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Effect of Seed Priming Treatment on the germination of Sesame

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ABSTRACT This experiment was conducted to find out optimum priming treatment conditions to the sesame seed as a preliminary study for enhancing sesame germination properties. Effective priming agents and concentrations for sesame seed were K_3PO_4, 200 mM and PEG6000, -1.0 MPa respectively. Optimum priming temperature and duration were 15℃, 4 days in view of germination speed and germination percentage. PEG6000 with -1.0 MPa was selected as an efficient priming treatment condition at 15℃, 4 days. This study suggested that priming treatment to sesame seed would be an effective technique enhancing sesame seed germination and shortening time to the T_{50} at the field condition, but the efficiency of priming treatments to the sesame seed would be strongly dependent on individual or integrated conditions of priming agent, concentration, temperature and duration etc.

Keywords : sesame, priming, germination speed, germination percentage

Seed priming technique is to treat seeds with low osmotic solution to improve germination percentage, speed and uniformity. Basic priming principle is up-taking water to achieve critical water content that accelerate metabolic activity in the controlled environments (Taylor, 1997). The controlled environmental factors for the optimum seed priming are water potential of priming medium, temperature and duration. Effective priming treatment can be achieved by controlling the osmotic solution concentration enough to prevent germination. Sesame which is resistant to aridity and with high-temperature adaptability, can be germinated at the minimum temperature above 12℃. But its sowing date in Korea usually comes to early May when the average temperature is less than 12℃ and soil moisture content is not enough to germinate sesame seed at the upland soil condition. Poor and uneven seedling germination increases labor cost and, eventually, decreases the efficiency of sesame seed production. Therefore, the bottom line of sesame cultivation in Korea would be determined by uniformal seedling germination percentage which could save labor time for uneven seedling supplement or thinning. Several experiments of priming or pellet treatment to the sesame seed were conducted to obtain healthy seedling germination(Kim *et al.,* 1997a; Kim *et al.,* 1997b; Kim *et al.,* 1997c). Oh *et al.* (1997) developed sesame seed pellet methods. According to the study, charcoal was one of the excellent materials to make pellet sesame seed with the properties of hardness, breakdown, destruction rate and germination percentage. The optimum sesame seed mixture rate was about 87g per 1ℓ of $CaCl_2$ solution. And the moisture absorption rate was greater in the order of peat+charcoal, peat, charcoal and zeolite. The optimum sesame seed pellet materials were charcoal with the about 92% germination percentage. Nevertheless, integrated priming technique for the sesame germination improvement was not yet completed. Thus, the object of this study was to determine the optimum agents, concentration, temperature and duration for the priming treatment to improve germination rate and speed of sesame seed.

MATERIALS AND METHODS

Sesame cultivar, Yangbaek' seeds were used for this experiment. Seeds were germinated in controlled temperature

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chambers at the Department of Functional Crops, National Institute of Crop Science, RDA during 2006. Each treatment combination consisted of 100 seeds in one plastic petri plate (100 mm diameter). Each plate had two pieces of filter paper wetted with 1.5 ml of water. The seeds were surface sterilized with 5% of NaOCl to protect seed borne infection followed by washing. The seeds were primed by solutions of polyethylene glycol (PEG 6000), K_3PO_4, KH_2PO_4, $Ca(NO_3)_2$, $NaNO_3$, KNO_3, KCl, NH_4NO_3, $CaCl_2$ and K_2SO_4. The osmotic water potentials levels of PEG 6000 were -0.50, -0.75, -1.00, and -1.50MPa according to Michel and Kaufman (1973). Other agent solutions were 100, 150, 200 and 250mM. Priming duration and temperature were 4, 6, 8, 10 days and 15, 20, 25, 30℃ respectively. Seeds were primed for 4 days at 15℃ and 20℃ according to Jeong *et al* (1994). After priming, seeds were given surface washing with distilled water then dried to near original weight under shade. To find out the effect of low and high temperature on the sesame germination, temperatures, 15, 20, 25, 30 and 35℃ were applied to the material with pre-primed under -1.00MPa PEG 6000, 20℃. Seeds were considered germinated when the radical was 2～3 mm in length. Germination percentage was calculated according to the technique of Standard Germination Test (ISTA, 1993). Count of germinated seed number was conducted at 12hr intervals for 6 days, and 24hr intervals from 7th day during 10 days. Germination speed (GS) was estimated according to the formula of McGuire (1962) as follows ; GS = [(No. of seedling)/(Days to first count) + ····· + (No. of seedling)/(Days to final count)]

It stated that the germination speed and percentage of primed sesame seeds were different according to the priming agent and it's concentration(Table 1).

The time to get 50% germination percentage (T_{50}) was calculated according to the following formula described by Coolbar *et al*(1984).

