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Effect of Temperature, Soil Water Potential and Osmoconditioning on Germination and Seedling Elongation of Corn and Soybeans

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温度・土壤水分포텐셜 및 滲透處理가 옥수수와 大豆의 發芽 및 苗伸長에 미치는 影響

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ABSTRACT

Germination and seedling elongation of maize (Dekalb XL 72B), and soybeans (Williams) were measured at two temperatures (15 and 35°C), three soil water potentials (–1.50, –0.5, and –0.05 MPa), and four polyethylene glycol 8000 (PEG) levels (0, 20, 30, and 50 percent). Twenty conditioned seeds of each cultivar were treated with 0.2% thiram and planted 2 cm deep in sterilized Mexico silt loam soil which was subsequently compacted to a bulk density of 1.20 g/cm^3. Seedling moisture content, dry weight, and length were measured for each treatment combination. Osmoconditioning with PEG showed little effect at high temperature or low soil water potential conditions. Soybeans had higher seedling moisture content than corn and both crops increased moisture uptake as soil water potential and temperature increased. Seedling length of corn was longer than soybeans at 35°C but shorter at 15°C. Seedling dry weight of corn decreased at 35°C and that of soybeans decreased as soil water potential increased.

INTRODUCTION

Osmoconditioning (OC) of seeds on corn and soybeans with polyethylene glycol - 8000 (PEG) offers a potential means for enhancing germination and emergence. The purposes of OC are to advance the germination time, to decrease the germination time span in a seed population, to impart tolerance in seeds or seedlings to suboptimal temperatures during seedling establishment and to increase yield.[12] Heydecker and Coolbear (1977)[7] reported that PEG would be non-toxic under the conditions of its use and would prevent the seeds from germinating for the period required to get them ready for near–immediate subsequent germination. Khan (1977)[11] also suggested that PEG treatment causes rapid germination of seedlings with no adverse effects on the seedlings. Seeds of many crops have been subjected to OC and positive results have been obtained with small seeds of vegetables and flowers.[1,2,8,10,13,16,18,19] Recent studies show that even large seeds such as corn and soybeans are amenable to the treatment.[6,12,17]

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Khan *et al.* (1978)[14] reported that OC improved germination and speeded elongation of sweet corn seeds at 10°C. Bodsworth and Bewley (1981)[5] found that OC promoted early and synchronous germination of corn and soybean seeds at 10°C. Knypl and Khan (1981)[15] found that the treatment with PEG improved the performance of soybean seeds as shown by advancement in the time of germination and an increase in the rate of germination and emergence at 8 or 15°C.

Depending on time and location of planting, soil conditions can vary from cold and wet to hot and dry. The objectives of this experiment were to investigate the effects of OC on seedling moisture uptake and seedling growth of corn and soybeans under a broader range of soil moisture and temperature conditions than normally encountered in the literature.

MATERIALS AND METHODS

Laboratory germination experiments were conducted in plastic pots (freezer containers) at the Department of Agronomy, University of Missouri-Columbia, Columbia, Missouri. A split plot design was used with four replications. Seeds treated with PEG-8000 (supplied from SIGMA Chemicals, St. Louis) solutions at 15°C for 9 days were planted along with a control in soil adjusted to water potentials of –1.50, –0.50, and –0.05 MPa and maintained at constant temperatures of 15 and 35°C. Observations were taken at 3 days for treatments at 35°C and 7 days for those at 15°C.

Prior to treatment, seeds of corn (Dekalb XL 72B), and soybeans (Williams) were screened to uniform size. Visibly cracked or diseased seeds were discarded. Twenty-five gram batches of seeds of each species were placed in 9 x 9 x 6 cm plastic pots (freezer containers), the bottom of which were lined with one sheet of Whatman No. 1 filter paper and 25 ml of 20, 30, or 50% PEG-8000 solution supplemented with 0.2 percent thiram. The containers were covered with plastic caps, sealed with three layers of masking tape, and transferred to a constant dark incubator at 15°C for 9 days. Untreated seeds with the same amount of thiram were kept dry under the same condition and germinated at the same time as the conditioned seeds.

At the end of 9 days, the seeds were withdrawn from the osmoticum, quickly rinsed with tap water to remove surface PEG, and blotted dry with paper towels. Seeds were air-dried at 25°C in a stream of air and then germinated in from 3 to 6 days. At the end of the drying period, seed moisture contents of each species were similar to those of the untreated seeds (Fig. 1).

