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Effect of Priming on Germination of Aged Soybean Seeds

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ABSTRACT

The object of this study is to determine the effect of priming on the germination ability and seedling emergence of aged soybean seeds in lab and field conditions. Artificial or natural procedure for seed aging was applied in this study. One seed lot was artificially aged for 3 to 5 days at 42℃ with high relative humidity (nearly RH 100%), and the other one was stored at room temperature for 17 months. Aged seeds were osmoconditioned in −1.1 MPa polyethylene glycol 8000 (PEG) solution for 3 days at 25℃ and air-dried. When Danyeobkong was aged for 4 days average germination was 61.5%, however, this improved to 98.5% after the priming treatment. Improvement of seed germination by priming the aged seed was consistent with large seed sized Jangyeobkong cultivar, indicating that the priming was effective in enhancing seed germinability regardless of seed size. Priming aged seeds also resulted in good stand establishment in the field trials. Germination of aged seeds of Danyeobkong without priming was 17.0%, whereas that of primed ones was 66.4%.

Key words : priming, soybean, aged seed, germination.

Poor stand establishment of soybeans in the field has been a serious problem in Korea, and that was due to unfavorable weather during planting season or to deteriorated seeds. To improve germination of seeds priming treatments including presoaking, hardening, humidification, and osmotic conditioning have been applied (Khan et al, 1979). The effect of priming has been known to improved the germination and emergence of seeds in many horticultural crops (Coolbear et al., 1984 ; Jett et al., 1996 ; Kang & Cho, 1996). Priming treatments improved emergence percentage, mean emergence time, and uniformity of emergence of sweet corn seed lots. The observed improvements were attributed to priming-induced quantitative changes in biochemical activities including greater amylase activity, increasing free sugars and DNA during seed germination (Sung & Chang, 1993). Osmoconditioning with 20-25% PEG offered an effective means for raising germination percentage and vigor index in deteriorated peanut seeds (Fu et al, 1988). The effect of priming on sun-dried French beans with a moisture content of 10%, aged at ambient temperature for up to four years was studied, and priming ameliorated aging induced membrane disruption and leakage of UV absorbing substances and improved seedling vigour (Pandey, 1988).

Studies about priming treatment of soybean seeds were limited. Knypl & Khan (1981) applied the priming technique for soybean seeds and reported that osmoconditioning improved the germination time and rate, and suggested its possibility. Osmoconditioning of soybean seeds followed by air-drying resulted in decreased germination and reduced radicle and plumule length while increasing radicle diameter of germinated seedlings (Armstrong & McDonald, 1992). Though a few studies about priming treatment of soybean seeds have been reported the effect, mechanism of that was poorly understood. This study was conducted to determine the effect of priming on the germination ability and seedling emergence of aged soybean seeds in lab and field conditions, and to determine the application possibility of priming treatment in soybeans.

MATERIALS AND METHODS

Seeds of soybean cultivars, small seed sized Danyeobkong and large seed sized Jangyeobkong were used for the laboratory experiments. One soybean seed lot was artificially aged for 3 to 5 days at 42℃ with high relative humidity (nearly RH 100%), and the other one was stored at room temperature for 16 months. Naturally aged seed lots were sampled every 3 months. For the priming of seeds, these were placed on the shelf in an enclosed cage and polyethylene glycol 8000 (PEG) solution was filled up to the level of the shelf, which was adjusted to various levels of water potential (0, −0.3, −0.6, −0.9, and −1.2 MPa). This preliminary test indicated that the optimum water potential for the priming of soybean seeds was between −0.9 and −1.2 MPa. From further studies the optimum and practical water potential for seed priming was −1.1 MPa. Both naturally and artificially aged seed lots were osmoconditioned in −1.1 MPa PEG solution for 3 days at 25℃ and air-dried. Four 50-seed samples of each seed lot were tested in paper towels at 25℃ for the standard germination test (AOAC, 1990). Following the procedures of the standard germination test, normal seedlings that were strong and at least 3.75 cm long at 4 days after planting were counted and those percentages were expressed as First germination (TeKrony & Egli, 1977). The time to get 50% germination rate (T_{50}) was calculated according to the following formula described by Coolbear et al. (1984).

