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Pepper Seed Respiration, Germination, and Seedling Development Following Seed Priming

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Abstract. **Seeds of jalapeno (*Capsicum annuum* L.) and tabasco (*Capsicum frutescens* L.) peppers were placed in aerated distilled water for 9.5 or 8 hr, respectively, or primed for 144 hr in aerated 3.0% or 2.75% KNO_3 solutions, respectively. After treatment, seeds from each replication were placed on moist filter paper in Petri dishes for germination tests, in rolled paper towels for radicle and hypocotyl development tests, or in 70-ml incubation jars for 24-hr respiration studies. All tests were maintained at 25C. Jalapeno seed germination percentage was not affected by seed priming, but the mean rate of germination was increased. Jalapeno hypocotyl development was advanced at 7 and 14 days following seed priming. Compared to the soak controls, primed jalapeno seed respiration rates were greater at 0.15 and 0.45 hr following removal from incubation solution, but were no different thereafter. Tabasco seed germination percentage and rate were positively influenced by priming treatment, but seedling hypocotyl development was only advanced at 7 days following treatment. Primed tabasco seed respiration rates were depressed significantly relative to the soak control, suggesting that priming treatment inhibits some aspect of seed metabolism during germination. These data support earlier observations that seed priming is not useful in tabasco field stand establishment efforts.**

Pepper (jalapeno and tabasco) seed vigor is a major concern in field stand establishment efforts (3, 4, 7, 11–14, 16, 24). Investigations of techniques to improve pepper germination and emergence are numerous (4, 6, 11, 13–15, 18, 24). One seed treatment method that has proven successful in increasing pepper seed vigor is osmoconditioning, or priming (11, 13, 14, 24). Priming treatment has not increased tabasco seed vigor, as it has other pepper types such as jalapeno (13, 16). Seed respiration rate has been used successfully as an index of seed vigor and has been found to correlate well with seedling development (1, 2, 8, 19–23). This study was undertaken to closely examine the response of tabasco pepper to seed priming relative to the known favorable response of jalapeno pepper.

In Fall 1987, seeds from 'McIlhenny Select' tabasco pepper were extracted from red-ripe fruit and afterripened for 21 days at 25C (4). Seeds of 'Jalapeno M' jalapeno pepper were obtained (Peto Seed Co.) and stored with tabasco seeds at 1C until testing. Assay results with 2,3,5-triphenyl tetrazolium chloride showed initial seed lot viabilities to be between 95% and 100%, and, at the time of treatments, initial seed germination percentages were 95% and 45% for jalapeno and tabasco seed, respectively.

Previous work (13, 16) showed that priming for 144 hr in a 3.0% or 2.75% KNO_3 solution for jalapeno and tabasco, respectively, resulted in optimum pepper seed germination response. Work preliminary to this study indicated that water soak periods of 9.5 and 8 hr for jalapeno and tabasco, respectively, were the minimum times that seeds required to achieve maximum moisture imbibition. These times were used in distilled water-soak treatments that served as controls to assure that seeds would not germinate during treatments or subsequent seed respiration measurements.

Samples (5 g) of seeds of each pepper type were primed in six aerated columns of optimum KNO_3 concentrations for 144 hr, or in aerated distilled water columns for optimum soak periods. All seed treatments were performed in the dark at 25C. After treatment, seeds were removed from incubation solutions, thoroughly rinsed with distilled water, and placed on paper towels (±1 min) to allow free moisture to drain from samples. One-half of each seed sample was sealed in 70-ml incubation jars fitted with a serum vial stopper. At 0.25, 0.5, 0.75, 1, 2, 6, 14, and 24 hr, two 1-ml gas samples were withdrawn from each jar for CO_2 measurements. To prevent excessive CO_2 buildup or O_2 depletion, all jars were thoroughly flushed with air after each sampling. All jars were held at 25C in the dark in an incubator between sampling times. Seeds remained moist throughout the 24-hr sampling period, but there was insufficient moisture for germination to subsequently occur, and radicle emergence was not observed in any treatment at any time during respiration measurements. Six replications of each treatment for each pepper type were used, treatments were arranged in a randomized complete

Table 1. Influence of seed treatment on jalapeno and tabasco pepper seed germination percentage, mean rate of germination (MRG), germination performance index (GPI) after 14 days on filter paper, and on seedling development in rolled towels.