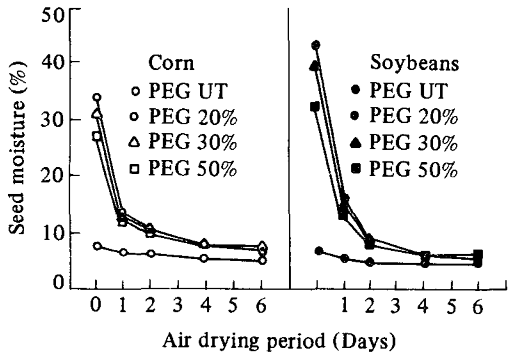

Fig. 1. Effect of air-drying period at room temperature on seed moisture content of corn and soybeans after osmoconditioning (OC) with PEG-8000. PEG UT is untreated control.

The germination medium was a Mexico silt loam (fine, montmorillonitic, mesic Udollic Ochraqualf) soil with a bulk density of 1.26 g/cm^3. It was obtained from the Agronomy Research Center near Columbia, air-dried, sieved, and sterilized in an autoclave for 4 to 5 hours. Twelve to 15 kg samples were adjusted to each soil moisture level and individually stored in plastic-lined metal cans until use. Twenty seeds from each treatment combination were planted 2 cm deep in 750-ml plastic pots (freezer containers) and the soil compacted to 1.20 g/cm^3 bulk density. A wooden container and piston were constructed to facilitate repeatable compaction of soil. Soil moisture contents at –1.50, –0.50, and –0.05 MPa were 14.4, 17.3, and 20.4 percent, respectively. Each pot was covered with a plastic cap and maintained at a constant temperature (15 or 35°C) during the germination period.

Seedling moisture content, seedling length, and seedling dry weight were measured for each treatment combination. Seed or seedling moisture content and dry weight were calculated following oven drying at 105°C to constant weight. Seedling length included lengths of both the hypocotyl and radicle. Analysis of variance was used to determine differences between and among factors. An arcsin transformation was used on data for seedling moisture content and a square root transformation was used for seedling length.

RESULTS AND DISCUSSION

Observations of seedling moisture content, seedling length, and seedling dry weight of corn and soybeans were measured at 3 days for treatments at 35°C and 7 days for those at 15°C.

Seedling moisture content of corn was higher after 3 days at 35°C than after 7 days at 15°C at all soil water potentials (Fig. 2). Differences in seedling moisture content due to temperature increased as soil water potential increased from −1.5 to −0.05 MPa. Seedling moisture content of corn decreased after OC with PEG as PEG concentration increased from 0 to 50 percent, especially at 35°C (Fig. 3). These decreases were linearly related to the concentration of the osmoticum at 35°C, but were observed only with 50 percent PEG when germination was at 15°C. In contrast to corn seedling moisture of soybeans was similar at the two temperatures. Seedling moisture content of soybeans was increased, however, as soil water potential increased from −1.50 to −0.05 MPa (Fig. 2). The increase was similar at both temperatures. The OC with PEG slightly increased seedling moisture content at 15°C but decreased it at 35°C (Fig. 3).

Seedlings of corn were longer at 35°C after 3 days than at 15°C after 7 days (Fig. 4). As with moisture uptake, differences in seedling length due to temperature increased as soil water potential

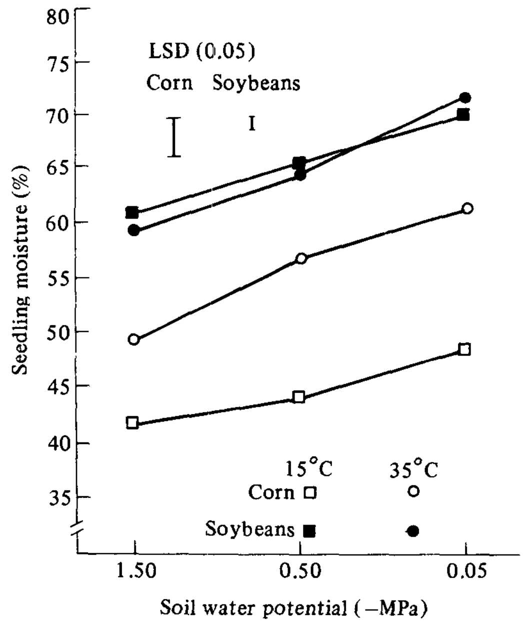

Fig. 2. Effect of temperature and soil water potential on seedling moisture content of corn and soybeans. Data are for 3 days at 35°C and 7 days at 15°C.

