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GROWTH AND SURVIVAL OF WHEAT SEEDLINGS AFTER DEHYDRATION AND REHYDRATION

Mohammed Guedira, James P. Shroyer, and Gary M. Paulsen*

The planting depth of wheat often is increased to place the seeds in damp soil when low surface moisture restricts germination and seedling development. However, planting seed deeply in dry soil often results in low emergence, slow seedling development, and thin stands. Even if moisture is adequate for germination of seeds, continued lack of precipitation might dehydrate seedlings and stop their growth until additional rain occurs to rehydrate them. The ability of seedlings to tolerate dehydration/rehydration is important for establishing stands of wheat. In addition, planting deeply and delaying emergence depletes carbohydrate reserves in the endosperm that are needed by the seedlings. This study was designed to determine the ability of wheat seedlings, especially the coleoptile and root, to withstand desiccation and the effect of the stress at different developmental stages on seedling emergence. A full account of the study was published in *Agronomy Journal 89:822-826 (1997).*

Procedures

Seedling Development after Dehydration and Rehydration. We used seeds of Larned, a tall, hard red winter wheat cultivar with a long coleoptile. Similarly sized seeds ranging from 5/64 to 7/64 inch in diameter were placed on paper towels. The towels

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were modified with paper wicks that were immersed in distilled water to maintain saturation and covered with aluminum foil to minimize evaporation. Each towel held 30 seeds.

Towels containing the seeds were kept in darkness in a germination chamber at 77°F and 80% relative humidity for 1, 2, 3, 4, or 5 d. After germination, seedlings were removed carefully and spread on dry towels to dehydrate. Nongerminated seeds were discarded, and the number of seedlings per paper towel was reduced to 20 by random selection. All manipulations were performed in a dark room under a dim green safelight.

Seedlings were dehydrated for 1, 2, 3, 4, or 5 d in the darkened growth chamber set at 77°F and 60% relative humidity. The developmental stage of the seedlings at the onset of dehydration is shown in Table 1. After the dehydration treatment, seedlings were rehydrated on moistened paper towels by the procedure used for germination until the first true leaf appeared.

Seedling development after rehydration was determined daily by changes in coleoptile and root lengths. Coleoptile length was measured from the point where the seedling ruptured the seed coat to the tip until elongation ceased. Root length was measured by spreading the roots over grid squares and counting the number of intercepts of roots with horizontal and vertical grid lines. The grid dimension was 0.2 inch; root length was the number of intercepts times 0.3206. Weight of the seed remnants in each treatment combination was measured after seedlings were dehydrated as an indication of endosperm reserve utilization. Samples of 10 seedlings each were air dried and weighed.

Experiments were arranged in a completely randomized block design with three replications of each treatment combination. Data were analyzed statistically by the general linear model method.

Seedling Emergence after Dehydration. Seeds that germinated for 1, 2, 3, or 4 d and were dehydrated for 2 d as described above and nongerminated seeds (0-d controls) were planted at six depths (1, 2, 3, 4, 5, and 6 inches) in vermiculite. Containers 20 inches long, 14 inches wide, and 8 inches high were used. Seeds and seedlings were in rows 14 inches long and 4 inches apart with 25 entries per row. The vermiculite was moistened with distilled water, and transparent covers were placed on the containers to prevent evaporation. Containers were held in environmental chambers maintained at 77°F during the 16-hr day and 60°F during the 8-hr night with 450 µmol $m^{-2}s^{-1}$ lighting during daytime.

Seedling emergence, defined as penetration of the coleoptile through the vermiculate surface, was measured daily. Seedling vigor was evaluated by an emergence rate index, which was calculated as the sum of daily observations of the number of emerged seedlings divided by the number of days from planting.

A split plot design with three replications was used. Planting depths were main plots, and days of germination were subplots in single rows. Analysis of variance was used to examine effects of days of germination before dehydration and seeding depth. Least significant differences at the 0.05 probability level were calculated to detect differences in emergence.

Results and Discussion

Seedling Development after Dehydration and Rehydration Survival was high after seedlings germinated for up to 3 d and were dehydrated for 1 to 3 d and then rehydrated (Fig. 1). After 4 d of germination, however, seedlings were increasingly susceptible to longer periods of dehydration. Seedling survival declined from 60% after 3 d of dehydration to zero after 5 d of dehydration. Seedlings that germinated for 5 d were highly susceptible to all but the l-d dehydration treatment.

