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Influence of Selected Surface Disinfestants, Fungicides, and Temperature on Seed Germination and Initial Growth of Southern Seaoats (*Uniola paniculata*)[1]

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Abstract

Seeds of southern seaoats (*Uniola paniculata* L.) were removed from storage at 4C (39F) and treated with the following selected surface disinfestants, fungicides, or combinations of these chemicals: nontreated (control), 1.3% sodium hypochlorite [NaOCl (chlorine bleach)], 2.6% sodium hypochlorite, RTU® (12.6% thiram + 0.34% thiabendazole), RTU®-PCNB (24% pentachloronitrobenzene), 1.3% sodium hypochlorite and RTU®, 2.6% sodium hypochlorite and RTU®, 1.3% sodium hypochlorite and RTU®-PCNB, or 2.6% sodium hypochlorite and RTU®-PCNB. Following treatment, seeds were germinated at an 8/16 hr thermoperiod of 35/20C (95/68F). The seed treatments and germination thermoperiod utilized were based on three preliminary trials that investigated the influence of selected surface disinfestants, fungicides, and temperature on seed germination of the species. Germination was recorded every 3 days for 30 days. Seed treatment was highly significant (P = 0.0001) for both total percentage germination and total percentage of decayed seeds. Germination of nontreated seeds was 45%, and four treatments resulted in germination > 80% [RTU®-PCNB (81%), 2.6% sodium hypochlorite and RTU® (83%), 1.3% sodium hypochlorite and RTU® (87%), and 1.3% sodium hypochlorite and RTU®-PCNB (89%)]. A subsequent experiment investigated the effects of the aforementioned treatments with the exception of 1.3% sodium hypochlorite and RTU®, both used alone, on initial seedling growth of the species. Following treatment, seeds were sown in containers filled with a peat-based medium and the containers placed in a growth chamber maintained at an 8/16 hr thermoperiod of 35/20C (95/68F) with long day conditions. Emergence data were recorded every 3 days for 45 days. After 45 days, the study was terminated and additional data recorded to include plant height (height of main stem), leaf number, length and width of the two longest leaves, and top and root dry weights. Surface disinfestant, fungicide, and combination treatments were highly significant (P = 0.0004). Percentage emergence of nontreated seeds was 35% and five of the seven treatments resulted in emergence ≥ 75% [2.6% sodium hypochlorite (75%), 1.3% sodium hypochlorite and RTU® (75%), 1.3% sodium hypochlorite and RTU®-PCNB (76%), 2.6% sodium hypochlorite and RTU®-PCNB (81%), and 2.6% sodium hypochlorite and RTU® (83%)] with negligible effects on seedling growth. There were significant treatment differences regarding some of the variables used to evaluate seedling growth. In most cases these differences were due to seedlings from nontreated seeds having lower values for each measured variable than values for the same variables from treated seeds. Results of both experiments demonstrate the potential value of chemical seed treatment during production of seedling transplants of *U. paniculata*.

Index words: sand dune species, beach and sand dune restoration, sexual propagation, chemical seed treatment, Poaceae.

Significance to the Nursery Industry

Seedling transplants of *Uniola paniculata* (southern seaoats) are in great demand for beach and sand dune restoration and stabilization. However, seed decay reduces germination and seedling emergence during production of transplants. Results herein demonstrate the importance of chemical seed treatment of the species and identify particular treatments that will inhibit decay and permit emergence ≥ 75% without adverse effects on initial seedling growth.

Introduction

There is much interest in production of seedling transplants of *Uniola paniculata* (southern seaoats), a perennial dune grass that ranges from southern Virginia to eastern Mexico (11). This interest has arisen due to the high demand for transplants of the species needed to restore beaches and stabilize sand dunes destroyed or damaged by tropical storms and erosion (1).

Seed germination of *U. paniculata* is not difficult, as the seeds do not posses any rigid internal dormancy at maturity. Seeds can be germinated without pretreatment but stratification (moist-prechilling) in some cases will increase total germination and rate of germination (2, 5, 9, 10). However, Burgess et al. (2) have observed that seed decay during germination caused by various fungal and possible bacterial pathogens can be a problem. Germination studies of this species by other researchers have not reported any serious seed decay problems, but most investigations describe treatment of seeds with sodium hypochlorite [NaOCl (chlorine bleach)] at rates ranging from 1.3% for 15 min (5, 9, 10) to 1.6% for 30 min (1) before initiation of experiments. The authors have used 1.3% sodium hypochlorite for 15 min as a surface disinfestant, with mixed results, and have concluded that more effective treatments are needed.

