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Effects of Temperature, Seed Water Content and Osmoconditioning on Germination and Seedling Elongation of Soybeans

Rak Chun Seong*, Harry C. Minor** and Eun Hi Hong***

溫度·種子水分含量 및 滲透處理가 콩의 發芽 및 苗伸長에 미치는 影響

成 樂 春*·해리 씨 마이너**·洪 殷 憙***

ABSTRACT

Germination and seedling elongation of soybeans [cult. 'Williams'] were measured at two temperatures (15 and 30 ℃), three seed water contents (30, 50, and 70%), and with and without polyethylene glycol-8000 (PEG) treatments. A split-plot design was used with four replications. Observations were made from two hours to eight days for each treatment combination.

Seeds were soaked with 30% PEG solution with 0.2% thiram at 15 C for six days, rinsed with deionized water and dried at 25.5 ℃ for three days. Ten treated or untreated seeds were placed on Whatman No. 1 (9 cm) filter paper in plastic petri-dishes to which sufficient deionized water was added to adjust seed moisture content to the desired level. The dishes were then sealed with parafilm and placed in a continuous programmed temperature chamber under dark condition.

Seedling growth did not occur at either temperature when moisture content was 50 percent or less. Osmoconditioning with PEG showed positive effects on seedling moisture uptake and seedling growth at 15℃ but little effect at 30℃. Seedling moisture content increased rapidly early in the germination period and reached 60% at 15 C for 56 hours and at 30℃ for 28 hours. Seedling growth started when seed moisture reached a critical point of 60% at 15℃, however, growth started after 20 hours of germination at 30℃. Seedlings of soybeans elongated more than four times faster at 30℃ than at 15℃. Water uptake during germination was characterized by two phases in this experiment.

INTRODUCTION

Establishment of a crop depends on successful germination. Various seed treatments have been reported to improve seed germination or seedling emergence. Osmoconditioning (OC) of seeds of soybeans with polyethylene glycol-8000 (PEG) offers a potential means for enhancing germination and emergence. The advantages of PEG over other

*培材大學 (Dept. of Horticulture, Pai-Chai University, Daejon 300, Korea)
** 미조리大學校 農科大學 (Agronomy Dept. College of Agriculture, University of Missouri-Columbia, Columbia, Missouri U. S. A)
*** 作物試驗場 (Crop Experiment Station, RDA, Suwon 170, Korea) 〈86. 10. 14 接受〉

osmotica have been discussed by Heydecker & Coolbear[14] and Khan[17]. Seeds of many crops have been subjected to OC and positive results have been obtained with small seeds of vegetables and flowers.[14,15,19]. Recent studies show that soybean seeds are amenable to the treatment[2,13,18,20,21,25].

Hunter & Erickson[16] reported that the seed moisture content required for soybean germination was about 50 percent[4]. However, Waldren & Flowerday[23] reported the water requirement for initiation of germination of soybeans to be about 60 percent. Toole *et al.*[22] and Berlyn[1] reported that moisture uptake occurs in stages during germination of seeds. Three phases of the germination process have been described by Ching.[5] These are (1) hydration and reactivation, (2) steady water content and respiration, and (3) cell division and growth. However, Fujisawa[7] reported that developments in phases (2) and (3) were dependent on processes occurring in their preceding phases, and appeared even within a single phase. These were dependent upon time, temperature, and the level of water stress.[10,11,12]

Wilson[24] 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℃. However, 30℃ is generally considered to be an optimal temperature for rapid emergence of soybeans[6]. Bowen & Hummel[3] reported that hypocotyl growth rate of soybean seedlings increased as temperature increased from 15 to 30℃ as did Gilman *et al.*[8] and Hatfield & Egli.[9]

The objectives of this experiment were to clarify relationships between OC and seed water content and to investigate the phases during germination in relation to temperature and seed water content of soybeans.

MATERIALS AND METHODS

Germination experiments were conducted at the Department of Agronomy, University of Missouri – Columbia. Seesds of soybeans [Cult. 'Williams'] were osmoconditioned with PEG-8000 (supplied by SIGMA Chemicals, St. Louis) solution. The OCed or untreated seeds were measured at two temperatures (15 and 30℃) and three seed water contents (30, 50, and 70 percent). Adjustments of seed water content using plastic syringe (5 or 10cc) were based on water-seed weight relationships illustrated in Fig. 1. Calculation of seed water content was used for 30 percent, Y = 0.43X; for 50 percent, Y = 1.00X; and for 70 percent, Y = 2.35X; where Y = water weight (g) and X = seed dry weight (g). A split plot was used with four replications. Observations were initiated 2 hours after the start of the experiment and continued for 8 days.