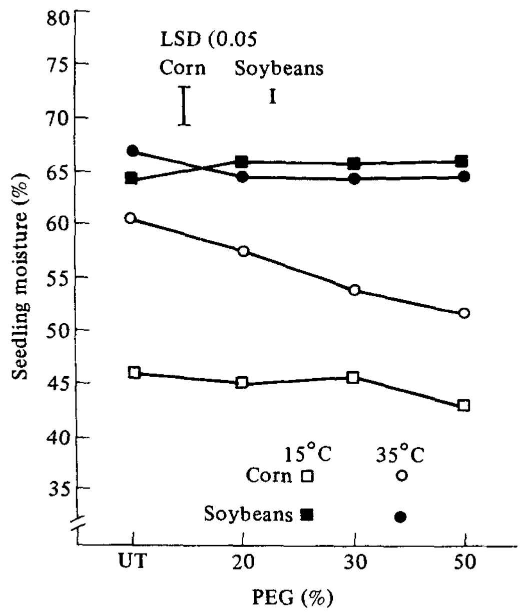

Fig. 3. Effect of temperature and PEG concentration on seedling moisture content of corn and soybeans. UT = untreated control. Data are for 3 days at 35°C and 7 days at 15°C.

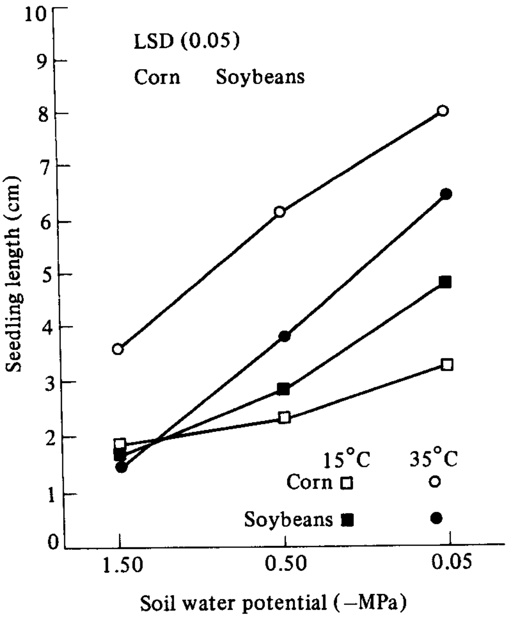

Fig. 4. Effect of temperature and soil water potential on seedling length of corn and soybeans. Data are for 3 days at 35°C and 7 days at 15°C.

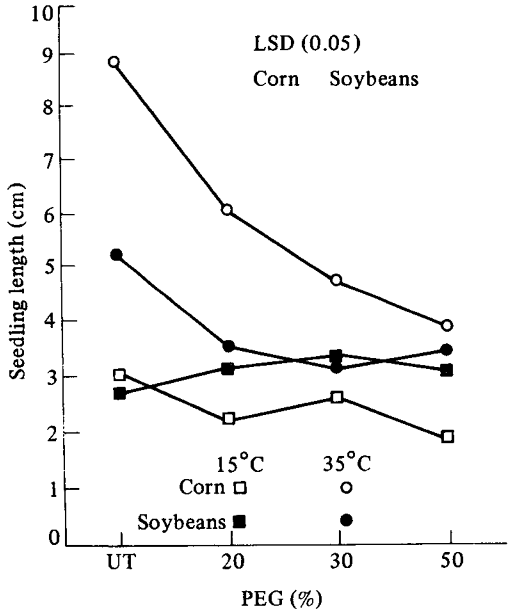

Fig. 5. Effect of temperature and PEG concentration on seedling length of corn and soybeans. UT = untreated control. Data are for 3 days at 35°C and 7 days at 15°C.

increased from –1.50 to –0.05 MPa. Due to slow growth at 15°C, emergence would not have been achieved from any depth greater than 3 cm even with favorable moisture condition (–0.05 MPa). OC with PEG increased seedling length as PEG concentration decreased from 50 to 0 percent at 35°C (Fig. 5). At 15°C, seedling length of corn was unaffected by PEG concentration. Seedling elongation of soybeans was accelerated by increased temperature only at soil water potential of –0.50 and –0.05 MPa (Fig. 4). Seedling length of soybeans was increased as soil water potential increased from –1.50 to –0.50 MPa. OC with PEG slightly increased seedling length of soybeans at 15°C but decreased it at 35°C compared with the untreated control (Fig. 5).