Temperature is also an important factor affecting seed germination of *U. paniculata*. Burgess et al. (2) investigated germination of the species at 25C (77F), 30C (86F), or at 8/16 hr thermoperiods of 30/20C (86/68F) or 35/25C (95/77F) and observed the highest total germination at 35/25C (95/77F). However, Seneca (9) noted optimum seed germination at 35/

[1]Received for publication February 2, 2004; in revised form August 25, 2004. This research was funded in part by the North Carolina Agricultural Research Service, Raleigh, NC 27695-7643. Assistance of Juan R. Acedo, Brenda T. Penny, Janet F. Spears, William H. Swallow, and the staff of the Southeastern Plant Environment Laboratory (Phytotron) is gratefully acknowledged. From a thesis submitted by T.L.B. in partial fulfillment of the requirements for the MS degree.

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18C (95/65F). Therefore, the following research was undertaken to study the effects of selected surface disinfestants, fungicides, and temperature on seed germination and initial seedling growth of *U. paniculata*.

Materials and Methods

Harvest of spikelets, seed extraction, and storage. Spikelets of *U. paniculata* were collected from a population of plants growing on Oak Island, (Brunswick County) NC on October 12, 1999. The plants were growing on sand dunes facing the Atlantic Ocean. Spikelets were placed in plastic bags and transported to Raleigh, NC. The spikelets were then removed from the plastic bags, placed on trays, and dried at approximately 21C (70F) for 5 weeks followed by seed extraction and storage at a seed moisture content of 9% in a sealed glass bottle at 4C (39F). Moisture content of the seeds was determined by calculating the mean moisture content of six 50-seed samples following drying at 105C (221F) for 24 hr.

Screening trials. Three preliminary studies (trials) were conducted to screen selected surface disinfestants and fungicides for the capacity to reduce seed decay during seed germination of *U. paniculata* at various germination temperatures (Table 1). The trials were conducted as follows.

Seeds were removed from storage and graded under a dissecting scope, which allowed removal of abnormal, damaged, or under-sized seeds and any debris. Graded seeds [approximately 6000 pure seeds per 28 g (1 oz)] were subjected to the following treatments: nontreated (control), 1.3% sodium hypochlorite [NaOCl (chlorine bleach)], 2.6% sodium hypochlorite, 30% hydrogen peroxide, Captan 400 (37.4% captan and 0.85% related derivatives), Cleary's 3336 + Captan 400 (50% thiophantate methyl + captan), RTU®-PCNB (24% pentachloronitrobenzene), RTU® (12.6% thiram + 0.34% thiabendazole), RTU®-VITAVAX®-EXTRA (16.7% carboxin + 1.2% imazalil + 1.5% thiabendazole), or RTU®-VITAVAX®-THIRAM (10% carboxin + 10% thiram). Seeds treated with sodium hypochlorite were soaked in a solution of the chemical for 15 min, rinsed with tap water, and allowed to dry at 21C (70F) for 30 min. The fungicide treatments of Captan 400, RTU®-PCNB, RTU®, RTU®-VITAVAX®-EXTRA, and RTU®-VITAVAX®-THIRAM were prepared as slurries by mixing 1 ml of the flowable formulations of these materials with 1 ml of distilled water. One half ml of each slurry was then used to treat seeds designated for fungicide treatment. After slurry treatment, the seeds were dried at 21C (70F) for 30 min. The Cleary's 3336 plus Captan 400 treatment was administered by soaking the seeds in 11 g (2 tbsp) Cleary's 3336 plus 20 g (2.5 tbsp) Captan 400/3.8 liter (1 gal) of water. Seeds were soaked for 15 min followed by drying at 21C (70F) for 30 min. Seeds treated with 30% hydrogen peroxide were soaked in a solution for 30 min, rinsed with tap water, and dried at 21C (70F) for 30 min.

