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PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 350 projects at a cost of $29 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

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Seashore Paspalum Performance to Potable Water

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SUMMARY

A study was conducted at the University of Florida to evaluate seashore paspalum germplasm irrigated with potable water and maintained under two maintenance regimes: putting green and fairway conditions. Eight greens-height and ten fairway-height accessions were established from sprigs (green) or plugs (fairway) and each test also had one seeded variety. One year after planting, whole plots were divided into sub-plots and ammonium sulfate was applied at 0.25, 0.50, or 1.0 lb N 1,000 ft^{-2} every two weeks (greens-height) or monthly (fairway-height). The study found:

- Significant dollar spot plagued the greens-height grasses during establishment. Greens-height 'Sea Isle Supreme' had the greatest dollar spot severity and 'Seadwarf' and 'Seaspray' had the lowest level of dollar spot incidence.
- On fairway-height selections, 'SI-99,' 'Salam,' and 'Sea Isle I' exhibited the greatest level of dollar spot activity and 'Seaspray' and 'Seaway' exhibited the least.
- 'Seadwarf' and 'Sea Isle 2000' were the two best performing cultivars when maintained at putting green heights. Top performing fairway-height cultivars were 'Seaway,' 'Aloha,' and 'Seagreen'. 'Neptune' consistently ranked poorly.
- No differences in thatch depth were observed between greens-height cultivars. However, N rates = 0.50 lb applied biweekly produced a 33% increase in thatch depth. Thatch depth among fairway-height cultivars differed with 'Neptune' yielding the greatest and 'Aloha' and 'Seaspray' yielding the least.

Seashore paspalum (*Paspalum vaginatum* Swartz) is a perennial warm-season turfgrass that is native to tropical and subtropical regions of the world (1). Seashore paspalum grows naturally in coastal environments and is often found in brackish marsh water or in close proximity to ocean waters. It also grows in areas that receive extended periods of heavy rains and low light intensity. Although the species has been in existence for many years, selection of cultivars for golf course use has been limited to the mid- and late-1990's with several new releases occurring in the past few years.

Interest in seashore paspalum is increasing as golf course irrigation is being relegated to use of reclaimed or saline water sources. Several studies have been conducted testing the tolerance of seashore paspalum to various concentrations of saltwater. Noaman and El-Haddad (6) exposed established seashore paspalum to three levels of salinity: 10 g/L (16 dS/m), 20 g/L (32 dS/m), and 40 g/L (64 dS/m). A reduction in plant height with increased salt concentration was apparent after 4 weeks and continued to decrease until the end of the experiment at 10 weeks. Similarly, as salt concentration increased from 16 dS/m to 64 dS/m, plant biomass decreased by 70% (6).

Marcum and Murdoch (5) subjected seashore paspalum and five other warm-season turfgrasses [manilagrass (*Zoysia matrella* (L.) Merr.), St. Augustinegrass (*Stenotaphrum secundatum* (Walt.) Kuntze.), 'Tifway' bermudagrass (*Cynodon dactylon* [L.] Pers. var. *dactylon* X *C. transvaalensis* Burtt-Davy), Japanese lawngrass (*Zoysia japonica* Steud.), and centipedegrass (*Eremochloa ophiuroides* [Munro] Hack) to five saltwater concentrations: 1 mM (1 dS/m), 100

Seashore paspalum was established for the fairway height study using 4" X 4" plugs planted on one-foot centers.

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mM (9 dS/m), 200 mM (17 dS/m), 300 mM (26 dS/m), and 400 mM (34 dS/m). Seashore paspalum growth rates were higher than the other turfgrass species at 34 dS/m. Seashore paspalum quality ratings were also higher than the other turfgrasses at all saltwater concentrations (5).

Wiecko (11) exposed seashore paspalum, bermudagrass, St. Augustinegrass, and centipedegrass to three different salinity levels (54, 37, and 19 dS/m) over two short-term salt stress durations (3 and 6 days). Seashore paspalum showed excellent salinity tolerance compared to the other grasses evaluated with the maximum injury of 18% at 54 dS/m after the 6-day salt stress duration. Bermudagrass injury was 30% at 54 dS/m after the 6-day salt stress duration and had only minor injury at lower salt concentrations. St. Augustinegrass exhibited up to 60% injury under the 6-day duration of 54 dS/m and centipedegrass showed complete necrosis (11).