$T_{50} = t_i + [(N/2-n_i)(t_j-t_i)] /(n_j-n_i)$, where : N = The final number of germination

n_i, n_j = Cumulative number of seeds germinated by adjacent counts at times when $n_i<N/2,n_j$

Data were analyzed using ANOVA procedure of SAS statistical software (SAS System for Windows, rel. 8.02, SAS Institute, Cary, NC, USA).

Table 1. Germination speed and percentage of primed sesame seeds as affected by different treatment agents and concentrations.

Treatment agent	Concentration (mM)	Germination speed (%)	Germination percentage (%)
Control	-	87	92
K_3PO_4	100	91	94
	150	94	94
	200	90	92
	250	91	94
KH_2PO_4	100	43	43
	150	53	55
	200	71	72
	250	89	92
$Ca(NO_3)_2$	100	17	19
	150	86	90
	200	94	96
	250	92	92
$NaNO_3$	100	89	93
	150	71	80
	200	60	84
	250	76	81
KNO_3	100	80	85
	150	69	85
	200	73	85
	250	75	83
KCl	100	27	37
	150	94	95
	200	77	83
	250	88	91
NH_4NO_3	100	93	93
	150	46	63
	200	73	75
	250	83	86
$CaCl_2$	100	14	17
	150	48	49
	200	91	91
	250	95	95
K_2SO_4	100	65	67
	150	66	69
	200	92	94
	250	92	95

†Data was the means of 100 seeds of sesame with six replications. Seeds were dark-primed at 20℃ for 4 days and dark-germinated up to 10 days.

RESULTS AND DISCUSSION

Effect of priming agent and concentration on the germination of sesame seed.

Analysis of variance indicated that treatment agents,

concentrations and their interaction significantly affected sesame germination properties (Table 2).

In general, several priming agents were selected according to the different crops. For example, K_3PO_4 and $Ca(NO_3)$ showed more effective treatment priming agents on pepper and tomato respectively (Jeong *et al.,* 1994). KCl showed highest germination speed and percentage in case of onion priming (Cho *et al.,* 2006). In this study, treatment agents, 'K_3PO_4', 'PEG6000', showed higher germination speed and germination percentage than that of control (Fig. 1). Haigh and Barlow (1987) said ion concentration accumulation in osmotic-priming seed would be in proportion to the time of treatment agent which would decrease metabolic mechanism of seed. In view of previous study, it assumed that $NaNO_3$ and KNO_3 show difference between germination speed and percentage.

Graphic data depicted in Fig. 2 show that germination speed and germination percentage are proportionally increased

Table 2. Analysis of variance with mean squares and treatment significance of sesame seed germination speed and percentage as affected by different treatment agents, concentrations and their interaction.

Source	Germination speed	Germination percentage†
Treatment agent (T)	1376.3**‡	1436.6**
Concentration (C)	4216.6**	2439.2**
T × C	1365.1**	1040.1**

† Germination percentage represents percentage seeds germinated in 10 days.
‡** means significantly different at 0.01 probability levels.

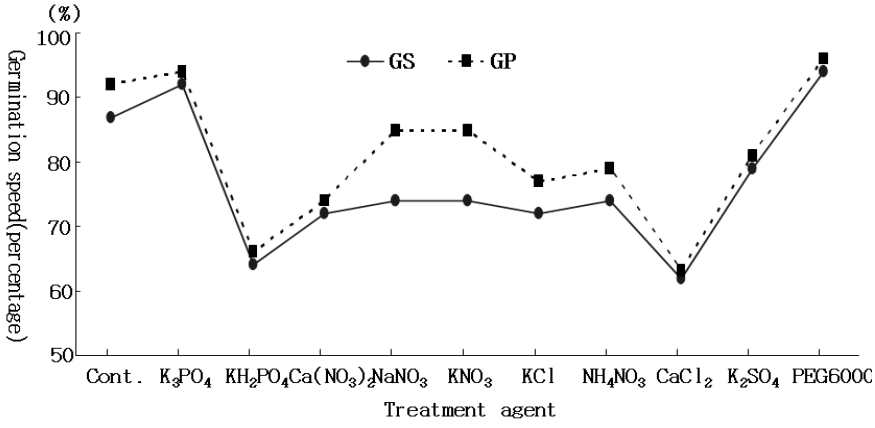

Fig. 1. Effect of different treatment agents on the germination speed (GS) and germination percentage (GP) of primed sesame seed.

