CULTIVAR

Registration of 'Aloha' Seashore Paspalum

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ABSTRACT

'Aloha' (Reg. No. CV-3, PI 652948) seashore paspalum (*Paspalum vaginatum* O. Swartz) was developed at the Everglades Research and Education Center, Institute of Food and Agricultural Sciences, University of Florida and jointly released by the Florida and Hawaii agricultural experiment stations. It was initially approved for release in early 2005 and a pending plant patent was submitted in late 2005. This variety of seashore paspalum was selected as an open-pollinated progeny derived from naturalized local landraces growing on the island of Hawaii and was tested in southern Florida under the coded breeding line number H99–47. Aloha was selected for improved agronomic, horticultural, and host-plant resistance traits including a faster rate of crop establishment and ground coverage, darker and deeper green leaf color, and superior resistance to the greenbug aphid (*Schizaphis graminum* Rondani; Homoptera:Aphididae). In comparison to a set of standard varieties, Aloha attained 50% plot coverage in less than 4 mo whereas the standards took, on average, more than 5 mo. The leaf color of Aloha was a darker green and had a deeper hue than the standard varieties, and the greenbug aphids took longer to reach reproductive maturity, had a shorter lifespan, and produced fewer offspring when cultured on Aloha. Aloha also exhibited a morphology distinct from the standards for a set of measured inflorescence and vegetative traits.

Throughout the southeastern states of Alabama, Florida, and Georgia there are five seashore paspalum varieties grown on 358 ha as foundation, registered, or certified seed (Southern Seed Certification Assn., 2009; Georgia Crop Improvement Assn, 2010). Currently, the paspalum market in the southeastern United States is dominated by the varieties 'SeaDwarf' (SDX-1) (DePew et al., 2002) and 'SeaIsle I' (Duncan, 2002). More recently, 'Sea Isle Supreme' (SI-198) was released into the Georgia market as a salt-tolerant seashore paspalum (Georgia Crop Improvement Assn, 2010). Over time, seashore paspalum has been identified for a number of turf applications in the southeastern United States, and both the acreage of this crop and the numbers of varieties have continued to expand (Duncan and Carrow, 2000; Beard, 1973).

The purpose of this breeding program was to identify and develop new turfgrass varieties for Florida's expanding seashore paspalum market and to enlarge the diversity of warm-season, clonally propagated, perennial turf species and varieties grown for the specialty turf markets. 'Aloha' (Reg. No. CV-3, PI 652948) was developed specifically as a regional variety for the subtropical and tropical regions of Florida. It was selected for its agronomic, horticultural, and host-plant resistance traits, including (i) a faster rate of crop establishment and ground coverage in southern Florida; (ii) a darker leaf color; and (iii) insect resistance. It was also compared to a set of standard varieties to compose a distinct morphological and botanical description. Aloha was tested in multiple years at three sites in the intended region of adaptation in southern Florida, including Charlotte, Highlands, and Palm Beach counties. Aloha is primarily intended for use in landscape and sports turf applications, where insect resistance and rapid ground coverage is advantageous.

Methods

This variety originated as an open-pollinated progeny derived from a polycross among a diverse set of naturalized and established local landraces in Hawaii (Murdoch and Nishimoto, personal communication, 2005). These naturalized landraces were planted at the Lalamilo Research Farm in Kamuela, Hawaii County and at the Magoon Research Farm in Oahu County. Aloha was selected at the Lalamilo