Selected not only for excellent tolerance to saline or recycled water, seashore paspalum also possesses excellent wear tolerance (8, 9) and good tolerance to reduced water input (3). It requires relatively low-fertility inputs needed to produce a dense, dark green turf (1), tolerates extended periods of low light intensity (4), and produces a dense root system.

Duncan and Carrow (1) noted disadvantages of seashore paspalum include poor shade tolerance and it is prone to increased thatch production, particularly when over-fertilized and over-irrigated. Unruh et al., (10) noted heightened sensitivity to many common herbicides. Additionally, limited data exists on nematode resistance and/or tolerance of seashore paspalum to nematode infestation (2). Comparative evaluations of seashore paspalum germplasm are limited. Therefore, the objective of this research was to evaluate seashore paspalum germplasm irrigated with potable water and maintained under two maintenance regimes.

Following establishment, turfgrass performance was measured by visual turf quality, color, density, root growth, and thatch depth.

Seashore paspalum grows naturally in coastal environments and is often found in brackish marsh water or in close proximity to ocean waters. Shown above is seashore paspalum at Old Collier Golf Club in Naples, FL.

Experimental Procedures

Establishment

An existing USGA specification putting green at the University of Florida, IFAS, West Florida Research and Education Center was stripped of existing bermudagrass, laser leveled, and fumigated with iodomethane (400 lbs acre^{-1}) on September 18, 2003. An existing native-soil (Orangeburg sandy loam (fine-loamy, kaolinitic, thermic Typic Kandiudults) with 78% sand, pH 6.0, and 1% O.M.) fallow area was also fumigated and prepared to receive the fairway-height accessions.

Seashore paspalum sod pieces were shipped to the research center from various locations in Florida and Georgia the following week and they were either plugged (fairway trial), sprigged (greens trial), or seeded (both trials) during the week of September 29, 2003. Sod pieces were either cut into 4-square-inch plugs and planted on 12" centers or shredded for sprigs (one slab per plot). 'Seaspray', a seeded cultivar, was planted at a rate of 1.5 lbs. per 1,000 ft^2. Each cultivar was planted into a 9' X 9' plot and each plot was replicated three times.

Nitrogen Treatments

In September 2004, whole plots were divided into sub-plots measuring 3 ft by 9 ft and ammonium sulfate was applied at 0.25, 0.50, or 1.0 lb N 1,000 ft^{-2} every two weeks (greens-height) or monthly (fairway-height). Other nutrients were routinely applied according to soil test recommendations.

Maintenance Practices

Greens-height grasses were mowed at least five times weekly at 0.140 inches with a Toro 3000 triplex greens mower. Fairway-height grasses were mowed three times weekly at ½" with a Toro Reelmaster 3100-D. To avoid potential contamination, plots were not vertical mowed or aerated during the study. Greens-height grasses were lightly topdressed periodically.

Evaluations Taken

Following establishment, turfgrass performance was measured by visual turf quality, color, density, root growth, and thatch depth. Visual evaluation of turf quality (1 to 9, where 1 was dead grass and 9 represented dark green uniform grass; 6.5 was the minimum acceptable turf

Cultivar	03 Jun ----- # loci / ft^2 -----		03 July ----- 1-9 Scale -----		23 Nov --% Plot Area Infected--	
Seadwarf	0.7	c †	1.7	c ‡	7.8	e §
Seagreen	2.1	bc	3.3	bc	31.1	bc
Sea Isle 2000	1.6	bc	3.7	b	22.2	cde
Sea Isle Supreme	10.7	a	6.0	a	51.1	a
SI-99	3.6	bc	4.0	b	45.6	ab
Salam	4.2	b	4.0	b	43.9	ab
Sea Isle I	2.3	bc	2.7	bc	30.0	bcd
Seaspray	0.7	c	1.7	c	13.9	de
LSD††	3.0		1.8		17.0	

† Number of disease loci were counted in two - 1 sq. ft. areas and averaged.