Following treatment, seeds were placed in covered 9-cm (3.5-in) diameter glass petri dishes (50 seeds per dish). Each dish contained two prewashed (rinsed) germination blotters (Filtration Sciences Corp. Mt. Holly Springs, PA) uniformly moistened with tap water. All dishes were placed in black sateen cloth bags and seeds were allowed to imbibe over night at 21C (70F). The following day, dishes were placed in unlit seed germination chambers at the Southeastern Plant Environment Laboratory (NC State Univ., Phytotron), Raleigh, NC (3). The chambers were maintained at constant temperatures of 25C (77F), 30C (86F), or 35C (95F) or 8/16 hr thermoperiods of 30/20C (86/68F), 35/25C (95/77F), 30/25C (86/77F), 35/30C (95/86F), or 35/20C (95/68F). Chamber temperatures varied within ± 0.5C (0.9F) of the set point. Temperatures within the petri dishes, as measured by a thermocouple, never deviated from ambient temperature by more than ± 1C (2F) of the set point. Germination blotters were kept moist with tap water throughout each experiment. Germinated and decayed seed counts were recorded every 3 days for 30 days and these seeds were removed from the dishes. A seed was considered germinated when radicle emergence was ≥ 1 mm (0.04 in).

The experimental design was a split-plot with temperatures as the main plots and surface disinfestant and fungicide treatments as the subplots. For each temperature, a seed treatment was replicated four times with a replication consisting of a petri dish containing 50 seeds. Data were subjected to analysis of variance (ANOVA) procedures and means separated by Fisher's protected least significant difference (LSD) at $P < 0.05$. Results of the trials indicated that some seed treatments were more effective than others and that a germination temperature of 35/20C (95/68F) appeared to be optimum (Table 2). Based on these data, the following two experiments were conducted.

Table 1. Trade, common, and chemical names (active ingredients) for each surface disinfestant and fungicide screened in the initial trials and some of which were used in Expts. 1 and 2.

Trade name	Common name	Chemical name (active ingredients)
Captan 400	captan	N-trichloromethylthio-4-cyclohexene-1,2-dicarboximide (37.4%) related derivatives (0.85%)
Cleary's 3336 + Captan 400	thiophanate methyl	dimethyl 4,4'-o-phenylenebis(3-thioallophanate) (50%)
	captan	N-trichloromethylthio-4-cyclohexene-1,2-dicarboximide (37.4%) related derivatives (0.85%)
RTU®	thiram	tetramethylthiuram disulfide (12.6%)
	thiabendazole	2-(4-thiozolyl)-benzimidazole (0.34%)
RTU®-PCNB	pentachloronitrobenzene	pentachloronitrobenzene (24%)
RTU®-VITAVAX®-EXTRA	carboxin	5,6-dihydro-2-methly-N-phenyl-1,4-oxathiin-3-carboxamide (16.7%)
	imazalil	1-[2-(2,4-dichlorophenyl)-2-(2-propenyloxy)-ethyl]-1H-imidazole (1.2%)
	thiabendazole	2-(4-thiazolyl)-benzimidazole (1.5%)
RTU®-VITAVAX®-THIRAM	carboxin	5,6-dihydro-2-methly-N-phenyl-1,4-oxathiin-3-carboxamide (10%)
	thiram	tetramethylthiuram disulfide (10%)
Hydrogen peroxide (30%)	hydrogen peroxide	hydrogen peroxide (30%)
Sodium hypochlorite (1.3%)	chlorine bleach	sodium hypochlorite (1.3%)
Sodium hypochlorite (2.6%)	chlorine bleach	sodium hypochlorite (2.6%)

Table 2. Results of three trials that investigated the influence of selected surface disinfestants, fungicides, and temperature on seed germination of *U. paniculata*. Each value for percentage germination represents mean germination percentage at 30 days of four petri dishes each containing 50 seeds.