Seedling dry weight of corn was decreased more at 35°C after 3 days than at 15°C after 7 days of germination (Table 1). Soil water potential and PEG concentration had no effect on seedling dry weight of corn. Seedling dry weight of soybeans decreased as soil water potential increased from –1.50 to –0.05 MPa, with larger decreases at 15°C than at 35°C. OC with PEG did not affect seedling dry weight of soybeans.

Highly significant positive correlation coefficients were found between seedling moisture content and seedling length of corn and soybeans (Table 2). Seedling dry weight of corn showed highly significant negative correlations with the other two variables. Seedling dry weight of soybeans showed a highly significant negative correlation with seedling moisture content.

Mean moisture content of corn seedlings was 45.1 and 56.1 percent at 15°C after 7 days and 35°C after 3 days of germination, respectively. Seedling moisture content of soybeans was 65.8 and 65.6 percent at the same 15 and 35°C, respectively. These results imply that soybean seedlings absorbed 20.7 and 9.5 percent more water than corn seedlings at 15 and 35°C, respectively.

Mean seedling length of corn was 2.5 and 6.0 cm at 15°C after 7 days and 35°C after 3 days of germination, respectively. However, seedling length

Table 1. Effect of temperature and soil water potential on seedling dry weight (g/100) of corn and soybeans.

Species	Soil water potential (MPa)	Temperature (°C)			
		15	35	mean	LSD (0.05)
Corn					
	−1.50	26.35	24.89	25.61	
	−0.50	26.01	24.92	25.47	
	−0.05	26.07	25.03	25.55	
	Mean	26.14	24.95		0.99
	LSD (0.05)			NS	NS
Soybeans					
	−1.50	17.77	17.03	17.40	
	−0.50	17.19	17.04	17.12	
	−0.05	16.84	16.09	16.91	
	Mean	17.27	17.02		NS
	LSD (0.05)			0.26	0.37

Table 2. Correlation coefficients among seedling moisture content, seedling length, and seedling dry weight of corn and soybeans.

Variable	Corn seedling		Soybeans seedling	
	Moisture content	Length	Moisture content	Length
Seedling length	0.920**		0.922**	
Seedling dry weight	−0.482**	−0.413**	−0.263**	−0.143NS

** significant at the 0.01 level of error probability.

of soybeans was 3.1 and 4.0 cm at 15 and 35°C, respectively. These results suggest that corn elongation is more rapid at high temperature than that of soybeans.

OC with PEG solutions showed an effect on seedling moisture uptake and seedling elongation of corn at 15 and 35°C in the soil moisture ranges tested. Khan *et al.* (1978)[14] reported that OC improved germination of sweet corn seeds at 10°C. OC promoted early and synchronous germination of corn at 10°C(Bodsworth and Bewley, *1981*).[5] However, Blacklow (1972)[4] found that rates of radicle and shoot elongation of corn seedlings were greatest at about 30°C and effectively ceased at 9°C.

The effect of OC with PEG solutions on seedling growth of soybeans was positive at the highest soil water potential at 15°C only (data not shown), indicating higher seedling moisture content and greater seedling length than untreated control. However, these effects did not occur at lower soil water potentials. Knypl and Khan (1981)[15] reported greater hypocotyl and root length of soybeans by OC with PEG solutions. And Khan *et al.* 1983)[13] suggested from the results of field experiments that OC with PEG may be an effective means of improving seedling establishment under cold and wet conditions.

摘　　要

옥수수品種(Dekalb XL 72B)과 大豆品種(Williams)의 發芽와 苗伸長을 두 溫度, 세 土壤水分 포텐셜 및 네 polyethylene glycol(PEG) 8,000 水準에서 測定하였다. 各 品種의 20處理種子를 0.2% Thiram에 處理하여 假比重 1.20으로 壓縮된 殺菌砂壤土에 2.0cm 깊이로 播種 分割區配置法 四反復으로 實施하였다.

1. PEG로 한 滲透處理는 高溫에서나 低土壤水分 포텐셜 條件에서 效果가 거의 없었다.

2. 大豆는 옥수수보다 높은 苗水分含量을 보였고 두 作物 모두 土壤水分 포텐셜과 溫度가 增加할수록

水分吸收가 增加되었다.

3. 옥수수의 苗長이 35℃에서는 大豆보다 길었으나 15℃에서는 짧았다.

4. 옥수수의 乾物重은 35℃에서 減少되었고 大豆의 乾物重은 土壤水分 포텐셜이 增加할수록 減少되었다.

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