‡ Disease activity rating on a 1-9 scale where 1=no disease and 9=plot area completely damaged.

§ Portion of a 1 sq. ft. area infected by disease.

†† Means followed by the same letter(s) in a column and are not significantly different according to Fisher's Protected LSD (P=0.05).

Table 1. Dollar spot (*Sclerotinia homoeocarpa*) disease incidence on greens-height seashore paspalum during the 2004 growing season at Jay, FL.

quality). Root weights were obtained from three one-inch diameter core samples taken from each plot. The soil was washed from the samples, roots were collected, weighed, dried for 48 hours at 72° C, weighed, and then ashed in a muffle furnace (450° C for 5 hours) and organic material weight was determined.

To determine thatch depth, three one-inch diameter core samples were taken from each plot, compressed lightly, and thatch depth was recorded. Disease incidence was also noted and evaluated when prevalent. The experimental design was an 8 X 3 (greens-height) or 10 X 3 (fairway-height) split-plot arranged in a randomized complete block with three replications. Main plots were cultivars and sub-plots were nitrogen rates. Data were averaged over quarters (Q_2 = Apr - June; Q_3 = July - Sep; Q_4 = Oct - Dec) and were subjected to analysis of variance procedures. Means were separated using Fisher's Protected LSD test at the 0.05 level of probability.

Results and Discussion

Establishment of Seashore Paspalum

Although sprigs were obtained from uniform sized slabs of grass, the planting rates were not uniform due to the number of nodes on the sprigs and plugs. Grass slabs obtained from breeders stock were harvested from areas maintained at ½" mowing height and slabs obtained from commercially available sources were maintained at 2" and thus, had a greater number of nodes from which roots could form. Consequently, the establishment rate was not assessed and limited data was collected during establishment.

Incidence of Dollar Spot Disease

Significant dollar spot (*Sclerotinia homoeocarpa*) plagued the greens-height grasses during the grow-in phase and then again towards the later part of 2004 (Table 1). In June and July (2004), greens-height 'Sea Isle Supreme' had the

Treatments	Turfgrass Quality†			
	Apr-Jun (Q2)	Jul-Sep (Q3)	Oct-Dec (Q4)	Mean
***Cultivar mean*‡**				
Seadwarf	5.4a §	6.2ab	4.9a	5.6a
Seagreen	5.2ab	5.7cd	4.2b	5.1b
Sea Isle 2000	5.3a	6.3a	5.0a	5.6a
Sea Isle Supreme	5.2ab	5.7cd	4.2b	5.1b
SI-99	5.4a	5.7cd	4.5b	5.2b
Salam	5.0bc	5.6d	4.2b	5.0b
Sea Isle I	5.0bc	5.9bc	4.2b	5.1b
Seaspray	4.8c	5.7cd	4.4b	5.1b
LSD	0.3	0.3	0.3	0.3

Fertilizer means	2005	2006	2005	2006	2005	2006	2005	2006
0.25 lb N/biweekly	4.1b	4.8c	4.9c	4.7c	3.0c	4.0c	4.1c	4.5c
0.50 lb N/biweekly	4.5a	6.0b	5.8b	6.1b	3.9b	5.3b	4.8b	5.9b
1.00 lb N/biweekly	4.7a	6.9a	6.3a	7.3a	4.3a	6.2a	5.1a	6.9a
LSD	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.3

Split-plot analysis				
Cultivar	0.0093	0.0009	0.0034	0.0006
Year x cultivar	0.7599	0.8485	0.1089	0.9712
Fertilizer	0.0001	0.0001	0.0001	0.0001
Cultivar x fertilizer	0.9578	0.9201	0.6557	0.8786
Year x fertilizer	0.0001	0.0001	0.0003	0.0001
Year x cultivar x fertilizer	0.8895	0.9639	0.7633	0.9599

† Quality visually rated on a 1-9 scale where 9 = best.

‡ Where a significant year by cultivar or year by fertilizer interaction occurred means were separated by year.

§ Means followed by the same letter(s) in a column and group are not significantly different according to Fisher's Protected LSD (P=0.05), n.s. = not significant.

