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Varietal Responses of Soybean Germination and Seedling Elongation to Temperature and Polyethylene Glycol Solution [1)]

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溫度와 PEG에 對한 大豆品種의 發芽 및 苗伸長 反應[1)]

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ABSTRACT

Germination and seedling elongation of soybeans [*Glycine max*. (L.) Merr., cults. Bangsakong, Hill, Paldalkong, Danyupkong, Baegwun-kong, Kwangkyokong, Changyupkong and Hwangkeumkong] were measured at two temperatures (15 and 30℃) and four polyethylene glycol 10,000 (PEG) solutions (0, 20, 30 and 35g/100g H_2O). Adjustments of PEG solution were based on water potentials of 0.0, -0.5, -1.1 and -1.5 MPa at room temperature. Observations were made at 3, 6, 9 and 12 days for 15℃ and 1, 2, 3 and 4 days for 30℃. Fifteen seeds of each cultivar were placed on Whatman No. 1 (9cm) filter paper in plastic pertridishes, and adjusted to 15 ml of the proper PEG solution supplemented with 0.2 percent thiram using automatic syringe. The dishes were covered with cap. The seeds were germinated at a continuous temperature of 15 or 30℃ under dark conditions for programmed period.

Seedling moisture content and seedling length of eight soybean cultivars decreased as PEG concentration increased both at 15 and 30℃. Cultivar differences in seedling moisture content and seedling length were found among eight soybean cultivars at temperatures of 15 and 30℃. Larger sized cultivar absorbed more moisture than samller sized cultivar. However, reverse results were obtained on the seedling moisture content of each of eight soybean cultivars. Cultiver Hill and Paldalkong showed greater seedling length than the other six cultivars from 20 to 30g/100g water of PEG concentrations both at 15 and 30℃. The results of this study indicated that germination test of soybean seeds in aqueous solutions of PEG has potential for screening soybean cultivars for improved emergence during moisture stress.

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INTRODUCTION

Successful soybean [*Glycine max*(L.) Merr.] production depends on the establishment of rapid and uniform emergence of seedlings from the soil. Speed of germination is intimately related to the intensity of moisture stress. Hunter and Erickson[7] concluded that the minimum seed moisture content required for germination of soybeans was about 50 percent[2] and soybeans required a soil moisture level not less than -0.66MPa for germination. However, Waldren and Flowerday[16] reported the water requirement for initiation of germination of soybeans to be about 60 percent. Wilson[17] found that soybeans of good quality germinated approximately as well at the low temperatures of 10 and 15 as at the higher temperatures of 25 and 30℃. Hypocotyl growth rate of soybean seedlings increased as temperature increased from 15 to 30℃[1,4,6].

Grabe and Metzer[5] found distinct cultivar differences in emergence ability of soybeans. These differences were related to the effect of temperature on hypocotyl elongation and appeared to be genetically controlled. Consistent genotypic differences existed for tolerance to high temperature during germination[3]. Somers et al[15] reported that the emergence of four sunflower (*Helianthus annuus L.*)cultivars was significantly different at soil water potentials from -0.4 to -1.4 MPa. Johnson and Wax[8] found that a greater number of laboratory tests of soybeans correlataed with field emergence in favorable seedled environ-ments than in unfavorable environments. However, the laboratory test measurement was correlated with emergence for all planting sites and dates of planting[18].

Polyethylene glycol (PEG) solutions appeared to be desirable for moisture stress simulation due to the lack of toxic effects and larger molecular weight which inhibits coat penetration[14]. Parmar and Moore[12] reported effects of simulated drought by PEG solutions on corn (*Zea mays L.*) germination and seedling development. Water absorbed by corn seeds decreased with increasing osmotic pressure levels[13]. Somers et al[15] tested the PEG germination for selecting sunflower cultivars and found that the relationships of emergence to soil water potential and germination to PEG water potential were similar. Kaufmann and Ross[9] reported the interaction of temperature and water potential. At given PEG concentrations, water potential increased linearly with temperature[11]. and the water potential of PEG solutions was evaluated by Michel[10].