Type of pepper and treatment	Germination (%)	MRG (days)	GPI (germ %/MRG)	Length (cm) 7 days Radicle	7 days Hypocotyl	14 days Radicle	14 days Hypocotyl
Jalapeno							
Soak 9.5 hr	98	2.4	40.9	5.1	1.9	7.7	5.9
Prime 144 hr	94	1.3	72.7	5.8	3.8	8.1	7.3
Significance	NS	*	**	*	**	NS	**
Tabasco							
Soak 8 hr	48	5.1	8.8	1.9	1.0	2.9	5.2
Prime 144 hr	93	2.8	34.0	2.1	1.6	2.5	5.5
Significance	**	*	**	NS	**	NS	NS

NS,*,**Nonsignificant and significant at the 0.05% and 0.01% levels, respectively.

Table 2. Correlation coefficients between pepper seed respiration rate and radicle and hypocotyl development at two stages.

Time of mean respiration rate measurement[z]	Jalapeno 7 days Radicle	Jalapeno 7 days Hypocotyl	Jalapeno 14 days Radicle	Jalapeno 14 days Hypocotyl	Tabasco 7 days Radicle	Tabasco 7 days Hypocotyl	Tabasco 14 days Radicle	Tabasco 14 days Hypocotyl
0–1	0.41**	0.76**	−0.14	0.84**	−0.58**	−0.73**	−0.15	0.11
1–2	0.45**	0.75**	−0.08	0.81**	−0.50**	−0.74**	0.12	−0.10
2–6	0.48**	0.39**	0.29*	0.37**	−0.43**	−0.66**	0.35**	−0.10
6–14	0.24*	0.01	0.31**	0.06	−0.54**	−0.53**	0.27*	0.19*
14–24	0.16	−0.08	0.32**	−0.02	−0.47**	−0.31**	0.21*	0.19*

[z]Hours after removal from incubation solution.
*,**Significant at the 0.05% and 0.01% levels, respectively.

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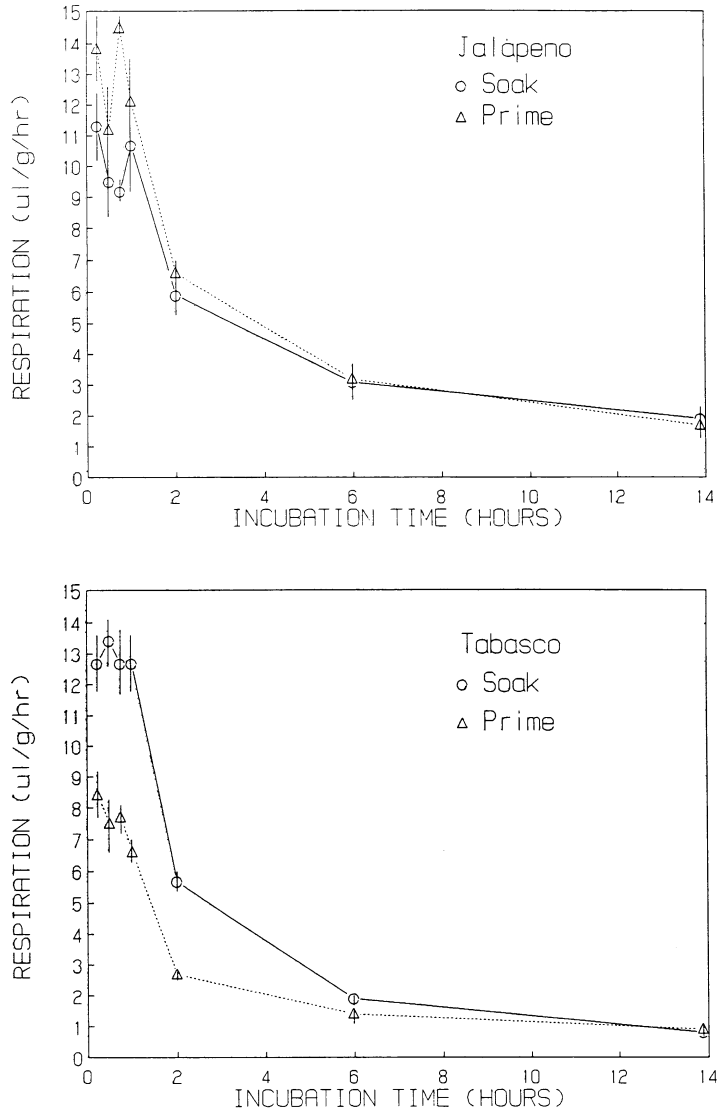