Table 2. Evaluation of green-height seashore paspalum cultivars and nitrogen rate on visual turf quality scores for the 2005-2006 growing seasons at Jay, FL.

greatest dollar spot severity followed by 'SI-99' and 'Salam.' Greens-height 'Seadwarf' and 'Seaspray' had the lowest level of dollar spot incidence in June and July.

During the late fall (November), dollar spot incidence ranged from a low of 8% ('Seadwarf') to 51% ('Sea Isle Supreme). Increasing nitrogen from 0.25 to 0.50 or 1.0 lbs. N 1,000 ft^{-2} on a bi-weekly basis reduced dollar spot incidence from 42% to 25% on the greens-height grasses (data not presented). On fairway-height selections, 'SI-99,' 'Salam,' and 'Sea Isle I' exhibited the greatest level of dollar spot activity and 'Seaspray' and 'Seaway' exhibited the least (data not presented).

Treatments	Thatch (mm) ‡	Root Weight† Fresh (g)	Dry (g)	Ash (g)
Cultivar means§				
Seadwarf	28.8	2.95	0.448a††	0.013
Seagreen	28.0	2.62	0.430ab	0.012
Sea Isle 2000	29.9	2.84	0.452a	0.012
Sea Isle Supreme	29.2	2.85	0.452a	0.013
SI-99	28.7	2.78	0.450a	0.014
Salam	26.6	2.40	0.363c	0.011
Sea Isle I	28.3	2.68	0.419abc	0.013
Seaspray	27.9	2.52	0.375bc	0.017
LSD	n.s.	n.s.	0.06	n.s.

Fertilizer means	2005-06	2005	2006	2005	2006	2005	2006
0.25 lb N/biweekly	22.9b	2.07a	2.94b	0.385a	0.435b	0.011	0.014b
0.50 lb N/biweekly	30.4a	1.96ab	3.84a	0.372a	0.519a	0.010	0.018a
1.00 lb N/biweekly	31.9a	1.69b	3.72a	0.315 b	0.515a	0.009	0.012b
LSD	2.2	0.32	0.41	0.057	0.057	n.s.	0.003

Split-plot analysis				
Cultivar	0.3830	0.1936	0.0147	0.2811
Year x cultivar	1.0000	0.3626	0.6912	0.1352
Fertilizer	0.0001	0.0118	0.1635	0.0364
Cultivar x fertilizer	0.5240	0.1072	0.4521	0.9901
Year x fertilizer	1.0000	0.0001	0.0012	0.0419
Year x cultivar x fertilizer	1.0000	0.2363	0.5296	0.8319

†Three one-inch diameter core samples were taken from each plot. Soil was washed from the roots and they were weighed, dried, and then ashed.

‡Three one-inch diameter core samples were taken from each plot, compressed lightly, and thatch depth recorded.

§ Where a significant year by cultivar or year by fertilizer interaction occurred means were separated by year.

†† Means followed by the same letter(s) in a column and group are not significantly different according to Fisher's Protected LSD (P=0.05), n.s. = not significant.

Table 3. Evaluation of green-height seashore paspalum cultivars and nitrogen rate on thatch/mat measurements for the 2005-2006 growing seasons at Jay, FL.

Seashore Paspalum Adaptation to Putting Green Mowing Height

Throughout the study, differences in turfgrass color, quality, and density were attributed to varietal differences, as well as rate of applied nitrogen. 'Seadwarf' and 'Sea Isle 2000' were the two best performing cultivars when maintained at putting green heights (Table 2). Averaged over the life of the study, few varietal differences were observed with the other six cultivars (Table 2). Nitrogen fertility had a greater influence on turf quality in 2006 than in 2005. Rates = 0.50 lbs N applied bi-weekly produced marginally accept-