Stand establishment is a critical period in the life cycle of soybeans. Depending on time and location of planting, soil conditions can vary from cold and wet to hot and dry. The objective of this experiment was to evaluate the potential usefulness of polyethylene glycol for simulating the influence of drought conditions on germination and seedling development of soybeans.

MATERIALS AND METHODS

Germination experiments were conducted at the Department of Horticulture, Pai Chai University, Daejon. Seeds of soybeans [*Glycine max*. (L.) Merr. cults. Bangsakong, Hill, Paldalkong, Danyupkong, Baegwunkong, Kwangkyokong, Changyupkong, and Hwangkeumkong] were measure at two temperatures (15 and 30℃) and four polyethylene glycol (PEG) 10,000 soultions (0, 20, 30 and 35g/100g H_2O). Adjustiments of PEG 10,000 solutions were based on water potentials of o.o, -0.5, -1.1 and -1.5 MPa at room temperature. Split plots in time were used with three replications. Observations were taken at 3, 6, 9 and 12 days for 15℃ and 1, 2, 3 and 4 days for 30℃.

Seeds of soybeans produced in 1986 were obtained from the Crop Experiment Station, RDA, Suwon. Seeds were screened to obtain uniform size. Visibly cracked or diseased seeds were discarded. Seed fresh weight, seed dry weight and seed moisture content of eight soybean cultivars recommended nationwide are shown in Table 1. Fifteen seeds of each cultivar were placed on What man No. 1 (9cm) filter paper in plastic petridishes, and adjusted to 15ml of the proper PEG 10,000 solution supplemented

Table 1. Seed fresh weight, dry weight and moisture content of eight soybean cultivars.

Cultivar	Seed fresh weight	Seed dry weight	Seed moisture content
	······g/100······		(%)
Bangsakong	10.0	9.0	9.3
Hill	13.5	12.2	9.5
Paldalkong	16.2	14.7	9.2
Danyupkong	17.1	15.4	9.9
Baegwunkong	20.0	18.0	9.8
Kwangkyo	20.4	18.5	9.4
Changyupkong	28.4	25.7	9.5
Hwangkeumkong	28.9	26.2	9.3
LSD 0.05	0.7	0.6	NS

NS : no significant.

with 0.2 percent thiram using automatic syringe. The dishes were covered with cap. The seeds were germinated at a constant temperature of 15 or 30℃ under dark conditions for specified period. Seeds or seedlings were withdrawn from the solution, quickly rinsed with tap water to remove surface PEG and blotted dry with paper towels.

Data recorded included seedling fresh weight, seedling dry weight, seedling moisture uptake, seedling moisture content and seedling length. Seed or seedling moisture content and dry weight were calculated following oven drying at 105℃ to constant weight. Seedling length included lengths of both the hypocotyl and radicle. All data were subjected to standard analysis of variance and correlation. In the analysis of variance, an arcsin transformation was used on data for seedling moisture content and a spuare root transformation was used on data for seedling length.

RESULTS AND DISCUSSION

Observations of seed or seedling moisture content, seedling length and seedling dry weight of eight soybean cultivars were measured at 3, 6, 9 and 12 days for treatments at 15℃ and 1, 2, 3 and 4 days for those at 30℃.

Seed or seedling moisture uptakes of eight soybean cultivars were reduced with polyethylene glycol (PEG) 10,000 solutions both at 15 and 30℃

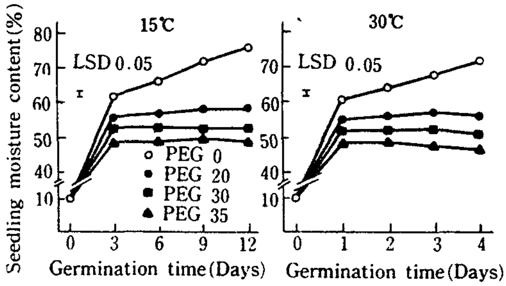

Fig. 1. Effects of temperature and PEG concentration during germination time on seedling moisture content of eight soybean cultivars.

(Fig. 1). Seed nor seedling moisture contents of eight soybean cultivars increased rapidly at the early stages of germination. The increase was until 3 days at 15℃ and 1 day at 30℃. There after, seed or seedling moisture contents of eight soybean cultivars were paralleled with PEG concentrations until 12 days at 15℃ and 4 days at 30℃. However, increase in seedling moisture content of PEG untreated control continued as germination time increased both at 15 and 30℃. Significat differences in seed or seedling moisture content of eight soybean cultivars were found among PEG concentrations from 20 to 35 g/100g water at all germination times both at 15 and 30℃.