Fig. 1. Influence of seed treatment on jalapeno (**top**) and tabasco (**bottom**) seed respiration rate for 14 hr following removal from water (soak) and KNO_3 (prime) incubation solutions. Each data point represents the mean respiration rate for the preceeding interval. Vertical bars represent ±SE of the means.

block, and all respiration studies were repeated twice.

Concentrations of CO_2 were measured in a Gow Mac Series 750 gas chromatograph using a flame ionization detector with a ruthenium methanizer and a 3.2 mm × 1.8 m Poropak Q stainless steel column. Oven temperature was maintained at 110C, and carrier gas (He) flow rate was 30 ml·min^{-1}. Respiration data are presented as μl CO_2/g fresh weight of seed per hr. Seed weights were determined before initiation of treatments.

After seed incubation in KNO_3 or water, the remaining half of each seed sample was used for germination and rolled towel tests. Germination tests consisted of four replications of 50 seeds each placed in 9-cm petri dishes on one layer of Whatman #2 filter paper moistened with 4 ml of distilled water. All petri dishes were placed in a dark incubator at 25C, and daily germination counts were made in the light for 14 days. A seed was considered to have germinated at first sign of radicle protrusion through the seed coat. Germination percentage and the mean rate of germination (MRG), the mean number of days for radicle emergence, were calculated as in ref. 13. In addition, a germination performance index (GPI) was calculated (4) to integrate the rate of germination and total germination percentage.

For seedling development studies, rolled towel tests were conducted using double-weight certified germination paper (Anchor Papers, St. Paul, Minn.). Twenty-five seeds were placed between two moistened rolled towels, and towels were placed vertically in a dark incubator at 25C. Four rolled towels per treatment were used and two towels were opened at each sampling time (at 7 and 14 days) for measurement of radicle and hypocotyl lengths. As with gas measurements, all germination and seedling development studies were repeated twice.

Priming jalapeno pepper seeds in KNO_3 significantly increased germination rate and the GPI relative to the soak control (Table 1). Seed germination percentage was high in both treatments and was not significantly affected. At 7 days following removal from incubation solutions, radicle and hypocotyl lengths of primed treatments were significantly greater than those of the soak controls. At 14 days, hypocotyl lengths of seedlings from primed seeds continued to be significantly greater than those of the controls, but there no longer was a significant difference in radicle lengths (Table 1). Stimulation of jalapeno seedling development by seed priming is consistent with earlier observations (13) and is similar to responses of tomato (*Lycopersicon esculentum* Mill.) (5) and other pepper types (10).

