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Effects of Temperature and Moisture Level during Preconditioning on Germination and Seedling Elongation of Soybean Seeds with and without Osmoconditioning

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温度, 種子水分 및 滲透處理가 大豆의 發芽와 苗伸長에 미치는 影響

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ABSTRACT

Germination and seedling length of soybean seeds (cultivar: Williams) with and without polyethylene glycol-8000 (PEG) treatments were measured following preconditioning at two temperatures (15 and 30°C) and two moisture levels [low (30 percent) and high (50 percent seed water content)] for 0, 2, 4, or 8 days. A split-split plot in time was used with four replications. Observations were made after two days of germination at 30°C

Seedling growth accelerated with two days of preconditioning at 30°C, but was reduced as preconditioning duration increased up to eight days at the same temperature. PEG treated preconditioned seeds exhibited reduced moisture uptake and seedling growth. Preconditioning at a high moisture level increased seedling moisture content and also increased seedling length until four days of preconditioning duration. Seedling dry weight decreased when preconditioning temperature was 30°C and when the high moisture level of preconditioning was continued for eight days.

INTRODUCTION

Successful emergence above the soil is a critical factor for crop establishment. Various seed treatments have been reported to improve seed germination or seedling emergence. Osmoconditioning (OC) of seeds with polyethylene glycol-8000 (PEG) produces enhancement of germination and emergence at low temperatures in small vegetable and flower seeds.[12,13,16,17] Knypl and Khan (1981)[19] reported in detail the optimum conditions for OC of soybean seeds to improve germination and soil emergence at suboptimal temperatures. Hepperly and Sinclair (1977)[11] suggested that solutions of PEG in water can be used without reducing seed viability as solvents for antibiotics with which soybean seeds are to be treated. However, Bodsworth and Bewley (1981)[2] concluded that air-drying of osmoconditioned (OCed) seeds reduced the ad-

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vantages gained by OC; the longer the period of drying, the greater the reduction.

Seeds swollen in water and sown while still in a moist condition germinated more rapidly than untreated seeds. Kidd and West (1919)[18] found that seeds soaked in a minimum amount of water and afterwards dried slowly at ordinary temperatures imbibed water and developed more rapidly when again allowed to take up water and germinate than untreated seeds. Chippindale (1934)[5] reported that with most species of grasses, an acceleration of germination resulted from presoaking. May *et al.* (1962)[20] reported that the drought resistance of crop plants could be increased by subjectng seeds to two or three cycles of wetting and drying prior to sowing. Seeds of tomato and oats were subject to hydration-dehydration treatments at various times during germination by Berrie and Drennan (1971).[1] They found little harmful effect if dehydration was imposed before cell division and enlargement had commenced. Hanson (1973)[8] found that imbibition and re-drying of wheat seeds accelerated subsequent coleoptile emergence markedly under unfavorable conditions. Idrid and Aslam (1975)[15] also found that the soaking of wheat seed in water followed by air-drying before planting accelerated germination. However, Hegarty (1977)[10] reported that hydration or hydration after dehydration of carrot seeds had very little effect on the seeds' abilitv to germinate in a favorable environment when the seeds were rehydrated.

Hunter and Erickson (1952)[14] reported that the seed moisture content required for soybean germination was about 50 percent.[4] However, Waldren and Flowerday (1982)[22] reported the water requirement for initiation of germination of soybeans to be about 60 percent. Wilson (1928)[23] 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°C. However, 30°C is generally considered to be an optimal temperature for rapid emergence of soybeans.[6] Bowen and Hummel (1980)[3] also reported that hypocotyl growth rate of soybean seedling increased as temperature increased from 15 to 30°C.[7,9]

Water deficits may result in delayed and reduced germination or may prevent germination completely. Hunter and Erickson (1952)[14] suggested that once a seed obtains a critical level of hydration it will proceed toward full germination. It is also known that physiological changes will occur under partial hydration even though germination (radicle emergence from the seed) is prevented. In the field, soil moisture conditions at seed depth are continuously changing (sinusoidal fluctuation of daily period)[21] and seeds may well experience a series of hydration and dehydration cycles before root growth commences. Thus, soil conditions will affect seed viability which is the capacity of a seed to germinate.