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$$T_{50} = t_i + \frac{(N+1)/2+n_i}{(n_j-n_i)} \cdot (t_j-t_i)$$

Where N is the final number of germination and cumulative numbers of seeds, n_i and n_j, are germinated at time t_i and t_j when $n_i < (N+1)/2 < n_j$. Artificially aged and non-aged seeds of two small seed sized cultivars, Danyeobkong and Kwangankong, and two large seed sized cultivars, Jangyeobkong and Hwangkeumkong were primed and planted in the field of the Yeungnam University Experimental Field on 15 May. Planting density between rows and hills were 60 cm and 15 cm, respectively, and two seeds were planted per hill.

RESULTS AND DISCUSSION

Priming treatment increased the germinability of aged seeds in two soybean cultivars (Table 1). As duration of artificial aging increased from 3.5 to 4.7 days, germination percentage of unprimed Danyeobkong seeds decreased significantly from 78.5% to 56.0%. When these seeds were primed, however, germination rates were retained over 95%. Improvement of seed germination by priming was consistent with large seed sized Jangyeobkong cultivar. Germination of Jangyeobkong seeds aged for 4.3 days was improved from 16.5% to 58.5% after priming treatment.

More significant improvement of 'first germination' by seed priming was recognized in both cultivars. The percentage of normal seedling, first germination, of Danyeobkong aged for 4.7 days was significantly improved from 11.5% to 76.0%, and that of Jangyeobkong aged for 4.3 days was improved from 3.5% to 20.5% after priming treatments. T_{50} was also reduced by priming treatment. These results indicated that priming was effective in enhancing germinability of aged soybean seeds regardless of seed size.

Germination of soybean seeds stored under room temperature decreased gradually as storage duration proceeded and decreased rapidly after 6 months in two soybean cultivars (Table 2 and 3). Priming treatment increased germination percentages of soybean seeds stored for more than 12 months. Germination of Danyeobkong and Jangyeobkong seed lots stored for 16 months improved by priming treatment from 10.0 to 50.5 %, and from 3.0 to 33.0%, respectively. Priming treatment also improved seed vigor shown as first germination. Percentages of first germination of the Danyeobkong and Jangyeobkong seed lots stored for 14 months were 27.0 and 13.0%, however, after priming treatment those improved to 63.5 and 54.5 %, respecti-

Table 1. Germinability of the artificially aged seeds and the effect of priming treatment to those in two soybean cultivars.

Cultivar	Aging (day)	Germination (%)		First germination (%)		T_{50} (day)		
		Unprimed	Primed	Unprimed	Primed	Unprimed (A)	Primed (B)	B-A
Danyeobkong	3.5	78.5[a†]	99.0[b]	49.0[a]	94.5[b]	1.4	0.5	−0.9
	4.1	61.5[a]	98.5[b]	13.5[a]	78.0[b]	0.9	0.5	−0.4
	4.7	56.0[a]	95.1[b]	11.5[a]	76.0[b]	2.2	0.6	−1.6
Jangyeokong	3.0	24.0[a]	61.5[b]	8.0[a]	32.0[b]	2.2	0.8	−1.4
	3.8	24.0[a]	60.5[b]	5.5[a]	20.0[b]	2.1	1.0	−1.1
	4.3	16.5[a]	58.5[b]	3.5[a]	20.5[b]	2.5	1.3	−0.8

† Two means with same letter within each row of characters (unprimed and primed) are not significantly different by $LSD_{0.05}$.

Table 2. Effect of priming treatment on the germinability of Danyeobkong seeds stored for 16 months under room temperature.

Storage duration (months)	Germination (%)		First germination (%)		T_{50} (days)†		
	Unprimed	Primed	Unprimed	Primed	Unprimed (A)	Primed (B)	B-A
0	98.0a‡	96.0a	78.0a	78.5a	0.9	0.7	−0.2
3	99.5a	98.0a	97.0a	47.5b	0.6	0.8	0.2
6	87.5a	93.0b	67.5a	68.0a	1.1	0.8	−0.3
9	81.0a	86.5a	30.5a	33.5a	1.2	0.6	−0.6
12	72.5a	86.5b	44.5a	65.5b	1.2	0.6	−0.6
14	50.0a	78.5b	27.0a	63.5b	1.6	0.6	−1.0
16	10.0a	50.5b	2.0a	23.0b	1.9	1.6	−0.3

† T_{50} indicates the days to 50% germination

‡ Two means with same letter within each row of characters (unprimed and primed) are not significantly different by $LSD_{0.05}$.