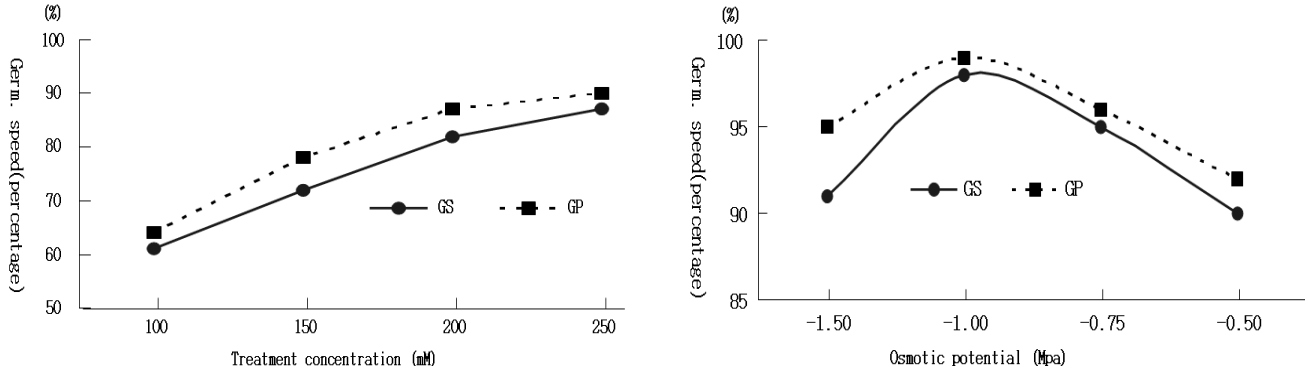

Fig. 2. Germination properties in response to treatment agent concentration of priming sesame seed as well as the relation between the germination of sesame seed and the osmotic potentials of PEG 6000 solution.

as treatment agent concentration increased. In general, it can be stated that primed sesame seed normally germinated above 200mM concentration.

Priming is a technique to hydrate seeds under controlled conditions and it is very important to find a critical water level of priming medium to enhance seed germination. Fig. 2 also shows the correlation between germination percentage and osmotic potential of PEG 6000. The germination percentage was continuously increased depending on the reduction of osmotic potential of PEG up to -1.0 MPa and sharply decreased afterwards. Thus, the critical osmotic potential level of PEG 6000 solution enhancing germination was -1.0 MPa and the osmotic potential was applied in all treatment of sesame priming seed in this study.

Effect of priming duration and temperature on the germination of sesame seed.

Result indicated that priming duration had significantly effect on the seed germination speed and germination percentage (Table 3). Priming duration, 4 or 6 days was an effective treatment condition for the sesame seed, but not much more effective than as in the control. Increasing priming temperature was associated with a significant decrease in the germination speed and germination percentage. The lowest priming temperature, 15℃, showed highest germination speed and germination percentage. The decrease of seed germination under the higher temperature condition could be partly attributed to the exposure of seeds to heat which results in the abnormality of enzyme systems.

The responses of germination speed and germination percentage were different depending on priming temperature and duration (Fig. 3). Germination properties were reduced as the priming duration increased, regardless of any priming temperature. Especially, germination speed was rapidly decreased from 4 days of duration at the 20℃, 30℃ primed temperature. But, germination percentage was steadily increased up to 4 days of priming duration. The most effective priming temperature and duration were 15℃, 4 days respectively, considering germination percentage.

Effect of germination conditions on the germination of primed sesame seed.

Table 4 shows that chamber temperature had not significantly effect on the seed germination speed and germination percentage except for the temperature at 10℃. In comparison of the control and priming treatment, germination speed and germination percentage were increased up to 20℃.

Final germination was generally much higher in the priming treatment than the controlled under all germination temperature. Conclusively, the optimum priming conditions for sesame seed were : 1) The effective priming agents were K_3PO_4 and PEG 6000. 2) The effective treatment concentration of the solution was above 200mM. 3) The

Table 3. Effect of priming duration and temperature on the germination properties and T_{50} of sesame seed.

Treatment[†]	Germination speed (%)	Germination percentage (%)	T_{50} (hr)
Control	93.0[a‡]	95.1[c]	20.9[ab]
4 days	87.8[b]	96.1[a]	20.8[ab]
6 days	88.0[b]	95.7[a]	20.3[b]
8 days	83.8[bc]	93.1[b]	22.7[a]
10 days	80.8[c]	90.3[c]	22.7[a]
15℃	93.5[a]	96.8[a]	19.4[b]
20℃	92.9[a]	96.4[a]	19.5[b]
25℃	85.5[b]	93.0[b]	20.7[b]
30℃	75.5[c]	90.1[c]	26.3[a]

[†] Seeds for priming duration were dark-primed in PEG 6000 -1.0MPa at 20℃.
[‡] Means followed by same letter within the same column are not significantly different at the 0.05 probability level using Duncan's multiple range test.