	Trial 1 Germination temperature				Trial 2 Germination temperature					Trial 3 Germination temperature		
Surface disinfestant or fungicide (trade name)	25C	30C	30/20C	35/25C	30/20C	30/25C	35/25C	35/30C	35C	30/20C	35/20C	35/25C
	Germination (%)				Germination (%)					Germination (%)		
Nontreated	3.6cB[z]	6.5dB	8.9eB	23.5dA	12.1dC	13.1cC	36.2dA	20.8cBC	25.4bB	21.0dB	44.7cA	25.9dB
Captan 400	31.3aB	28.5abB	53.1aA	49.4abA	54.9bcA	30.5bC	54.1bcA	38.1bBC	45.5aAB			
Cleary's 3336 + Captan 400					49.8bcA	30.6bB	53.0cA	36.4bB	37.6aB	38.9cC	69.2bA	57.5bB
RTU®	22.0bC	32.0aB	47.3abA	50.5abA	55.2bcA	41.0aB	61.5bcA	41.3abB	35.5aB	50.5bB	74.5abA	65.4bcA
RTU®-PCNB	23.3abC	28.4abC	43.3bcB	52.2abA	75.3aA	44.5aB	72.6aA	49.2abB	24.0bC	71.0aA	74.4abA	77.6aA
RTU®-VITAVAX®-EXTRA	13.5bA	13.4cdA	21.7dA	19.3dA								
RTU®-VITAVAX®-THIRAM	32.1aA	22.6bcB	38.9bcA	34.3cA								
Hydrogen peroxide (30%)	20.1bB	17.1cB	36.7cA	41.7bcA						50.3bB	73.8abA	54.3cB
Sodium hypochlorite (1.3%)					61.0bA	38.3abB	63.8abA	46.3abB	43.9aB	49.7bB	72.7abA	64.9bA
Sodium hypochlorite (2.6%)										49.2bC	80.4aA	62.5bcB

[z]Mean separation within columns (lowercase letters) and rows (uppercase letters) for a trial by Fisher's protected LSD, $P < 0.05$.

Influence of selected surface disinfestants, fungicides, or combinations of these chemicals on seed germination (Expt. 1). On September 8, 2000, seeds were removed from storage and treated following the procedures described above with the following chemicals: nontreated (control), 1.3% sodium hypochlorite [NaOCl (chlorine bleach)], 2.6% sodium hypochlorite, RTU®-PCNB (24% pentachloronitrobenzene), RTU® (12.6% thiram + 0.34% thiabendazole), 1.3% sodium hypochlorite and RTU®, 2.6% sodium hypochlorite and RTU®-PCNB, 1.3% sodium hypochlorite and RTU®, or 2.6% sodium hypochlorite and RTU®-PCNB. Seeds treated with a combination of sodium hypochlorite and a particular fungicide were first soaked in solutions of either 1.3% or 2.6% sodium hypochlorite for 15 min then rinsed with tap water and allowed to dry for 30 min followed by slurry treatment and drying.

Seeds were germinated as described for the screening trials at an 8/16 hr thermoperiod of 35/20C (95/68F). The experimental design was completely randomized with nine treatments replicated four times with each replication consisting of a covered 9-cm (3.5 in) diameter glass petri dish containing 50 seeds. As in the screening trials, each dish also contained two prewashed (rinsed) germination blotters. Germinated and decayed seed counts were recorded every 3 days for 30 days and these seeds were removed from the dishes. A seed was considered germinated when radicle emergence was ≥ 1 mm (0.04 in). Data were subjected to analysis of variance (ANOVA) procedures and means separated by Fisher's protected least significant difference (LSD) at $P < 0.05$.

Influence of selected surface disinfestants, fungicides, or combinations of these chemicals on initial seedling growth (Expt. 2). On January 3, 2001, seeds were removed from storage and treated following the procedures described above with the following chemicals: nontreated (control), 2.6% sodium hypochlorite, RTU®-PCNB (24% pentachloronitrobenzene), 1.3% sodium hypochlorite and RTU® (12.6% thiram + 0.34% thiabendazole), 2.6% sodium hypochlorite and RTU®, 1.3% sodium hypochlorite and RTU®-PCNB, or 2.6% sodium hypochlorite and RTU®-PCNB.

Following treatment, two seeds were sown per tube in Ray Leach SuperCells [cell diameter = 3.8 cm (1.5 in), height = 21 cm (8.3 in), volume = 164 cm^3 (10 in^3)] (Stuewe and Sons, Corvallis, OR)] filled with ferti·lome® which consists of Canadian sphagnum peat (80%), perlite, and wood charcoal (Voluntary Purchasing Groups, Inc., Bonham, TX).

Tubes were then placed in a growth chamber [C-chamber (3)] at the Southeastern Plant Environment Laboratory (NC State Univ., Phytotron), Raleigh, NC. The chamber was maintained at an 8/16 hr thermoperiod of 35/20C (95/68F) with an 8-hr photoperiod during the high temperature portion of the cycle. Chamber temperature varied within ± 0.5C (0.9F) of the set point. During the 35C (95F) portion of the cycle, the chamber used a combination of cool-white fluorescent and incandescent lamps that provided a photosynthetic photon flux (*PPF*, 400–700 nm) of 411 µmol/m^2/sec (31.1 klx) plus photomorphogenic radiation (PR, 700–850 nm) of 7.4 W/m^2. Incandescent lamps providing a *PPF* of 40 µmol/m^2/sec (2.0 klx) plus PR of 5.7 W/m^2 were used to interrupt the 16-hr dark period between 11:00 PM and 2:00 AM daily.