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Research Farm in 1999 and assigned the experimental designation H99–47. This research farm is located on the northwest coast of the island between Mauna Kea and the Kohala Mountains at an elevation of 760 m.a.s.l. and receives an average of 25 to 50 cm of annual rainfall. It was initially selected as a unique seedling and was included with 15 other unique individuals from locations throughout Hawaii that represented Hawaii County's diverse array of microclimates. All seedlings, including H99–47, were selected for visible turfgrass performance traits (color, density, leaf texture, uniformity, and quality) and to represent the diversity of phenotypes in the region. Once selected, individuals were vegetatively propagated, transferred to Florida for evaluation, and maintained as vegetative clones. In Florida, these 15 selections were again subjected to visual selection for turfgrass performance traits. In the second phase, a number of these individual clones were advanced for comparison to a set of standard varieties in unreplicated plots in Charlotte County, FL. In the third phase, a set of elite clones was evaluated under standard production practices in a three-replicate randomized block design at test sites in Charlotte, Highlands, and Palm Beach counties, FL. These clones were compared to the standard varieties SeaDwarf, SeaIsle 1, and 'SeaGreen'. In addition, host-plant resistance to the greenbug aphid [*Schizaphis graminum* Rondani (Homoptera:Aphididae)] and to the tropical sod webworm [*Herpetogramma phaeopteralis* Guenee (Lepidoptera: Pyralidae)] and morphological differences between Aloha and a set of standards were determined in Palm Beach County. Data were analyzed using PROC GLM in SAS with means separated by LSD at a 0.05 significance level (SAS Institute, 2001).

Characteristics and Variety Description

The seashore paspalum (*Paspalum vaginatum* O. Swartz) variety Aloha was developed at the Everglades Research and Education Center of the Florida Agricultural Experiment Station in cooperation with the Hawaiian Agricultural Experiment Station. It was approved for release 2005, a plant patent was submitted 2005, and a trademark was submitted in 2007.

The floral morphology of Aloha was compared to that of SeaIsle 1 and SeaDwarf for 14 traits. Four of these traits described the peduncle morphology, and 5 were used to describe the racemes. Because *Paspalum vaginatum* has a bifurcated inflorescence, data were collected on both the long and short raceme (Table 1). Overall, Aloha differed significantly from the standard varieties for 8 of the 14 inflorescence traits. In general, Aloha had a more robust floral morphology than either SeaDwarf or SeaIsle 1, which generally presented the more refined morphology. The overall length of the inflorescence, as measured from the apex of the seedhead to the uppermost or flag-leaf node, was 13–15% longer on Aloha than on the standards varieties and is attributed to the extended length of both the peduncle and racemes of Aloha (Table 1). As anticipated, the sheath of the flag leaf, which covers the peduncle, was correspondingly longer on Aloha, and the flag leaf itself was significantly longer in comparison with that of SeaIsle 1 or SeaDwarf (Table 2). Raceme morphology also varied both within and among the varieties. Within each variety, the long racemes were 5.0–10.0% longer than the short racemes (Table 1). Among the varieties, Aloha produced longer long racemes by 17–19%, and 20% longer short racemes than either of the standard varieties, and these differences were repeated for the floret morphology traits (Table 1). Within varieties, there were 8–10% more florets produced on the long racemes as compared to the short racemes. Among varieties, Aloha produced from 9 to almost 11% more florets on the long racemes and 16–20% more on the short racemes than either of the standards (Table 1). Across all the varieties, floret density per length of raceme was highest on SeaDwarf and lowest on Aloha, where it ranged from an average of one floret 1.71 mm to one per 1.85 mm.

Table 1. Comparison of floral traits of Aloha, SeaIsle 1, and SeaDwarf.

Trait	Aloha	SeaIsle 1	SeaDwarf
	mean ± SE (mm)		
Overall shoot length†	94.70 ± 1.66	84.05 ± 1.56	82.01 ± 1.87
Peduncle length‡	61.03 ± 1.34	54.56 ± 1.28	52.93 ± 1.54
Peduncle width§	0.98 ± 0.02	0.90 ± 0.02	0.98 ± 0.04
Exposed peduncle length¶	12.24 ± 0.82	12.87 ± 1.00	13.77 ± 0.79
Long raceme			
Raceme length#	34.30 ± 0.50	29.20 ± 0.46	28.60 ± 0.86
Raceme width††	1.54 ± 0.03	1.42 ± 0.02	1.69 ± 0.03
Floret number‡‡	18.25 ± 0.48	16.50 ± 0.36	16.70 ± 0.54
Glume length§§	3.10 ± 0.02	3.02 ±0.02	2.92 ± 0.05
Glume width¶¶	1.51 ± 0.03	1.48 ± 0.01	1.38 ± 0.03
Short raceme			
Raceme length#	31.75 ± 0.51	26.38 ± 0.57	26.38 ± 0.77
Raceme width††	1.70 ± 0.05	1.59 ± 0.05	1.77 ± 0.05
Floret number‡‡	17.40 ± 0.50	14.50 ± 0.44	14.95 ± 0.65
Glume length§§	2.75 ± 0.06	2.76 ± 0.04	2.86 ± 0.04
Glume width¶¶	1.17 ± 0.02	1.18 ± 0.03	1.13 ± 0.03

†Overall shoot length was measured from the first node on the peduncle subtending the inflorescence to the top of the longest raceme.