Treatments	Turfgrass Quality†						
	Apr-Jun (Q2)		Jul-Sep (Q3)		Oct-Dec (Q4)	Mean	
***Cultivar means*‡**	**2005**	**2006**	**2005**	**2006**	**2005-06**	**2005**	**2006**
Seadwarf	4.3de§	3.5c	5.1cd	3.8cd	4.2bc	4.5bc	3.8c
Seagreen	4.4de	4.2b	5.3bc	4.1bc	4.4b	4.7abc	4.2b
Sea Isle Supreme	4.8abc	3.5c	5.0cd	3.7de	3.7ef	4.5bc	3.6cd
SI-99	4.9a	3.1d	5.4bc	3.7de	3.8def	4.7ab	3.6d
Salam	4.9ab	3.7c	5.1cd	3.4e	3.7ef	4.6bc	3.6cd
Sea Isle I	4.2ef	3.1d	4.8d	3.5e	3.9cde	4.3c	3.5d
Seaspray	4.8abc	3.7c	5.2cd	4.2b	4.0cd	4.6bc	4.1b
Neptune	4.0f	3.4cd	4.5e	3.7de	3.6f	3.8d	3.7cd
Seaway	4.5cde	5.1a	5.6b	5.3a	5.0a	5.0a	5.2a
Aloha	4.6bcd	3.6c	5.9a	4.2b	4.2bc	4.8ab	4.1b
LSD	0.3	0.4	0.4	0.3	0.3	0.3	0.2

Fertilizer means			**2005**	**2006**	
0.25 lb N/month	3.6c	4.2c	3.4c	4.0b	3.8c
0.50 lb N/month	4.1b	4.5b	3.8b	4.1b	4.2b
1.00 lb N/month	4.6a	5.1a	4.5a	4.6a	4.7a
LSD	0.13	0.1	0.2	0.2	0.1

Split-plot analysis				
Cultivar	0.0021	0.0001	0.0001	0.0001
Year x cultivar	0.0025	0.0050	0.4890	0.0213
Fertilizer	0.0001	0.0001	0.0001	0.0001
Cultivar x fertilizer	0.9039	0.1589	0.9019	0.5464
Year x fertilizer	0.8877	0.2525	0.0062	0.7315
Year x cultivar x fertilizer	0.8956	0.6860	0.8840	0.9803

† Quality visually rated on a 1-9 scale where 9 = best.

‡ Where a significant year by cultivar or year by fertilizer interaction occurred means were separated by year.

§ Means followed by the same letter(s) in a column and group are not significantly different according to Fisher's Protected LSD (P=0.05), n.s. = not significant.

Table 4. Evaluation of Fairway-height seashore paspalum cultivars and nitrogen rate on visual turf quality scores for the 2005-2006 growing seasons at Jay, FL.

able to acceptable turf quality in 2006; whereas no N rate applied during 2005 yielded acceptable turf quality with the exception of the highest rate applied during Q3. Reduced quality scores in 2005 are attributed to the influence of excessive rainfall (2005 - Q2 = 22.2"; Q3 = 30.5" versus 2006 - Q2 = 10.2"; Q3 = 13.3") on soluble ammonium sulfate. Turfgrass color and density estimates mirrored the quality ratings (data not presented).

No differences in thatch depth were observed between greens-height cultivars (Table 3). However, N rates = 0.50 lb applied biweekly produced a 33% increase in thatch depth (Table 3). Most greens-height cultivars produced similar root dry mass with the exception of 'Seaspray' and

Treatments	Thatch (mm) ‡	Root† Fresh (g)	Root† Dry (g)	Root† Ash (g)
***Cultivar mean*§**				
Seadwarf	21.9 b††	1.336	0.290	0.039 bc
Seagreen	19.2 cd	1.120	0.257	0.035 bc
Sea Isle Supreme	19.3 cd	1.009	0.244	0.044 bc
SI-99	20.0 b-d	1.107	0.261	0.046 b
Salam	20.9 bc	0.950	0.224	0.041 bc
Sea Isle I	20.0 b-d	1.212	0.306	0.045 bc
Seaspray	18.2 d	1.201	0.245	0.048 b
Neptune	26.3 a	0.976	0.207	0.029 c
Seaway	21.4 bc	1.385	0.274	0.046 b
Aloha	18.4 d	1.428	0.318	0.071 a
LSD	2.5	n.s.	n.s.	0.017
Fertilizer means				
0.25 lb N/month	20.1 b	1.192	0.264	0.044
0.50 lb N/month	20.1 b	1.119	0.249	0.041
1.00 lb N/month	21.5 a	1.206	0.276	0.048
LSD	1.3	n.s.	n.s.	n.s.
Split-plot analysis				
Cultivar	0.0044	0.3761	0.2382	0.0284
Year x cultivar	0.9823	0.5146	0.7860	0.7844
Fertilizer	0.0743	0.6599	0.3988	0.3128
Cultivar x fertilizer	0.3939	0.4368	0.6082	0.2743
Year x fertilizer	0.2156	0.2241	0.9468	0.6363
Year x cultivar x fertilizer	0.3384	0.5545	0.4044	0.0302

†Three one-inch diameter core samples were taken from each plot. Soil was washed from the roots and they were weighed, dried, and then ashed.

