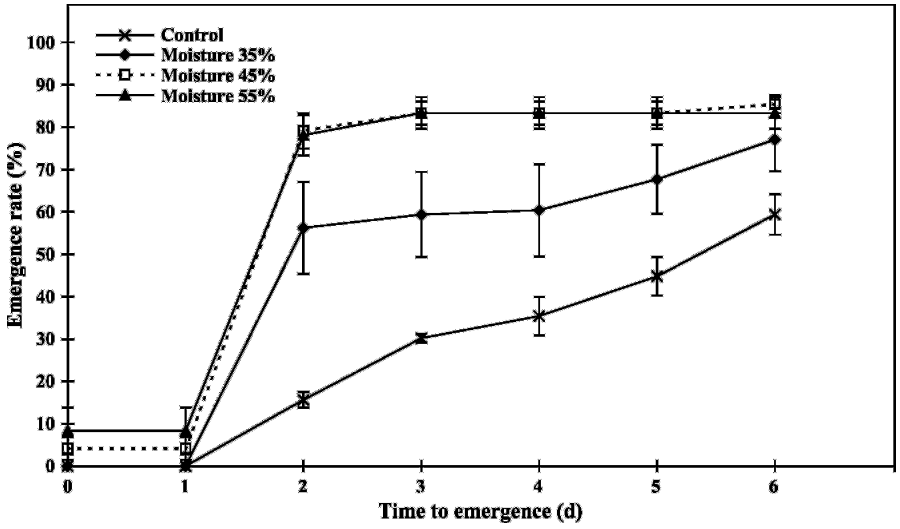

Fig. 4. Effects of post-sown priming with different moisture contents of the seeding mixture at 30 °C (86.0 °F) for 5 d on lettuce emergence at 32.5 °C (90.50 °F) in Expt. 3. Vertical bar = SE.

(1988), and Khan et al., (1990), respectively, reported that tripotassium phosphate, polyethylene glycol, ground shale, and synthetic calcium silicate were effective for priming. These priming treatments require high levels of technical expertise, and seeds usually are treated by professional seed processors before being sown at agricultural nurseries.

Post-sown priming for 'Patriot' seeds with a seeding mixture was most effective in the 20 °C/1 d/ 55% moisture group. Strong priming effects have been obtained in malabar spinach with 15 °C/10 d/41% to 45% moisture (Miura et al., 1997) and in parsley with 25 °C /5 d/45% moisture (Miura et al., 2001). The optimum conditions for different vegetables seem to reflect physiological conditions of the seeds. Moisture content from 45% to 55% is similar to moisture levels of common seeding mixtures. Thus, moisture contents can be easily adjusted.

Cost factors are important for evaluating the economy of cell tray seeding. Taking into account the costs of temperature control units capable of lowering the temperature to 15 °C to 20 °C in agricultural facilities, 30 °C/3 d/ 55% moisture and 30 °C/5 d/45% to 55% moisture appear preferable to 20 °C/1 d/55% moisture. It is noteworthy that these treatments improved emergence on day 6 under 32.5 °C to about 80%, a level satisfactory for commercial lettuce production.

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