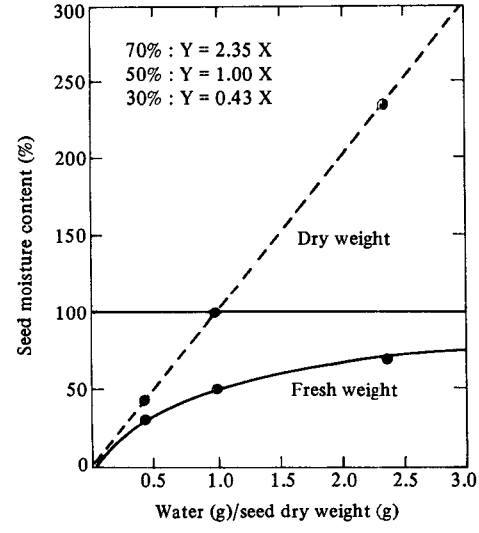

Fig. 1. Relationship between dry weight and fresh weight in determination of seed or seedling moisture content.

Seeds of soybeans produced in 1983 were obtained from the Missouri Seed Improvement Association. Seeds were screened to obtain uniform size. Visibly cracked or diseased seeds were discarded. Seeds in 20 g batches were placed in 9 x 9 x 6 cm plastic pots (freezer containers) lined with one strip of Whatman No. 1 filter paper and 20 ml of 30 percent 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 an incubator at 15℃

in continuous dark for 6 days. Untreated seeds were kept dry under the same temperature conditions as the conditioned seeds. Seeds were withdrawn from the osmoticum, quickly rinsed with deionized water to remove PEG and blotted dry with paper towels. Seeds were germinated after 3 days of air-drying at 25.5 ± 1.5C in a stream of air (RH = 53 ± 3 percent). Moisture contents of Occed and untreated seeds are presented in Fig. 2.

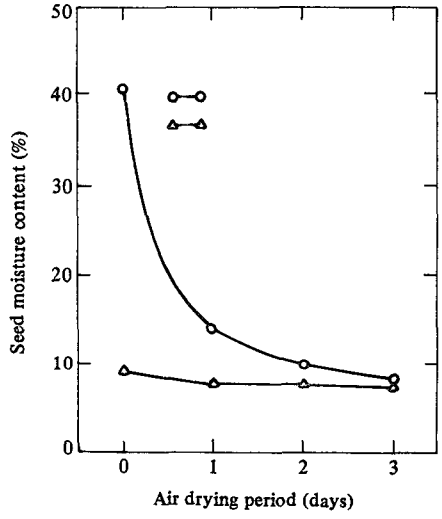

Fig. 2. Effect of air-drying period at 25.5℃ (RH = 53%) on seed moisture content of soybeans after osmoconditioning (OC) with PEG-8000.

Ten OCed or untreated seeds were placed on Whatman No. 1 (9 cm) filter paper in plastic petridishes, and adjusted to the proper seed water content with deionized water supplemented with 0.2 percent thiram. The dishes were sealed with parafilm. The seeds were germinated at a constant temperature of 15 or 30℃ under dark conditions. Data recorded included seedling moisture content, seedling length, and seedling dry weight which were started from 2 hours to 8 days. Seed or seedling moisture content and dry weight were calculated following over 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 analysis of variance, an arcisin transformation was used on data for seedling moisture content, and a square root transformation was used on data for seedling length.

RESULTS AND DISCUSSION

Seed or seedling moisture contents of soybeans were higher at 30℃ than at 15℃ until 32 hours of germination (Fig. 3 and 4). Thereafter, seed or seedling moisture content of soybeans was higher at 15℃ than at 30℃ presumably, due to evaporation, even though the dishes were sealed with parafilm. Significant differences were found among seed water content levels from 30 to 70 percent at all germination time. OC with PEG increased seed or seedling moisture content of soybeans from 2 hours to 56 hours of germination time. However, increases in seed or seedling moisture content with OC gradually reduced as germination time increased. No significant differences in seed or seedling moisture content resulted from OC after 64 hours of germination.