Seedlings were thinned to one seedling per tube after emergence (leaving the larger of the two seedlings) and fertilized daily with half-strength Phytotron nutrient solution (3), which was applied after seedling emergence and once the first leaf was visible. To ensure that each tube designated for nontreated seedlings had one seedling, additional nontreated seeds were germinated in a covered 9-cm (3.5 in) diameter glass petri dish inside the growth chamber. On day 15, no seedlings had emerged in 14 tubes sown with nontreated seeds. One germinated seed was planted in each of these tubes to provide an adequate number of nontreated seedlings for comparison.

Emergence data (days to emergence of the coleoptile through the growing medium of the first seed to germinate) were recorded every 3 days for 45 days. After 45 days, the study was terminated and additional data recorded to include plant height (height of main stem), leaf number, length and width of the two longest leaves, and top and root dry weights. Leaf width measurements were taken at the midpoint of each leaf and dry weights were recorded after drying for 48 hr at 70C (158F). Percentage emergence and average days to emergence for nontreated seeds were calculated excluding the 14 seeds planted on day 15. The experimental design was a randomized complete block with six blocks, seven treatments per block, and seven tubes per treatment. Data were subjected to ANOVA procedures and means separated by Fisher's protected LSD at $P < 0.05$. Pairwise comparisons of percentage emergence and average days to emergence were calcu-

lated using the 'PDIFF' option on LSMEANS under PROC GLM of SAS (SAS Inst., Inc., Cary, NC).

Results and Discussion

Influence of selected surface disinfestants, fungicides, or combinations of these chemicals on seed germination (Expt. 1). Seed treatment with sodium hypochlorite and a particular fungicide, either alone or in combination, was essential to achieve germination > 50% (Fig. 1). Seed treatment was highly significant (P = 0.0001) for both total germination percentage and total percentage of decayed seeds. Generally, treatment of seeds with sodium hypochlorite in combination with a particular fungicide resulted in greater germination than seed treatment with only a fungicide or sodium hypochlorite. Although the treatments were not statistically different, the highest total germination was realized for seeds treated with a combination of 1.3% sodium hypochlorite and RTU®-PCNB (89%) followed by 1.3% sodium hypochlorite and RTU® (87%), 2.6% sodium hypochlorite and RTU® (83%), and RTU®-PCNB (81%).

As expected, the greatest percentage of decayed seeds was noted for the nontreated seeds (38%), which was significantly different as compared to all other treatments (Fig. 1). Interestingly, although 1.3% and 2.6% sodium hypochlorite alone were relatively effective in reducing seed decay this did not necessarily correspond to increased germination (< 75%). Some treatments had significantly greater germination with the same amount of seed decay as the sodium hypochlorite treatments (> 80%).

Although four of the seed treatments resulted in germination > 80% with the highest germination of 89% for seeds treated with 1.3% sodium hypochlorite in combination with RTU®-PCNB, there may be room for improvement (Fig. 1). Prior to conducting this research viability tests with 2,3,5-triphenyltetrazolium chloride (TZ or TTC) (4) estimated that seed viability was > 95%. Thus, germination approaching 100% may be feasible. This may, however, be difficult to attain because of what appears to be a multitude of fungal pathogens such as *Alternaria* Nees spp., *Eppicocum* Lk. spp., *Fusarium* Lk. spp., and *Helminthosporium* Lk. spp., which were tentatively identified from a sample of seeds taken from the seed lot used to conduct the present research. In addition to various fungal pathogens, bacteria may also contribute to seed decay. The presence of various seed pathogens, particularly fungi, may be related to the extremely humid and moist maritime environment in which *U. paniculata* is endemic (11). Despite the possibility of germination greater than that reported herein (Fig. 1), germination of 80% would appear to be commercially acceptable.