Seedling growth of eight soybean cultivars was not visible when PEG concentration was 35g/100g water at all germination times at 15℃ (Fig. 2). Seedling lengths of eight soybean cultivars were decreased as PEG concentration increased both at 15 and 30℃. At 15℃, seedling lengths of eight soybean cultivars decreased singificantly from 6 to 12 days of

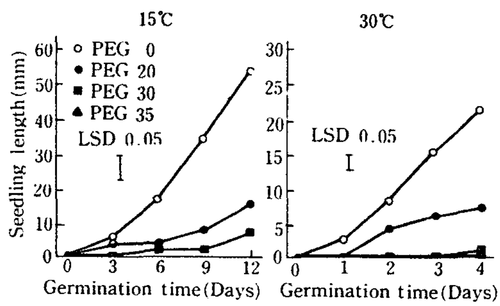

Fig. 2. Effects of temperature and PEG concentration during germination time on seedling length of eight soybean cultivars.

germination time compared to PEG untreated control. However, the decreases in seedling lengths of those cultivars were found from 1 day of germination time at 30℃.

Seed or seedling dry weights of eight soybean cultivars were similar among PEG concentrations from 20 to 35g/100g water at temperatures of 15 and 30℃ (Fig. 3). With PEG untreated control, seed or seedling dry weights of eight soybean cultivars decreased compared with those of PEG treatments at 9 and 12 days of germination time at 15℃. These decreases in seed or seedling dry weights of those occurred from 2 to 4 days of germination time at 30℃. PEG treatments did not affect seed or seedling dry weights of eight soybean cultivars, indication

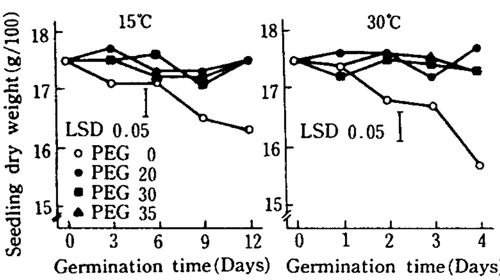

Fig. 3 Effects of temperature and PEG concentration during germination time on seedling dry weight of eight soybean cultivars.

that PEG inhibited water penetration into the seeds or seedlings causing reduced respiration.

Highly significant positive correlation coefficients were found among initial seed fresh weight, seedling fresh weight, seedling dry weight and seedling moisture uptake (Table 2). Seedling moisture content showed highly significant negative correlations with the other four variables. Seedling length showed no singificant correlations with all other five variables.

Cultivar differences in seedling fresh weight, seedling dry weight, seedling moisture uptake, seedling moisture content and seedling length of eight soybean cultivars were found as shown in Table 3. Seedling fresh weight, Seedling dry weight and seedling moisture uptake of eight soybean cultivars increased both at 15 and 30℃ as initial cultivar seed size increased (Table 1), indicatiog that larger sized cultivar absorbed more moisture than smaller sized cultivar. However, reverse results were obtained on the seedling moisture contents of eight soybean cultivars both at 15 and 30℃. On the other hand, seedling length of each of eight soybean cultivars showed no consistence to cultivar seed size at temperatures of 15 and 30℃.

Seedling moisture content and seedling length of

Table 2. Correlation coefficients among seed fresh weight, seedling length, seedling fresh weight, seedling dry weight, seedling moisture uptake and seedling moisture content of eight soybean cultivars.

Variable	Seed fresh weight	Seedling length	Seedling fresh weight	Seedling dry weight	Seedling moisture uptake
Seedling length	-0.5558 NS				
Seedling fresh weight	0.9980 **	-0.5262 NS			
Seedling dry weight	0.9991 **	-0.5528 NS	0.9990 **		
Seedling moisture uptake	0.9952 **	-0.4969 NS	0.9990 **	0.9961 **	
Seedling moisture content	-0.9834 **	0.4564 NS	-0.9833 **	-0.9822 **	-0.9830 **

** : significant at the 0.01 probability level.

NS : no significant.