The objectives of this experiment were to determine the effects of temperature and moisture level during preconditioning on germination and seedling elongation of soybeans and to investigate continuity of any OC effect on germination and seedling elongation of soybeans under the above conditions.

MATERIALS AND METHODS

Germination experiments were conducted at the Department of Agronomy, University of Missouri-Columbia, Columbia, Missouri. Seeds of soybeans [*Glycine max* (L.) Merr. Cult. 'Williams') were osmoconditioned (OCed) with polyethylene glycol-8000 (PEG) (supplied by SIGMA Chemicals, St. Louis) solution. The OCed or untreated seeds were hydrated at two temperatures (15 and 30°C) and two moisture levels [30 (Low Moisture Level = LM) and 50 (High Moisture Level = HM) percent seed water content] for four durations (0, 2, 4, and 8 days).

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 6cm plastic pots (freezer containers) lined with one strip of Whatman No. 1 filter paper and 20 ml of 30 percent PEG solution supplemented with 0.2

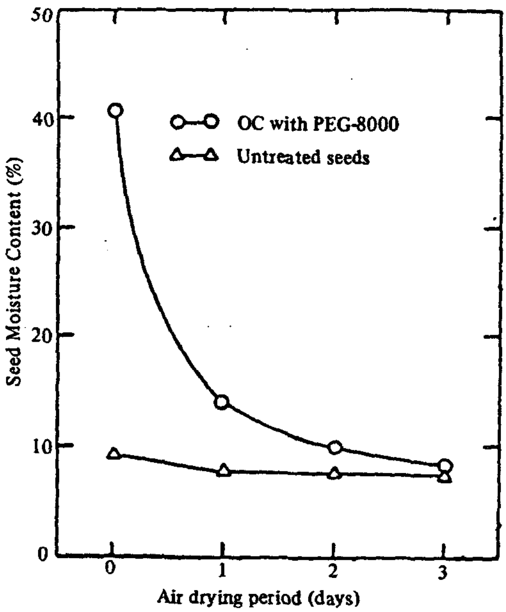

Fig. 1. Effect of air-drying period at 25.5°C (RH = 53%) on seed moisture content of soybeans after osmoconditioning (OC) with PEG-8000.

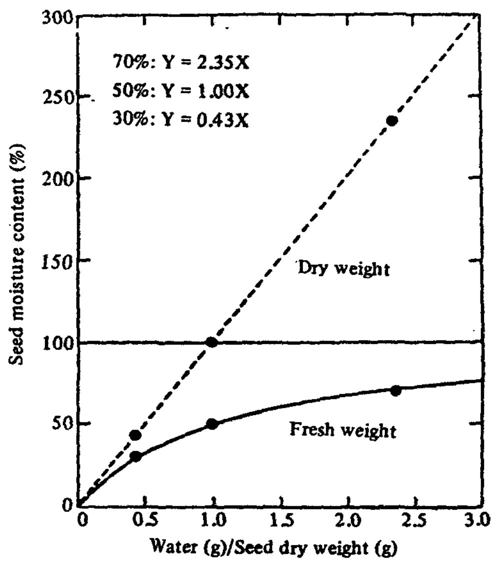

Fig. 2. Relationship between dry weight and fresh weight in determination of seed or seedling moisture content.

percent thiram. The containers were covered with plastic caps, sealed with three layers of masking tape, and transferred to an incubator at 15°C in continuous dark for six days. Untreated seeds were kept dry under the same conditions as the conditioned seeds. Seeds were withdrawn from the osmoticum, quackly rinsed with deionized water to remove PEG and blotted dry with paper towels. Seeds were preconditioned as described below, after three days of air-drying at 25.5 ± 1.5°C in a stream of air (RH = 53 ± 3 percent). Moisture contents of OCed and untreated seeds are presented in Fig. 1. Following drying, observations were made after 2 days of germination at 30°C under continuous dark condition.