Seeds treated with RTU®-PCNB germinated readily, however, abnormal radicle development was observed among these seeds. The radicles appeared twisted and lacked root hairs on all seeds that germinated after treatment with RTU®-PCNB, either alone or in combination, with sodium hypochlorite. This observation concerned the authors and raised the possibility of potential adverse effects from RTU®-PCNB treatment influencing seedling growth, which provided in part the basis for Expt. 2.

Influence of selected surface disinfestants, fungicides, or combinations of these chemicals on initial seedling growth (Expt. 2). Surface disinfestant, fungicide, and combination treatments were highly significant (P = 0.0004) and were essential to achieve emergence > 60% with five of the seven treatments resulting in emergence > 75% (Table 3). Emergence for nontreated seeds was only 35% and emergence for all chemical seed treatments was significantly greater than the nontreated seeds and ranged from 64 to 83%. Results of the various seed treatments generally confirm what was observed in Expt. 1 (Fig. 1) regarding the need for chemical seed treatment of *U. paniculata* and the report by Burgess et al. (2) that decay is a problem during seed germination of the species.

There were no apparent adverse effects of the various chemical seed treatments on seedling growth (Table 3). Among these treatments, there were no significant differences in stem height, length of the second longest leaf, width of the longest leaf, top dry weight, and root dry weight. However, as mentioned previously there were significant differences in percentage emergence. There were also significant differences regarding average days to emergence, number of leaves, length of the longest leaf, and width of the second longest leaf. In most cases, the significant differences were due to the nontreated seeds having lower values for each measured variable than values for the same variables of the treated seeds.

Although percentage emergence was lowest for the nontreated seeds (35%, Table 3) these seeds emerged essentially in the same length of time as the treated seeds with one exception. Average number of days to seed emergence for seeds treated with 1.3% sodium hypochlorite and RTU®-PCNB was longer (17.3 days) in comparison to nontreated seeds (12.0 days). Although this difference was significant, the authors question whether a difference of 5.3 days would have any practical significance regarding commercial production of seedling transplants.

The authors noted in Expt. 1 that seeds treated with RTU®-PCNB, either alone or in combination, with sodium hypochlorite germinated readily although abnormal radicle development was observed. This raised the possibility that RTU®-PCNB would have adverse effects on seedling growth. Despite RTU®-PCNB resulting in reduced emergence in comparison to some of the other treatments, it had no deleterious affects on the other recorded variables used to evaluate seedling growth.

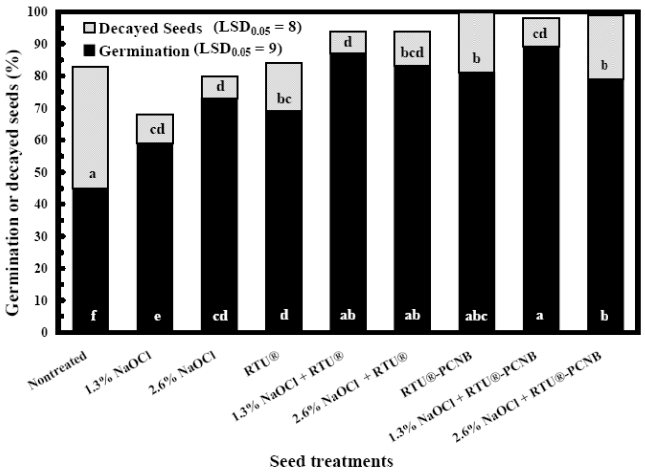

Fig. 1. Influence of selected surface disinfestants, fungicides, or combinations of these chemicals on seed germination and seed decay of *U. paniculata* (Expt. 1). Lowercase letters within the black vertical bars denote mean separation among seed treatments for total germination by Fisher's protected LSD at P < 0.05. Lowercase letters within the gray vertical bars denote mean separation among seed treatments for total decayed seeds by Fisher's protected LSD at P < 0.05.

Table 3. Influence of selected surface disinfestants, fungicides, or combinations of these chemicals on initial seedling growth of *U. paniculata* (Expt. 2). Values for each parameter are means of six blocks each consisting of seven seedlings per treatment.