‡Three one-inch diameter core samples were taken from each plot, compressed lightly, and thatch depth recorded.

§ Where a significant year by cultivar or year by fertilizer interaction occurred means were separated by year.

†† Means followed by the same letter(s) in a column and group are not significantly different according to Fisher's Protected LSD (P=0.05), n.s. = not significant.

Table 5. Evaluation of Fairway-height seashore paspalum cultivars and nitrogen rate on thatch and mat measurements for the 2005-2006 growing seasons at Jay, FL.

'Salam' which produced approximately 20% less root dry matter (Table 3).

Seashore Paspalum Adaptation to Fairway Mowing Height

Turfgrass quality gradually deteriorated over the 2005-06 growing seasons. However, the

Interest in seashore paspalum is increasing as golf course irrigation is being relegated to use of reclaimed or saline water sources. Shown above is 'SeaDwarf' seashore paspalum at Lost Key Golf Club in Perdido Key, FL.

top performing cultivars consistently were 'Seaway,' 'Aloha,' and 'Seagreen' (Table 4). 'Neptune' consistently ranked poorly. 'Neptune' is a coarse, open type that doesn't produce as dense a canopy as other finer textured cultivars. Increasing N fertility promoted improved turf quality. However, even the highest rate (1.0 lb N/month) failed to give acceptable turf quality (Table 4). Subtle differences in turfgrass color and density were observed during the study (data not presented).

In 2005, no differences between cultivars were observed except for July where 'SI-99' and 'Seadwarf' had the greatest chlorophyll meter index readings and 'Seaspray' and 'Neptune' had the lowest readings (data not presented). Throughout the 2005 growing season, increasing N rates resulted in higher chlorophyll meter readings. At no time in 2006, however, were differences observed between cultivars or N rates for chlorophyll meter index readings (data not presented).

Over two growing seasons differences in thatch depth were attributed to N rates (1.0 lb > 0.50 lb or 0.25 lb) (Table 5). Similarly, thatch depth among cultivars differed with 'Neptune' yielding the greatest (26.3 mm) and 'Aloha' and 'Seaspray' yielding the least (18.4mm and 18.2 mm, respectively). Differences in root weights were negligible.

Conclusions

The susceptibility of seashore paspalum to dollar spot is known to be problematic and Raymer (7) is conducting research to identify superior breeding lines. He notes that 'Sea Isle 2000' is a commercial cultivar exhibiting the best dollar spot resistance (7). Our data places 'Sea Isle 2000' towards the top of the varieties we evaluated. Given the level of rainfall received during 2004 (Q2 = 15.99"; Q3 = 30.27"; Q4 = 17.41"), it is not surprising to see this level of disease incidence.

The rates of ammonium sulfate evaluated in this study were not sufficient to maintain acceptable turf quality during periods of heavy rainfall. Using insoluble N sources augmented

with foliar applications of soluble N should be considered by those managing seashore paspalum. Throughout the study there was never an interaction between cultivar (green- or fairway-height) and N rate. This suggests that cultivar performance is not heavily influenced by N rate.

Variation in thatch accumulation was affected more by N rate for green-height grasses than due to cultivar differences. However, the opposite appears true for the cultivars maintained at fairway-heights. This most likely is attributed to morphological development under the close mowing height versus the higher height-of-cut. However, shoot counts do not correlate well with thatch accumulation (data not presented).

This study was conducted using potable well water for irrigation. Commercial advertisements for seashore paspalum cultivars make claims to varietal differences in salt tolerance. These claims need to be assessed in field studies conducted under controlled conditions.

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