Priming tabasco pepper seeds in KNO_3 significantly increased germination percentage, MRG, and the GPI (Table 1). Typical of previous seed vigor observations (13, 16), unprimed control seeds used in this study had a low germination percentage (48%). As quantified by radicle emergence in petri dishes, seed priming treatment almost doubled seed germination percentage. Stimulation of subsequent seedling development by priming was only apparent for the first 7 days following seed treatment (Table 1). At 7 days, seedlings from primed seeds had significantly greater hypocotyl lengths. After 14 days, however, stimulation of seedling development as a result of seed priming had ceased. This observation supports previous discrepancies observed between tabasco seed germination performance in petri dishes and emergence performance in the laboratory and field (13, 16). In contrast to jalapeno, primed tabasco seed radicle emergence is enchanced in germination tests on filter paper, yet, subsequent hypocotyl development often does not occur and seedling emergence is not observed in greenhouse media or in field soils.

Seed respiration rates of primed jalapeno and tabasco seeds were compared to those of the water soak controls (Fig. 1). Respiration rates of the two pepper types followed a similar pattern over a 24-hr period. Respiration rates were greatest during the first hour, then dropped sharply between 1 and 6 hr. From 6 to 14 hr, there were only slight changes in seed respiration of both pepper types. The respiration rates of neither jalapeno nor tabasco seeds changed significantly between 14 and 24 hr and therefore are not presented.

Respiration rates of primed jalapeno seeds were significantly greater than those of the water soak control at 0.15 and 0.75 hr after treatment (Fig. 1). Koehler (9) and Malnassy (10) noted significant stimulation of seed respiration rates due to seed priming in tomato and pepper, respectively. Specifically, Malnassy found that primed pepper (*C. annuum* cv. Yolo Wonder) seeds respired at significantly higher rates than the controls during both the imbibitional phase and the period of radicle emergence. In the present study, significantly greater jalapeno respiration rates were only evident during the first hour following seed treatment.

Respiration rates of primed tabasco seeds, however, were significantly less than those of the control from 0 and 6 hr following

treatment (Fig. 1). At 14 hr, rates of the two treatments did not differ significantly. Depression of seed respiration due to priming or osmoconditioning treatment has not been previously noted, and suggests that controlled moisture imbibition treatment of tabasco seed inhibits some aspect of seed metabolism during germination events.

Correlation coefficients between seed respiration rate and radicle and hypocotyl growth are found in Table 2. Respiration rates between 0 and 6 hr of both peppers were slightly better-correlated with seedling development than rates measured later. Jalapeno seed respiration rates were generally positively correlated with advanced seedling development at 7 and 14 days. Although significant correlations between jalapeno seed respiration and subsequent seedling development did exist, they were not as significant and consistent as those found by others with corn (*Zea mays* L.) (19, 22, 23), pea (*Pisum sativum* L.) (2), soybean (*Glycine max* L.) (1), and wheat (*Triticum aestivum* ssp. *compactum* MacKey) (8).

Depressed tabasco seed respiration rates as a result of seed priming were negatively correlated with seedling development at 7 days (Table 2). The negative correlations are due to the brief stimulation of seedling development at this time. It is possible that there are fewer significant correlations between respiration and seedling development at this time due to the lack of significant seed treatment differences. Variations in respiratory metabolism of corn also did not explain differences in germination percentages or vigor ratings (17).

Significant negative correlations at 7 days, and few significant positive correlations at 14 days, between tabasco seed respiration and seedling development indicate that seed respiration is not a valuable index of tabasco seed vigor. Depressed tabasco seed respiration rates do, however, help to partially explain poor subsequent seedling performance at 14 days following seed priming. For jalapeno pepper, significant correlations at 7 days between seed respiration and seedling development indicate that seed respiration rates following seed treatment may serve as an accurate measure of seed vigor. The differences in crop response of the two pepper types to seed priming was striking. Seed treatment of jalapeno resulted in higher seed respiration and faster seedling development rates. Seed treatment of tabasco resulted in depression of seed respiration and only a brief stimulation of hypocotyl development at 7 days. The complexities of tabasco seed germination processes remain puzzling, and the inability to stimulate emergence performance with seed treatment dictates further investigation.

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