Surface disinfestant, fungicide, or combinations	Emergence (%)	Avg. days to emergence	Plant ht (mm)	No. of leaves	Length of longest leaf (mm)	Length of second longest leaf (mm)	Width of longest leaf (mm)[z]	Width of second longest leaf (mm)[z]	Top dry wt. (mg)	Root dry wt. (mg)
Nontreated	34.5c[y]	12.0a[y]	33.1[w]	3.4b[x]	89.1b[x]	59.1[w]	1.9[w]	1.6c[x]	16[w]	14[w]
RTU®-PCNB	64.3b	14.2ab	37.1	3.5ab	102.9ab	68.3	2.2	1.8ab	18	16
2.6% sodium hypochlorite	75.0ab	13.5ab	41.0	3.8a	112.0a	73.6	2.2	1.9a	22	20
1.3% sodium hypochlorite + RTU®	75.0ab	14.2ab	38.3	3.7a	110.7a	70.2	2.4	1.9a	20	19
2.6% sodium hypochlorite + RTU®	83.3a	14.7b	39.8	3.7a	114.4a	74.3	2.2	1.9ab	22	18
1.3% sodium hypochlorite + RTU®-PCNB	76.2ab	17.3c	36.5	3.4b	103.2ab	63.5	2.1	1.7bc	18	16
2.6% sodium hypochlorite + RTU®-PCNB	81.0a	13.5ab	38.1	3.6ab	108.4a	66.6	2.1	1.8abc	20	17

[z]Measured at the midpoint.

[y]Pairwise comparisons made using the 'PDIFF' option on LSMEANS under PROC GLM of SAS (SAS Inst., Inc., Cary, NC).

[x]Mean separation within columns by Fisher's protected LSD, $P < 0.05$.

[w]Not statistically significant.

In Expt. 1 the various seed treatments were evaluated in terms of germination by defining germination as radicle emergence ≥ 1 mm (0.04 in). However, in Expt. 2 germination was not recorded because of the nature of the study and percentage emergence was recorded. Thus, a direct comparison of percentage germination data in Fig. 1 with percentage emergence data in Table 3 is difficult, if not impossible. If one does compare values for percentage emergence of the seven treatments used in Expt. 2 that were also included in Expt. 1, but evaluated in Expt. 1 in terms of percentage germination, the values are generally less in Expt. 2. For example, germination of the nontreated seeds in Expt. 1 was 45% in comparison to seedling emergence of 35% for the nontreated seeds in Expt. 2. Also in Expt. 1 there were four treatments that resulted in germination > 80% [RTU®-PCNB (81%), 1.3% sodium hypochlorite and RTU® (87%), 2.6% sodium hypochlorite and RTU® (83%), and 1.3% sodium hypochlorite and RTU®-PCNB (89%)] but in Expt. 2 those same treatments resulted in percentage emergence of 64, 75, 83, and 76%, respectively. Since the manner in which Expt. 2 was conducted simulates more closely greenhouse production practices, values for percentage emergence may be a more realistic indicator of how the various fungicides and surface disinfestants will perform under actual seedling production conditions.

Although there have been no previous reports on the use of various surface disinfestants and fungicides to reduce seed decay during germination of *U. paniculata*, beneficial effects of fungicide seed treatments have been noted for many forage grasses. Michail and Carr (8) reported significant improvement of establishment of species of ryegrass (*Lolium* L. spp.), fescue (*Festuca* L. spp.), cocksfoot (*Dactylis* L. spp.), and timothy (*Phleum* L. spp.) by fungicidal seed treatments. Seed treatment of cultivars of ryegrass with the fungicides Benlate [benomyl (methyl 1-(butylcarbamoyl)-2-benzimidazole carbamate)] and Captan (captan) provided excellent protection against *Fusarium* spp. even on the most susceptible cultivars (6, 7). Lewis and Clements (7) also reported that the combination of Subdue [metalaxyl (N-2,6-dimethylphenyl)-N-(methoxyacetyl)-DL-alaninate)] and Mycozol (thiabendazole) provided results similar to that of Benlate plus Captan.

In summary, five of the seven seed treatments utilized in this experiment resulted in percentage emergence of 75 to 83% with negligible effects on seedling growth of *U. paniculata*. This demonstrates that a variety of chemical treatments may be used to reduce seed decay during production of seedling transplants of the species. Choice of a particular treatment will undoubtedly need to include consideration of various factors such as effectiveness, cost, and whether or not the material(s) selected for use are registered for use on *U. paniculata*. Although the surface disinfestant and fungicide treatments tested provided control of seed decay, the potential for higher germination and emergence percentages may exist since viability tests with 2,3,5-triphenyltetrazolium chloride (TZ or TTC) (4) indicated that initial seed viability was > 95%.

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