‡Peduncle length was measured from first node subtending the inflorescences to the point where the bifurcation is initiated.

§Peduncle width was measured at the widest part of the peduncle.

¶Exposed peduncle length is the average length of the peduncle not covered by the flag-leaf sheath.

#Raceme length was measured from the apex of each seedhead to the base of the raceme.

††Raceme width was measured at the broadest part of each seedhead.

‡‡Floret number is the average count of seed-producing florets on the raceme.

§§Glume length is a measure of the average glume length on the seed located at the midpoint along the floret.

¶¶Glume width was measured at the widest part of the glume.

Table 2. Comparison of flag-leaf traits of Aloha, SeaIsle 1, and SeaDwarf.

Trait	Aloha	SeaIsle 1	SeaDwarf
		mean ± SE (mm)	
Flag-leaf length	7.64 ± 0.88	3.85 ± 0.64	4.53 ±0.79
Flag-leaf width†	1.01 ± 0.09	0.61 ± 0.09	0.66 ±0.11
Sheath length‡	48.82 ± 0.87	41.42 ± 0.88	39.89 ±0.82

†Flag-leaf width was measured at the widest part of the leaf.

‡Sheath length was measured from the base of the flag leaf to the first node subtending the inflorescence.

Table 3. Comparison of the leaf-morphology traits of Aloha, SeaIsle 1, and SeaDwarf.

Trait	Aloha	SeaIsle 1	SeaDwarf
	mean ± SE (mm)		
Leaf length	58.90 ± 1.38	54.36 ± 1.80	57.95 ± 2.18
Leaf width†	2.94 ± 0.07	3.05 ± 0.09	3.03 ± 0.10
Internode length	24.07 ± 0.76	27.21 ± 0.73	22.28 ± 0.85
Internode width‡	1.76 ± 0.04	1.90 ± 0.03	1.83 ± 0.03

†Flag-leaf width was measured at the widest part of the leaf.

‡Internode width was measured at the widest part of the internode.

The stolon and leaf morphology of the vegetative tissue was measured on fully expanded leaves and internodes 10 nodes below the meristem (Table 3). Unlike the previously measured traits, there were no significant differences among the three varieties for average leaf length, although Aloha produced leaves that were >4.5 mm longer than SeaIsle 1 and only ≤1.0 mm longer than SeaDwarf, which was expected to have the more refined leaf structure. On average, Aloha displayed the narrowest leaf width of the three varieties, but again these differences were not statistically significant. Significant differences did exist for the internode measurements: Aloha and SeaDwarf had shorter internodes than SeaIsle 1 (Table 3). The internode width of Aloha was significantly shorter than SeaIsle 1, but no significant difference was detected between Aloha and SeaDwarf for this trait (Table 3). Although these differences were statistically meaningful, they are difficult to discern visually.

Color and pigment in the leaf and stolon and rhizome tissues varied among the three varieties and was determined by a comparison of fresh leaf and stolon samples to color panels in the Munsell color chart (Munsell Color, 1977). The adaxial leaf surface of all three varieties presented a green hue that ranged from 5GY to 7.5GY, but Aloha produced leaves with a darker green color [5GY (5–4/4) to 7.5GY (5–4/4)] than either SeaDwarf [5GY (6–5/4) to 7.5GY (5–4/4)] or SeaIsle 1 [5GY–7.5GY (6–5/4)], while the chroma was identical for all three varieties. The internode tissue of Aloha also produced a green color that ranged from 5GY (6–5/6) to 7.5GY (6–5/6) and was darker than that of either SeaDwarf [5GY (7–6/6) to 7.5GY 7–6/6)] or SeaIsle 1 [5GY (7–6/8) to 7.5GY (7–6/6)]. The purplish anthocyanin pigments in the node and internode tissues were essentially the same, and although all of these color differences in the vegetative tissues could not be separated statistically, they were visibly discernable and imparted this darker color to the canopy. Color patterns in the reproductive structures, including the stigmatic tissue and racemes of each variety, were similar. The color of the exposed peduncles, which support the racemes, had more of a yellow hue [2.5GY (6–5/6)] on SeaDwarf than either on Aloha or SeaIsle 1, both of which had an identical color range of 5GY (6–5/6) to 7.5GY (6–5/6).