Table 3. Seedling fresh weight, dry weight, moisture uptake, moisture content and length of eight soybean cultivars at 15 and 30℃

Cultivar	Seedling fresh weight	Seedling dry weight	Seedling moisture uptake	Seedling moisture content	Seedling length
A. 15℃	g/100			(%)	(mm)
Bangsakong	24.8	9.3	15.5	60.3	8.9
Hill	30.6	12.0	18.6	59.1	9.4
Paldalkong	36.3	14.5	21.8	57.3	11.0
Danyupkong	36.3	14.7	21.6	57.9	7.3
Baegwunkong	42.9	17.8	25.1	56.6	9.5
Kwangkyo	43.9	18.2	25.7	56.4	11.0
Changyupkong	57.9	25.5	32.3	54.3	5.6
Hwangkeumkong	57.6	25.8	31.8	53.7	6.6
LSD 0.05	1.8	0.6	1.6	0.8	2.7
B. 30℃					
Bangsakong	22.4	9.1	13.3	58.2	3.5
Hill	29.3	11.9	17.4	58.1	5.8
Paldalkong	34.6	14.6	19.9	55.6	6.5
Danyupkong	34.5	14.8	19.6	56.0	2.7
Baegwunkong	41.1	17.8	23.3	55.3	5.2
Kwangkyo	41.8	18.2	23.6	54.9	5.5
Changyukong	57.0	25.9	31.1	53.2	2.2
Hwangkeumkong	55.3	25.6	29.7	52.6	2.4
LSD 0.05	1.2	0.4	0.9	0.6	1.6

eight soybean cultivars were affected with PEG concentrations both at 15 30℃ (Fig. 4). Seedling moisture content and seedling length of eight soybean cultivars were reduced as PEG concentration increased from 20 to 35g/100g water at temperatures of 15 and 30℃. Cultivar differences in

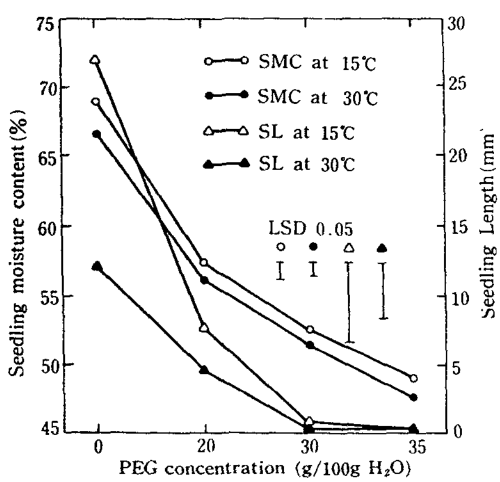

Fig. 4. Effects of PEG concentration on seedling moisture content and seedling length of eight soybean cultivars at 15 and 30℃

seedling length of eight soybean cultivars were found with PEG concentrations (Table 4). With PEG untreated control, Seedlings of cultivar Kwangkyo elongated most rapidly at 15℃ among eight soybean cultivars. However, cultivar Hill and Paldalkong showed greater seedling length than other six soybean cultivars from 20 to 30g/100g water of PEG concentrations both at 15 and 30℃.

Hunter and Erickson[7] found that the seed moisture content required for soybean germination was about 50 percent[2]. However, Waldren and Flowerday[16] reported that the water requirement to begin germination of soybeans was about 60 percent. Grabe and Metzer[5] found distinct cultivar differences in emergence ability of soybeans. In this experiments, cultivar differences in seedling moisture content and seedling length of soybeans were found among eight cultivars and appeared to be genetically controlled.

PEG solutions appeared to be disirable for moisture stress simulation[14]. Parmar and Moore[12] reported effects of simulated drought by PEG

Table 4. Seedling moisture content and length on PEG concentration of eight soybean cultivars at 15 and 30℃.