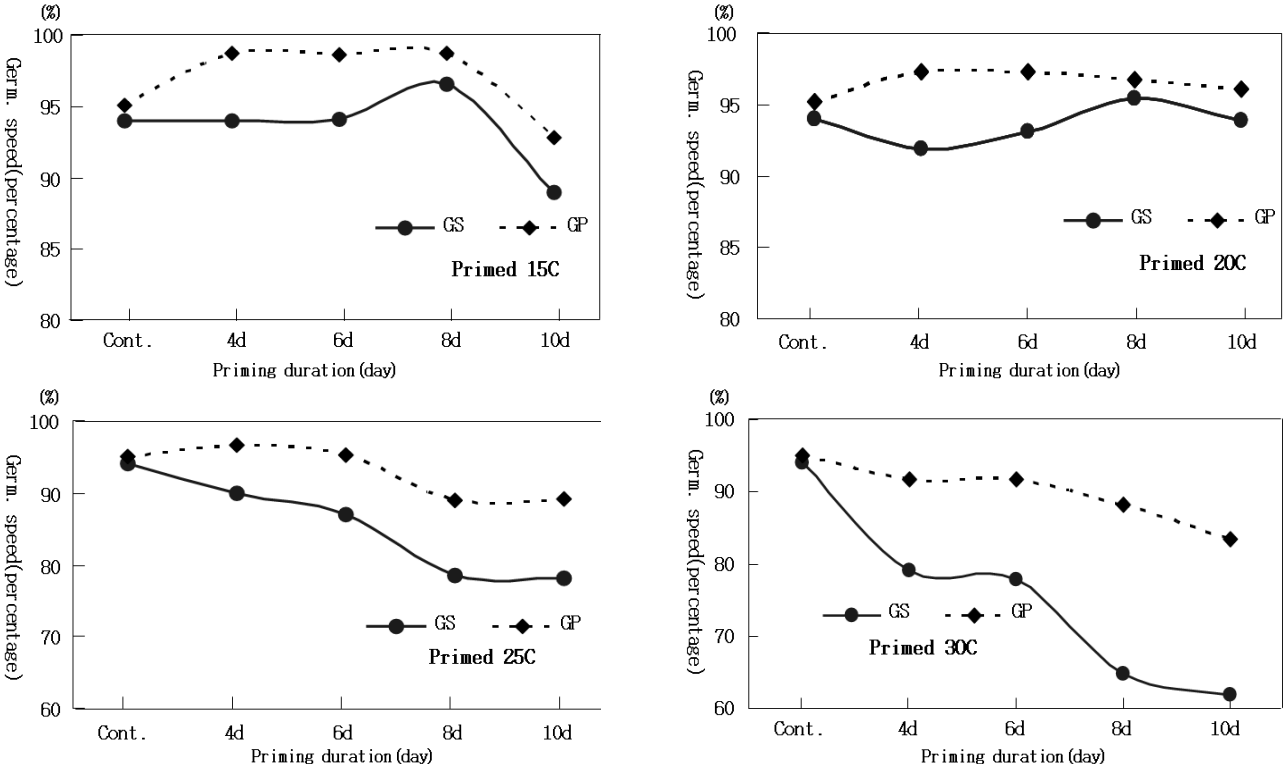

Fig. 3. Relationship between priming duration and germination depending on the priming temperature for sesame seeds. Khan *et al*., (1995) said that the cold tolerance effect of priming could be derived from the activation or synthesis of large number of enzymes and higher mobilization of storage reserves before sowing.

Table 4. Effect of germination conditions on the germination properties of primed sesame seed.

Germination condition		Germination speed (%)	Germination percentage (%)
Temperature(℃)	Seed treatment†		
10	Control	83.4[b]	87.1[b]
	primed	94.6[a]	97.6[a]
15	Control	93.4[a]	96.0[a]
	primed	95.6[a]	98.0[a]
20	Control	96.3[a]	97.3[a]
	primed	96.3[a]	98.3[a]
25	Control	57.3[c]	98.3[a]
	primed	91.7[a]	98.0[a]
30	Control	92.3[a]	97.3[a]
	primed	93.9[a]	98.0[a]

† Seeds were dark-primed in PEG 6000 -1.00MPa at 15℃ for 4 days.
‡ Means followed by same letter within the same column are not significantly different at the 0.05 probability level using Duncan's multiple range test.

optimum osmotic potential solution of the PEG 6000 was -1.0MPa. 4) The most effective priming temperature to increase germination was 15℃. 5) The optimum priming duration was 4 days in view of germination speed and germination percentage. This study indicated that more effective priming conditions of sesame seed were strongly

dependent on the priming agent, concentration, temperature, duration and their treatment combination.

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