Additionally, four varieties were compared at southern test sites in Charlotte and Palm Beach counties for their rate of crop establishment as measured by the increases in three "grow-in" traits: the rate of plot coverage, the stolon count, and the stolon length. At the Charlotte County site, all four varieties exhibited statistically significant differences for plot coverage from the first month of data collection (Fig. 1). Ultimately, Aloha covered the plots significantly faster than SeaDwarf, SeaGreen, or SeaIsle 1. It attained 50% plot coverage in 3.75 mo, whereas SeaIsle 1 and SeaGreen attained 50% plot coverage only by the middle of the fifth month, and SeaDwarf took more than 8 mo to attain 50% plot coverage (Fig. 1). Similar results were obtained at the Palm Beach County site, where Aloha reached 50% plot coverage in 4 mo, whereas SeaIsle 1, SeaGreen, and SeaDwarf achieved 50% plot coverage in 5.5, 6, and 7 mo, respectively. The number of stolons generated was higher for Aloha and

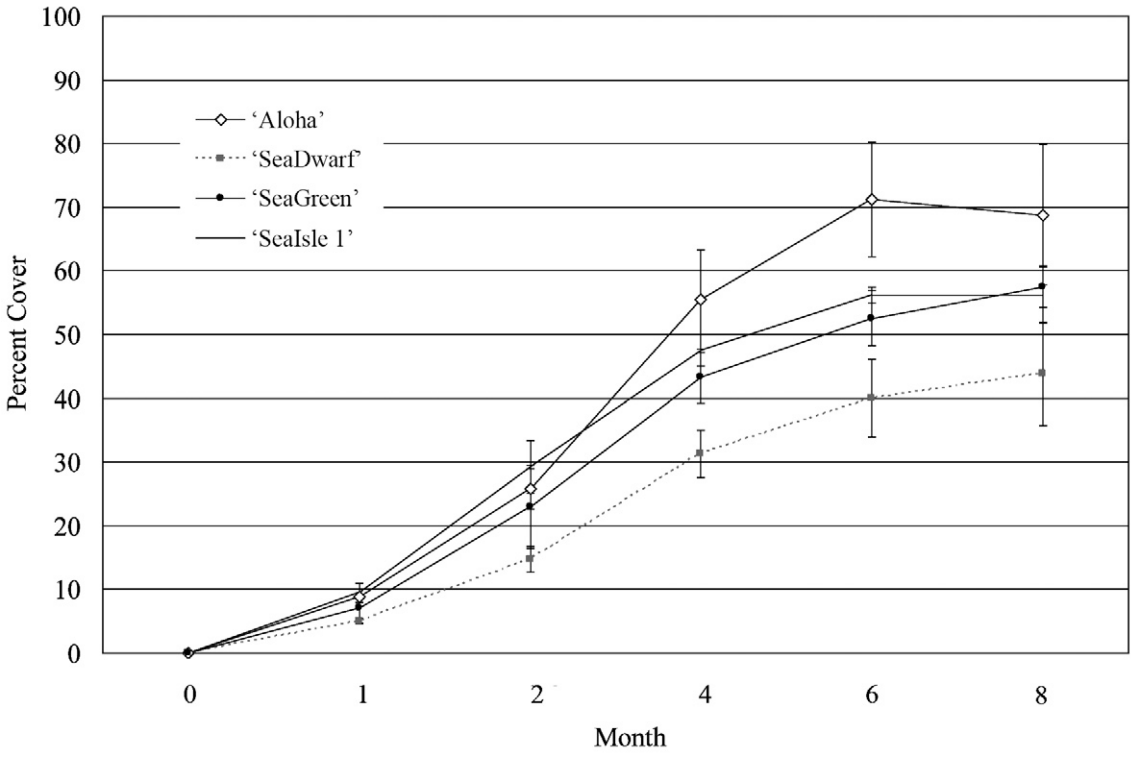

Figure 1. Comparison of cumulative average plot coverage measured on a monthly basis among 'Aloha', 'SeaDwarf', 'SeaIsle 1', and 'SeaGreen' in Charlotte County, FL.