Cultivar	Seedling moisture content(%)				Seedling length(mm)			
	PEG 0	PEG20	PEG30	PEG35	PEG 0	PEG20	PEG30	PEG35
A. 15℃								
Bangsakong	72.1	60.3	56.1	53.0	27.5	7.6	0.6	0.0
Hill	70.0	59.2	55.5	51.6	27.5	9.3	0.8	0.0
Paldalkong	70.9	57.7	51.6	49.2	30.8	12.5	0.7	0.0
Danyupkong	69.0	58.2	53.9	50.5	21.6	7.6	0.1	0.0
Baegwunkong	68.4	56.9	52.6	48.7	30.6	7.3	0.1	0.0
Kwangkyo	68.9	56.7	51.5	48.3	35.5	8.8	0.0	0.0
Changyupkong	65.6	55.5	49.6	46.6	18.7	3.1	0.6	0.0
Hwangkeumkong	65.7	54.5	49.1	45.6	23.0	3.4	0.0	0.0
B. 30℃								
Bangsakong	67.1	58.7	55.2	51.8	9.6	4.1	0.2	0.1
Hill	67.6	58.9	54.5	51.4	14.6	7.1	1.5	0.1
Paldalkong	68.7	55.8	51.4	46.5	16.6	8.8	0.6	0.0
Danyupkong	65.6	57.0	52.7	48.9	7.3	3.2	0.1	0.0
Baegwunkong	66.2	55.8	51.3	47.9	15.8	5.0	0.1	0.0
Kwangkyo	67.1	55.8	50.3	46.6	16.8	4.9	0.1	0.0
Changyupkong	64.6	54.5	49.1	44.8	7.5	1.3	0.0	0.0
Hwangkeumkong	64.2	53.9	48.4	43.8	7.8	1.7	0.0	0.0

LSD 0.05 : Between cultivars within PEG concentration : 1.7 and 5.5 at 15℃, and 1.3 for seedling moisture content and 3.3 for seedling length at 30℃. Between PEG concentrations within cultivar : 1.8 and 7.9 at 15℃, and 1.3 for seedling moisture content and 4.6 for seedling length at 30℃

solutions on corn (*Zea mays* L.) germination and seedling development. Water absorbed by corn seeds decreased with increasing osmotic pressure levels[18]. Somers et al[15] tested the PEG germination for the selection of sunflower (*Helianthus annuus* L.) cultivars being able to emerge under low soil moisture conditions and found that the relationships of emergence to soil water potential and germination to PEG water potential were similar. The results of this study indicated that germination test of soybean seeds in aqueous solutions of PEG has potential for screening soybean cultivars for improved emergence during moisture stress.

摘　　要

溫度(15℃ 및 30℃)와 PEG溶液(O, 20, 30 및 35g/100g H_2O) 농도를 달리여 大豆品種(放射콩, Hill콩, 八達콩, 短葉콩, 白雲콩, 光敎, 長葉콩 및 黃金콩)의 發芽와 苗伸長 반응을 測定하였다. PEG溶液 농도의 調節은 常溫에서 0.0, -0.5, -1.1 및 -1.5 MPa 水分포텐셜을 基礎로 하였다. 試料의 採取는 15℃에서 3, 6, 9 및 12日 間隔으로, 30℃에서는 1, 2, 3 및 4日間隔으로 實施하였다. 品種當 15粒의 種子를 plastic petridish 안의 Whatman No. 1 (9cm) 濾紙위에 놓아 自動 注射器로 0.2% Thiram을 添加한 濃度別로 PEG溶液을 15 ml 씩 調節하였다. Plastic petri-dish를 Cap으로 封하여 15℃ 및 30℃ 恒溫의 無光條件下에서 發芽시켰다.

8個 品種의 苗水分含量과 苗長이 15℃ 및 30℃에서 共히 PEG溶液 濃度가 增加할수록 減少되었다. 苗水分含量과 苗長의 品種間差異가 두 溫度에서 共히 發見되었다. 大粒種이 小粒種보다 많은 量의 水分을 吸收하였으나 水分含量(%)은 小粒種이 높았다. Hill 콩과 八達콩은 두 溫度에서 共히 PEG溶液濃度 20에서 30g/100g H_2O까지 他品種들에 比較하여 큰 苗長을 보였다. 本 試驗의 硏究結果에서 PEG溶液 농도에 대한 大豆發芽반응 試驗으로 旱魃時 出現 增進을 위한 大豆品種 選拔 可能性이 있음을 보였다.

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