As presented in Fig. 3 and 4, seed or seedling moisture content of soybeans increased rapidly at the early stages of germination. The increase was faster at 30℃ than at 15℃. At 15℃, seed moisture content of soybeans achieved 40 percent in 12 hours and 60 percent in 56 hours when initial seed water content was 70 percent. However, seed or seedling moisture content of soybeans reached over 50 percent at 12 hours and 60 percent at 28

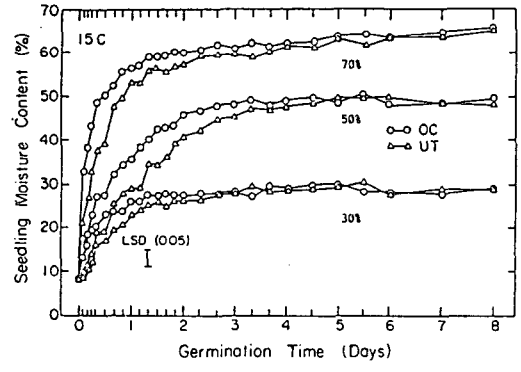

Fig. 3. Effect of seed water content with germination time on seedling moisture content of PEG-treated (OC) and untreated (UT) soybeans at 15℃.

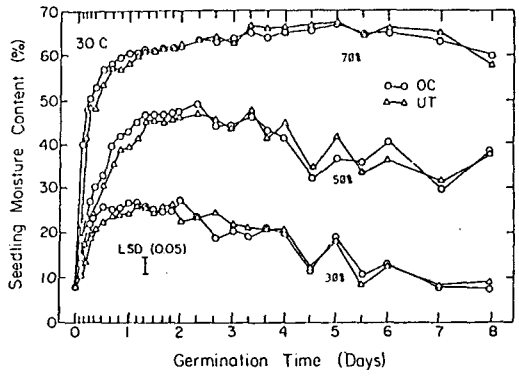

Fig. 4. Effect of seed water content with germination time on seedling moisture content of PEG-treated (OC) and untreated (UT) soybeans at 30℃.

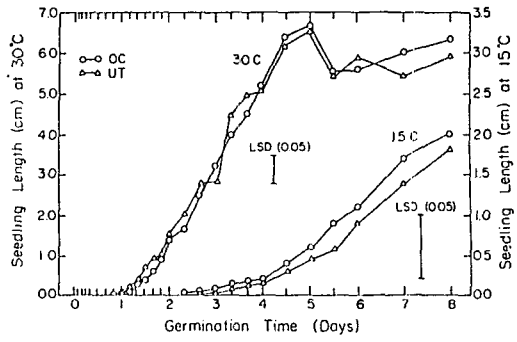

Fig. 5. Effect of temperature with germination time on seedling length of PEG-treated (OC) and untreated (UT) soybeans at 70% seed water content.

hours of germination with the same seed water content at 30℃. On the other hand, at 30℃, seed or seedling moisture contents of soybeans were decreased after 120 hours of germination time with 70 percent initial seed water content, and the lower seed water content caused seed moisture content to decrease even earlier.

Effect of OC with PEG on seed or seedling moisture content of soybeans was found at 15℃ (Fig. 3). Seed or seedling moisture contents of soybeans were significantly increased with OC at all levels of seed water content at 15℃. With 70 percent of initial seed water, seed or seedling moisture content of soybeans was increased with OC from 2 hours to 80 hours of germination.

Seedling growth of soybeans was not visible when initial seed water content was 50 percent or less. With 70 percent of initial seed water, seedling lengths of soybeans were longer at 30℃than at 15℃ at all germination times (Fig. 5). At 15℃, seedling growth of soybeans started at 56 hours, however, seedling growth of soybeans started at 20 hours at 30C.

A significant effect of OC with PEG on seedling length of soybeans was found under low temperature conditions (Fig. 5). Seedling length of soybeans was increased with OC at all germination times after seedling growth of soybeans started at 15C. At 30℃, seedling length of soybeans was reduced after 5 days (120 hours) of germination due to the dry condition of the petri-dishes, indicating that even though sealed, the petri-dish with a parafilm seal lost moisture or seedling respiration was accelerated at high temperature causing water stress in petri-dishes.

Seed or seedling dry weight of soybeans was decreased as germination time increased (Date not shown). Seed or seedling dry weights of soybeans were similar at temperatures of 15 and 30℃. With 70 percent initial seed water, seed or seedling dry weights decreased compared with those with 30 and 50 percent of seed water. These decreases on seed or seedling dry weight of soybeans occurred after 4 days (96 hours) of germination. OC with PEG showed no differences on seed or seedling dry weight of soybeans.

Significant correlation coefficients were found among seed or seedling moisture content, seedling length, and seed or seedling dry weight of soybeans (Table 1). Seed or seedling moisture contents were

Table 1. Correlation coefficients among seedling moisture content, seedling length, and seedling dry weight of soybeans.