Average maximum coleoptile length at the end of the rehydration period was affected more by duration of germination than duration of dehydration (Fig. 2). The coleoptile lengths of seedlings from seeds that germinated for 1 d were reduced to about 80% of the length of coleoptiles of control seedlings and did not differ among dehydration treatments. Longer periods of germination greatly reduced coleoptile growth after dehydration and rehydration. Most of the coleoptile length after 3 d of germination was present before the dehydration treatment. Little or no elongation occurred after seedlings were dehydrated and rehydrated.

The mean rate of coleoptile elongation following germination, dehydration, and rehydration reflected the change in coleoptile length (data not shown). Growth was rapid after 1 d of germination but decreased progressively as the germination period lengthened to 2, 3, and 4 d. Prolonged dehydration had little effect after only 1 d of germination, but it progressively decreased the rate of elongation after 2, 3, or 4 d of germination.

Dehydration after germination also greatly affected the survival and growth of roots (data not shown). Seedlings that germinated for 1 d retained the original seminal roots, which recovered from all dehydration treatments. For seedlings that germinated longer than 1 d, new roots replaced the origi-

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nal ones, which did not survive dehydration. Maximum root length decreased more than maximum coleoptile length as the days of germination increased. Extending the period of dehydration had little effect on seedlings that germinated for 1 or 2 d. But for seedlings that germinated for 3, 4, or 5 d, dehydration was increasingly detrimental to root growth. Few roots were produced after 5 d of germination, even with the l-d dehydration treatment.

The weight of the seed remnants changed little during germination for 1 or 2 d but then decreased rapidly until the fifth day, when is leveled off (Fig. 3). Changes in the dry weight of seeds during germination undoubtedly reflected loss of carbohydrates and proteins from the endosperm for growth and respiration of the seedlings. Reserves of these constituents were depleted quickly to low levels during the late stages of germination.

Seedling Emergence after Dehydration. Emergence of seedlings from vermiculite illustrated the adverse effects of advanced stages of germination on stand establishment after dehydration and rehydration. Germination for 1 to 3 d followed by dehydration for 2 d had little effect on emergence of seedlings from shallow planting (Fig. 4A). As planting depth increased, however, all germination periods longer than 1 d followed by 2 d of dehydration reduced seeding emergence. Germination for 1 d increased the emergence rate of seedlings from l- and 2-inch depths relative to nongerminated control seeds (Fig. 4B). Germination for longer periods followed by 2 d of dehydration decreased the emergence rate index as the planting depth increased. The few seedlings that emerged after germination for 3 or 4 d, dehydration, and planting 3 inches or deeper were chlorotic and soon died. When seedlings did not emerge, their coleoptile stopped growing, and the first true leaf often developed below the soil surface.

Table 1. Development of Larned wheat seedlings after 1 to 5 d of germination.

Days of Germination	Coleoptile Length	Root Length	Root Number
	—inches±SE—		
1	0.04±0.02	0.08±0.03	3
2	0.23±0.11	2.13±0.37	3
3	0.94±0.31	3.86±0.55	4
4	2.16±0.50	5.40±0.71	5
5	3.00±0.51	10.50±1.40	5

Note: Measurements were taken immediately before seedlings were subjected to dehydration treatments.

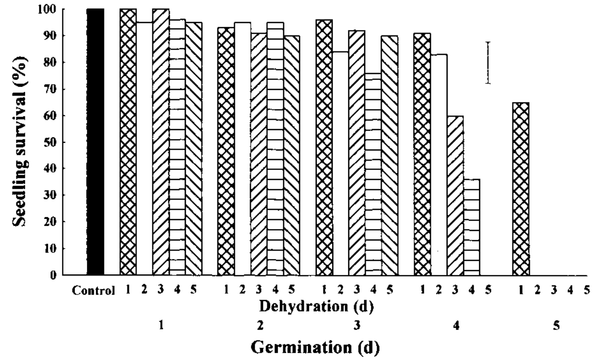

Figure 1. Mean survival of seedlings from wheat seeds that germinated for 1 to 5 d, were dehydrated for 1 to 5 d, and then were rehydrated. Control seedlings were not dehydrated. Vertical bar is LSD (0.05)=15.5.