Twenty OCed or untreated seeds were placed on Whatman No. 1 (9 cm) filter paper in a plastic petridish, and adjusted to the calculated seed water content with deionized water supplemented with 0.2 percent thiram. Adjustments of seed water content using plastic syringe (5 or 10 CC) during preconditioning were based on water-seed weight relationships illustrated in Fig. 2. The calculation of seed water content used for 30 percent was Y = 0.43X, and that for 50 percent was Y = 1.00X, where Y = water weight (g) and X = seed dry weight (g). The dishes were sealed with parafilm. The seeds were placed at a constant temperature of 15 or 30°C under dark conditions for the specified durations. The hydrated seeds were then air-dried at 25.5°C (RH = 53 percent) for three days as in Fig. 1. Moisture contents of hydrated seeds with or without OC are presented in Fig. 3.

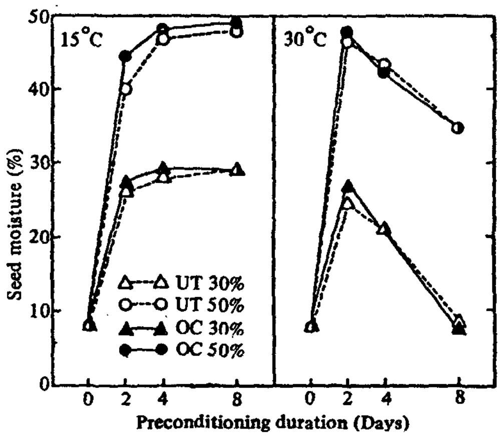

Fig. 3. Effect of temperature and moisture levels during preconditioning on seed moisture content of PEG-treated (OC) and untreated (UT) seeds of soybeans.

These twenty preconditioned seeds with or without OC were placed on Whatman No. 1 (9 cm) filter paper in the plastic petri-dish, adjusted to 75 percent seed water content with deionized water supplemented with 0.2 percent thiram, and the dish again sealed with parafilm. The seeds were germinated at a continuous temperature of 30°C under dark conditions. Observations were made after two days of germination for each treatment combination. Data recorded included seedling moisture content, seedling length, and seedling dry weight. 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. 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 square root transformation was used on data for seedling length. The experimental design was a split-split plot in time with four replications.

RESULTS AND DISCUSSION

Seedling moisture contents of soybeans after two days of germination at 30°C were not affected by preconditioning temperatures of 15 or 30°C (Fig. 4). However, seedling moisture content of soybeans was increased with high moisture level (HM) as compared with low moisture level (LM), and also by extending the duration of preconditioning from

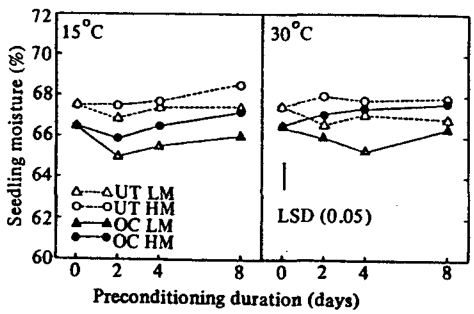

Fig. 4. Effects of temperature and moisture levels during preconditioning on seedling moisture content of PEG-treated (OC) and untreated (UT) seeds of soybeans.

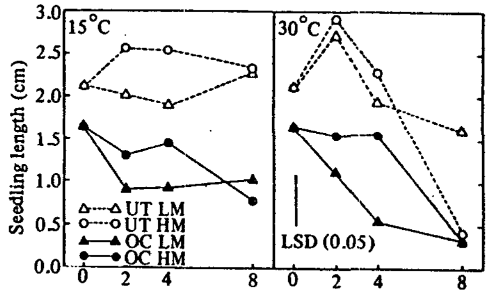

Fig. 5. Effects of temperature and moisture levels during preconditioning on seedling length of PEG-treated (OC) and untreated (UT) seeds of soybeans.