Table 3. Effect of priming treatment on the germinability of Jangyeobkong seeds stored for 16 months under room temperature.

Storage duration (months)	Germination (%)		First germination (%)		T_{50} (days)†		
	Unprimed	Primed	Unprimed	Primed	Unprimed (A)	Primed (B)	B-A
0	96.0a‡	94.0a	73.5a	80.0a	1.2	0.7	−0.5
3	99.0a	94.0a	87.5a	48.0b	1.1	0.9	−0.2
6	88.5a	95.0b	55.0a	66.0a	1.2	0.6	−0.6
9	77.0a	83.5a	12.5a	18.0a	1.6	1.0	−0.6
12	63.5a	79.5b	28.0a	55.0b	1.6	0.9	−0.7
14	37.5a	66.0b	13.0a	54.5b	1.9	0.8	−1.1
16	3.0a	33.0b	0.0a	10.5b	3.4	2.2	−1.2

† T_{50} indicates the days to 50% germination

‡ *Two means with same letter within each row of characters (unprimed and primed) are not significantly different by* $LSD_{0.05}$.

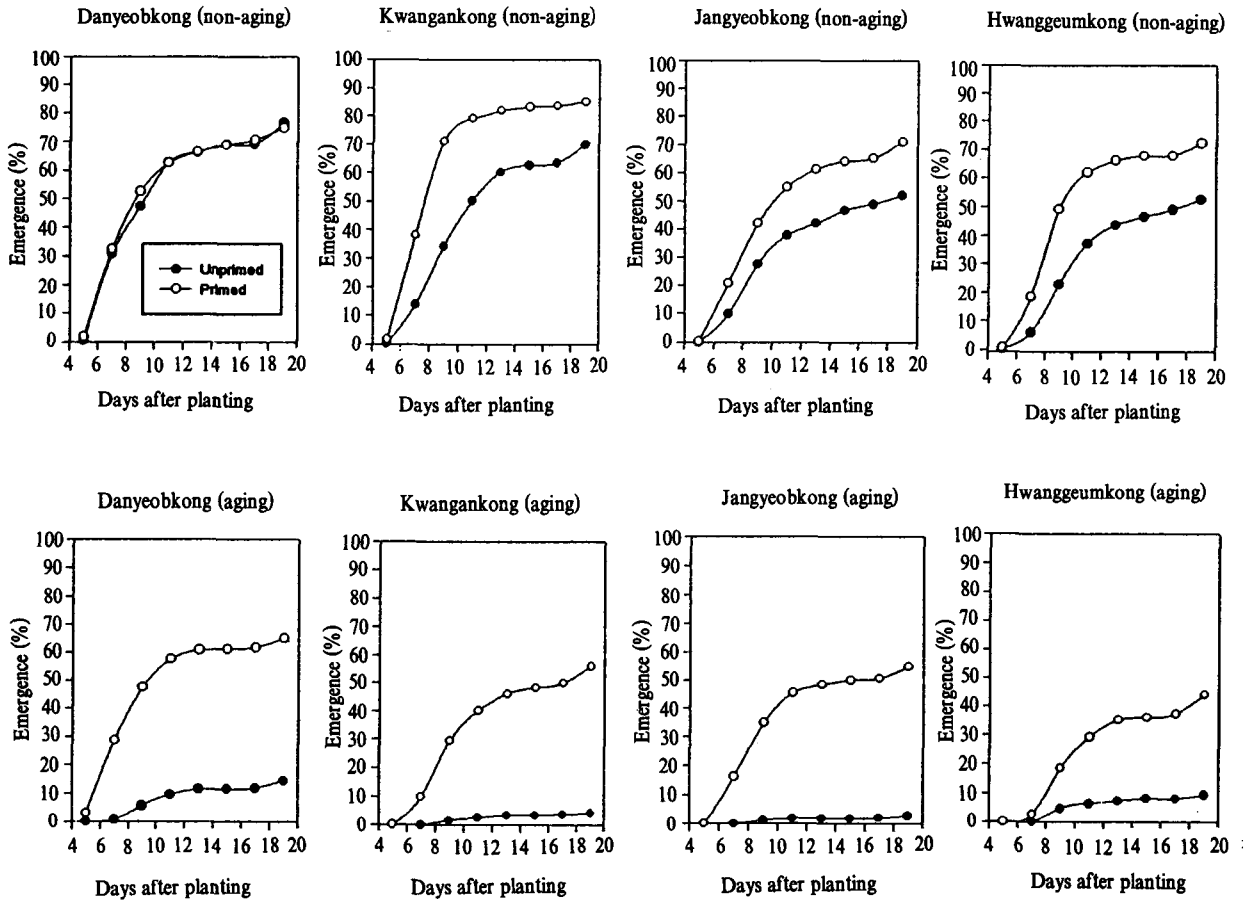

Fig. 1. Field emergence rate of the primed and unprimed seeds after artificial aging or non-aging in eight soybean cultivars.

vely. First germination of the seed lots stored for 9 months were relatively quite low. These abnormal results were due to the infection by fungal diseases during germination tests in both cultivars. Priming treatment of soybean seeds stored more than 12 months also reduced T_{50} by 0.3 to 1.2 days.

Artificially aged and non-aged seeds of four soybean cultivars were primed and planted in the field. The priming effect for non-aged seeds in the field is shown in the upper row of Fig. 1. There was no difference in emergence rate between unprimed and primed seed lots in non-aged Danyeobkong. The emergence rate of non-aged

and unprimed Danyeobkong seeds was 78% in the field. Considering field conditions, standard germination such as this could increase and this seed lot might be quite vigorous. As shown in Table 2 and 3, there were also no significant priming effects on the vigorous seed lots before storage. This results were thought to be due to the high seed vigor of non-aged Danyeobkong seed lot. The final emergence rates of non-aged Kwangankong, Jangyeobkong, and Hwangkeumkong seed lots were comparatively lower than those of Danyeobkong seeds, however, priming treatment significantly improved the emergence rates of those cultivars.