Variable	Seedling moisture Content	Seedling Length
Seedling Length	0.468 **	
Seedling Dry Weight	−0.219 **	−0.239 **

** Significant at the 0.01 level of error probability.

correlated positively with seedling length (0.468**). Seed or seedling dry weights were negatively correlated with seedling length (-0.239**) of soybeans.

As presented in Fig. 3 and 4, a critical point of seed moisture uptake was found with 70 percent of initial seed water. Seed or seedling moisture contents of soybeans reached about 60 percent in 28 and 56 hours of germination times at 30 and 15C, respectively. At the lower temperature, seeds or seedlings of soybeans absorbed moisture at half of rate as at 30℃(Fig. 6).

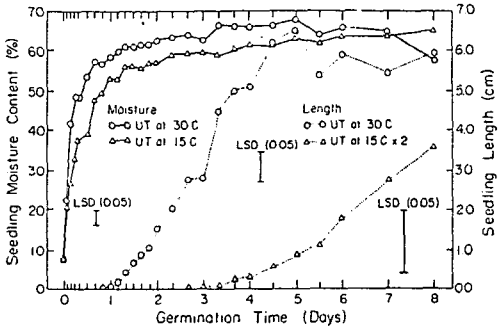

Fig. 6. Effect of temperature with germination time on seedling moisture content and seedling length of untreated (UT) soybeans at 70% seed water content.

Seedling growth of soybeans started when seed moisture content reached between 50 and 60 percent moisture. At 15℃, seedling growth of soybeans started after 56 hours. However, seedling growth of soybeans started in 20 hours at 30℃(Fig. 5). Growth rate of soybean seedling was about four times faster at 30C compared with 15℃(Fig. 6).

Waldren & Flowerday[23] reported that the water requirement to begin germination of soybeans was about 60 percent. However, Hunter & Erickson[16] reported that the seed moisture content required for soybean germination was about 50 percent also was reported by Cardwell.[4] Bowen & Hummel[3] found that hypocotyl growth rate of soybean seedlings increased as temperature increased from 15 to 30℃ as did Gilman *et al.*[8] and *Hatfield & Egli.*[9] Thus, 30℃is generally considered to be an optimal temperature for rapid emergence of soybeans.[6]

In this experiment, two stages of water uptake during germination of soybean seeds were evident, the first involving absorption and the second, seedling growth. Three phases of the germination process have been described by Ching.[5] However, Fujisawa[7] reported that development in phases were dependent on processes ocurring in their preceding phases, and they appeared even with two phases. These were dependent upon time, temperature, and the level of water stress.[10, 11, 12]

At 15℃, OC with PEG accelerated both moisture uptake and seedling growth of soybeans as shown in Fig. 3 and Fig. 5. Knypl & Khan[21] reported that germination and emergence of soybeans were accelerated with OC at 15℃. The similar results were obtained by Bodsworth & Bewley[2] and Khan *et al.*[18]

摘　　要

콩 品種(williams)의 發芽와 苗伸長을 두 溫度, 세 種子, 水分含量 및 Polyethylene glycol-800 (PEG) 處理와 無處理에서 測定하였다. 分割區配置法 四反復으로 實施하였으며 試料를 2時間부터 8日까지 各處理 組合에서 採取하였다. 콩種子를 0.2% Thiram을 添加한 30% PEG 溶液에 놓아 15℃에서 6日間 沈漬後 蒸溜水로 洗滌하여 25.5℃에서 3日間 乾燥하여 10個의 處理 또는 無處理 種子를 plastic petri-dish 안의 9 cm 濾過紙에 놓아 水分含量에 相當한 蒸溜水를 添加하였다. Parafilm으로 密封하여 恒溫無光條件의 處理 溫度에서 發芽시켰다.

水分含量이 50% 또는 以下인 處理에서는 두 溫度 모두 苗伸長이 일어나지 않았다. PEG를 利用한 滲透處理는 15℃에서는 苗水分 吸水와 苗伸長間에 正의 相關 效果를 보였으나 30℃에서는 거의 없었다. 種子 또는 苗水分含量은 發芽期間동안 初期에 急速히 增加하여 15℃에서는 56時間에, 그리고 30℃에서는 28時間에 60%에 到達하였다. 苗伸長은 種子水分含量이 15℃에서는 60%에서 시작되었지만 30℃에서는 20時間에 시작되었다. 콩苗는 15℃에 比하여 30℃에서 四倍 以上伸長되었다. 發芽期間 동안의 水分吸收樣相은 이 試驗에서는 두 段階로 特定되었다.

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