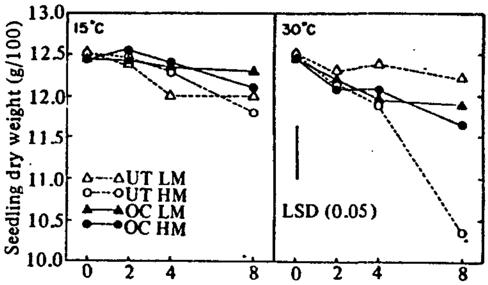

Fig. 6. Effects of temperature and moisture levels during preconditioning on seedling dry weight of PEG-treated (OC) and untreated (UT) seeds of soybeans.

zero to eight days. Seeds preconditioned with OC had less seedling moisture content than seeds preconditioned without OC at all durations of preconditioning.

Mean seedling lengths of soybeans were unaffected by preconditioning temperatures (Fig. 5). Soybeans preconditioned at 30°C for two days had longer seedlings than those preconditioned for other durations. With soybeans preconditioned at 15°C seedling length decreased with each increase in preconditioning duration. At the HM level, seedling length of soybeans increased up to four days of preconditioning duration, then decreased with eight days of preconditioning duration. Preconditioning following OC decreased seedling elongation of soybeans compared with preconditioning without OC, and seedling length was reduced more as preconditioning duration increased from zero to eight days.

Seedling dry weights of soybeans were not affected by preconditioning temperatures of 15 or 30°C (Fig. 6). With eight days of preconditioning duration, seedling dry weight of soybeans was decreased more at the 30°C preconditioning temperature than by 15°C, and was reduced more with the HM level than with the LM level. No difference was found among seedling dry weights which could be attributable to OC.

Highly significant correlation coefficients were found among seedling moisture content, seedling length and seedling dry weight of soybeans (Table 1). Seedling moisture contents were correlated positively with seedling length (0.459**), while

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

Variable	Seedling moisture content	Seedling length
Seedling length	0.459 **	
Seedling dry weight	−0.334 **	0.113 NS

** *Significant at the 0.01 level of error probability.*

seedling dry weights were negatively correlated with seedling moisture contents (-0.334**).

Preconditioning on soybeans increased seedling length when it lasted two days at 30°C (Fig. 5). May *et al.* (1962)[20] reported that one cycle of hydration of spring wheat increased its drought resistance. *Hanson (1973)[8], and Idrid and Aslam* (1975)[15] found that one cycle of hydration-dehydration accelerated germination of wheat seeds under unfavorable conditions.

Bodsworth and Bewley (1981)[2] suggested that air-drying of OCed seeds reduces the advantages gained by OC; the longer the period of drying, the greater the reduction. In this experiment, OCed seeds without proconditioning showed no effect on soybean germination. Presumably, repeated hydration and dehydration cycles would result in reduction of viability of soybean seeds.

The recommended details of preconditioning *with water appear to be based mainly on empirical* experiments. It is known that crop seeds can be *treated under conditions of partial hydration so* that physiological changes in the seeds will occur, but germination is prevented. However, preconditioning temperature and moisture level for preconditioning largely affect physiological processes of the seeds.

摘　　要

滲透處理와 無處理의 大豆種子(品種 : Williams)에 대하여 두가지 溫度(15, 30℃)에서 두가지의 種子水分含量(30%, 50%)으로 調節된 條件으로 ·0, 2, 4 및 8日間 前處理함에 있어서 時間別 細細區配置法 4反復으로 配置하여 發芽와 苗伸長을 調査하였던 바 主要結果는 다음과 같다.

1. 콩의 苗伸長은 30℃에서 2日間 前處理함으로서 促進되었으나 같은 溫度에서 前處理期間이 길수록 抑制되었다.

2. 滲透處理後 前處理된 種子는 水分吸收와 苗伸長이 떨어졌다.

3. 種子水分含量이 50%로 調節된뒤 前處理된 것은 苗의 水分含量을 增加시켰으며 4日間까지의 前處理는 苗伸長을 크게 하였다.

4. 苗의 乾物重에서는 前處理溫度가 30℃ 일때와 種子水分含量이 50%로 調節되어 8日間 前處理하였을 때 減少되었다.