Priming effect for aged seeds in the field is shown in the lower row of Fig. 1. Emergence rates of aged seed lots before priming treatment were below 15% in all cultivars. In spite of low seed vigor, the emergence rates of aged seed lots were conspicuously improved after the priming treatment in four cultivars. Though Danyeobkong and Kwangankong were small and Jangyeobkong and Hwangkeumkong were large seed sized cultivars, improvement of seed germination by priming the aged seed was consistent in all cultivars. This result indicated that the priming was effective in enhancing seed germinability regardless of seed size.

Studies related to the priming treatment of soybean are quite limited. Knypl & Khan (1981) found that osmoconditioning improved the performance of soybean seeds as shown by shortened germination time and an increase in the rate of germination and emergence at suboptimal temperatures (8 or 15℃). Applicable water potential for the priming of soybean seeds in this study was in the range of −0.9 to −1.2 MPa, Therefore −1.1 MPa of PEG solution was used. This range almost coincided with that of Knypl & Khan' (1981), −8.6 to −11.9 bars. The improvement and enhancement of germination by the priming of aged soybean seed was recognized in this study, and the priming treatment of non-aged vigorous seeds was not effective.

However, osmoconditioning under the unfavorable water potential range, from −0.4 to −0.8 MPa, followed by air-drying resulted in decreased germination of soybeans (Armstrong & McDonald, 1992). Many studies have related the priming induced germination enhancement to the improvement in membrane integrity as well as the increases in protein and nuclei acid syntheses (Khan et al., 1978; Fu et al., 1988; Sung & Chang, 1993). Coolbear et al., (1984) analyzed low temperature pretreated tomato seeds and found no reduction in the rate of loss of either amino acids or reducing sugars. It was also known that the plasma membrane, which in cells of dry soybean seeds are disorganized and disrupted, became relatively intact and continuous for the period of imbibition (Webster & Leopold, 1977). Though priming of poor quality soybean seed lots resulted in increased seed vigor, the mechanism was not understood in this study. Information from the cited results could be useful for further studies.

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