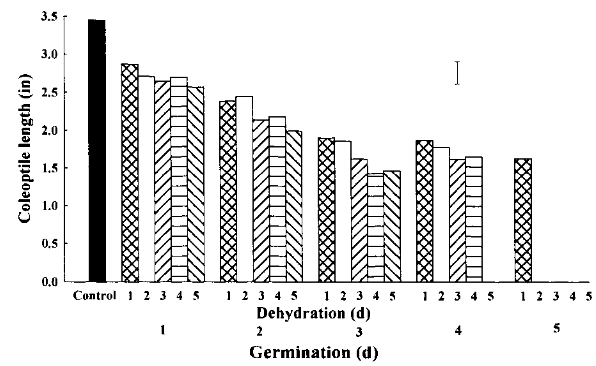

Figure 2. Maximum coleoptile length of seedlings from wheat seeds that germinated for 1 to 5 d, were dehydrated for 1 to 5 d, and then were rehydrated. Control seedlings were not dehydrated. Vertical bar is LSD (0.05)=0.30.

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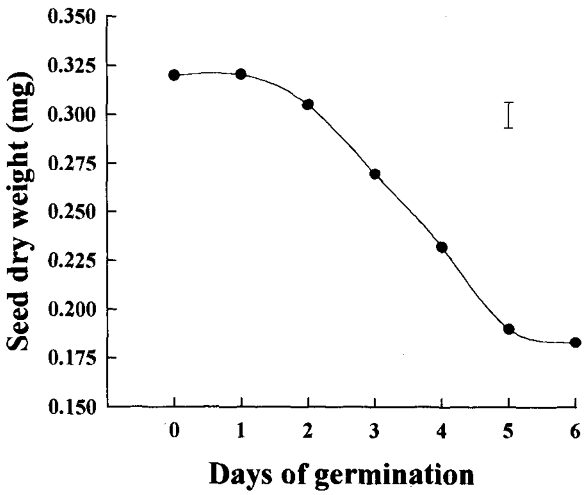

Figure 3. Mean dry weight of remnants of wheat seeds that germinated for 1 to 6 d. Vertical bar is LSD (0.05)=0.013.

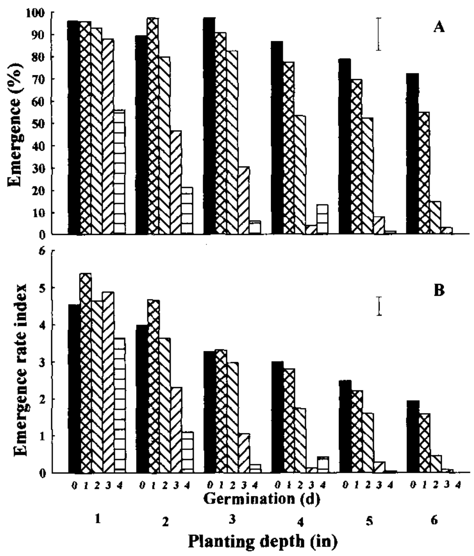

Figure 4. Mean percentage emergence (A) and emergence rate index (B) of wheat seedlings from nongerminated seeds (0-d controls) and seeds that germinated for 1 to 4 d, were dehydrated for 2 d, planted 1 to 6 inches deep, and rehydrated. Vertical bars are LSD (0.05)=14.5(A) and 0.50(B).

Conclusions

- Wheat seedlings that have germinated for 1 to 3 d might survive drying out and rehydration by rain and produce a stand. Seedlings at advanced stages of germination might not survive even mild dehydration.
- Dehydration shortens the coleoptile of wheat seedlings and reduces emergence from deep planting. Seed should not be planted deeper than 80% of the maximum coleoptile length of non-stressed seedlings.
- Dehydration injures roots as severely as shoots and might hinder establishment and survival of seedlings even if they emerge.
- Poor survival and growth after dehydration and rehydration of seedlings at advanced stages of development are related to loss of tolerance to desiccation and depletion of seed reserves.

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