REFERENCES

1. Berrie, A. M. M. and D. S. H. Drennan. 1971. The effect of hydration-dehydration on seed germination. New Phytol. 70: 135-142.
2. Bodsworth, S. and J. D. Bewley. 1981. Osmotic priming of seeds of crop species with polyethylene glycol as a means of enhancing early and synchronous germination at cool temperatures. Can. J. Bot. 59: 672-676.
3. Bowen, H. D. and J. W. Hummel. 1980. Critical factors in soybean seedling emergence. pp. 451-469. In Frederick T. Corbin (ed.) World Soybean Research Conference II: proceedings. Westview Press. Boulder, Colorado.
4. Cardwell, V. B. 1984. Seed germination and crop production. In M. B. Tesar (ed.) Physiological Basis of Crop Growth and Development. pp. 53-92. American Society of Agronomy, Crop Science Society of America. Madison,

Wisconsin.

5. Chippindale, H. G. 1934. The effect of soaking in water on the seeds of some gramineae. Ann. Appl. Biol. 21: 225-232.
6. Delouche, J. C. 1953. Influence of moisture and temperature levels on the germination of corn, soybeans, and watermelons. Proc. Assoc. Off. Seed Anal. 43: 117-126.
7. Gilman, D. F., W. R. Fehr and J. S. Burris. 1973. Temperature effects on hypocotyl elongation of soybeans. Crop Sci. 13: 246-249.
8. Hanson, A. D. 1973. The effects of imbibition drying treatments on wheat seeds. New Phytol. 72: 1063-1073.
9. Hatfield, J. L. and D. B. Egli. 1974. Effect of temperature on the rate of soybean hypocotyl elongation and field emergence. Crop Sci. 14: 423-426.
10. Hegarty, T. W. 1977. Seed activation and seed germination under moisture stress. New Phytol. 78: 349-359.
11. Hepperly, P. R. and J. B. Sinclair. 1977. Aqueous polyethylene glycol solutions for treating soybean seeds with antibiotics. Seed Sci. Tech. 5: 727-733.
12. Heydecker, W. and P. Coolbear. 1977. Seed treatments for improved performance; survey and attempted prognosis. Seed Sci. Tech. 5: 353-425.
13. Heydecker, W., J. Higgins and Y. J. Turner. 1975. Invig oration of seeds? Seed Sci. Tech. 5: 881-888.
14. Hunter, J. R. and A. E. Erickson. 1952. Relation of seed germination to soil moisture tension. Agron. J. 44: 107-109.
15. Idris, M. and M. Aslam. 1975. The effect of soaking and drying seeds before planting on the germination and growth of *Triticum vulgare* under normal and saline conditions. Can. J. Bot. 53: 1328-1332.
16. Khan, A. A. 1977. Preconditioning, germination, and performance of seeds. In the Physiology and Biochemistry of Seed Dormancy and Germination. pp. 283-318. North-Holland Pub. Co. New York.
17. Khan, A. A. K. Tao, J. S. Knypl and B. Borkowska. 1978. Osmotic conditioning of seeds: Physiological and biochemical changes. Acta Hort. 83: 267-278.
18. Kidd, F. and C. West. 1919. Physiological predetermination; the influence of the physiological condition of the seed upon the course of subsequent growth and upon the yield. IV. Review of the literature. Chapter III. Ann. Appl. Biol. 5: 220-251.
19. Knypl, J. S. and A. A. Khan. 1981. Osmoconditioning of soybean seeds to improve performance at suboptimal temperatures. Agron. J. 73: 112-116.
20. May, L. H., E. J. Milthorpe and F. L. Milthorpe. 1962. Pre-sowing hardening of plants to drought. Field Crop Abstr. 15: 93-98.
21. Rose, C. W. 1968. Water transport in soil with a daily temperature wave. I. Theory and experiment. Aust. J. Soil Res. 6: 31-44.
22. Waldren, R. P. and A. D. Flowerday. 1982. Seeds and seeding. Ch. 5. In Introductory Crop Science. Burgess Pub. Co. Minneapolis, Minnesota.
23. Wilson, H. K. 1928. Wheat, soybean and oat germination studies with particular reference to temperature relationships. Agron. J. 20: 599-619.