SeaIsle 1 across the duration of these experiments, but after the fourth month, stolon numbers were difficult to discern because the stolons intertwined into a uniform closed canopy. SeaDwarf consistently produced measurably shorter stolons than Aloha, SeaGreen, and SeaIsle 1. In a vegetatively propagated turf variety, the establishment and rapid canopy closure permits earlier harvests and generally requires fewer inputs. This agronomic feature conveys important economic advantages that are particularly useful for growers in the southern production regions of the state where land is more expensive, water is more restricted, and production costs are higher.

In southern Florida, seashore paspalum is frequently attacked by the tropical sod webworm and the greenbug aphid. The greenbug aphid is a newly established insect pest on seashore paspalum (Nuessly et al., 2004) and was first identified on seashore paspalum at multiple locations in Florida. It has subsequently been classified as the "Florida biotype" (Nuessly et al., 2008). Aloha was compared to an array of varieties, including SeaDwarf, SeaIsle 1, SeaGreen, and SeaWay, for resistance to the greenbug aphid (Nagata et al., 2005). All varieties were infested with nymphs from two separate laboratory-maintained colonies and were monitored for three traits: the rate of development to reproductive maturity, longevity, and fecundity (Table 4). Aphids grown on Aloha and SeaIsle 1 took the longest time to reach sexual maturity, and this development rate was significantly different from SeaDwarf, SeaGreen, and SeaWay. 'Sea Wolf', a pasture-type seashore paspalum was also included in this experiment, but greenbugs did not produce any nymphs on Sea Wolf, and adults forced to stay on the grass died within several days. The longevity of these aphids was significantly shorter on Aloha than on any of the other four varieties. The aphids only lived for an average of 16.3 d on Aloha, whereas their life expectancy ranged from an average of 24.9–29.4 d on the other varieties (Table 4). The reproductive rate of the aphid was also significantly reduced on Aloha in comparison to the other varieties. Sexually mature aphids produced an average of only 14.6 offspring on Aloha, but an average of 29.1–38.4 offspring were produced on the four other varieties (Table 4). Although the mechanism of this antibiosis-based resistance is unknown, it is clear that aphids that (i) mature later, (ii) live shorter reproductive lives, and (iii) have lower reproduction rates should all contribute to less crop damage and require fewer costly pesticide applications in southern Florida.

In a second set of host-plant resistance experiments using the same standard varieties used to evaluate greenbug aphid resistance, Aloha was assessed for resistance to the tropical sod webworm. The fifth-instar larval weight gain was measured over 4-d intervals. Statistically significant resistance was demonstrated only by Sea Wolf; no significant differences existed among the turfgrass varieties, although Aloha displayed the lowest insect weight gain among this group. Sea Wolf was the only variety to significantly slow the rate of sod webworm weight gain among all varieties (Table 5).

In summary, Aloha differed from the standard commercial varieties in several traits. Horticulturally, its more desirable deeper green color and unique morphology resulted in a distinct appearance relative to the other varieties of seashore paspalum tested and currently marketed in the southeast. Aloha also exhibited a significantly faster rate of crop establishment in the southern production regions. These factors impart important agronomic and economic advantages relative to harvest intervals, crop maintenance, and production costs. Aloha also demonstrated improved host-plant resistance to the greenbug aphid. Overall, Aloha exhibited a significant improvement over the standard seashore paspalum turfgrass varieties grown in Florida and should have a competitive advantage within this specialty turfgrass market.

Availability

Aloha is licensed exclusively to Environmental Turf Inc., 4366 E. Kinsey Rd., Avon Park, FL 33825 (www.environmentalturf.com [verified 7 Sept. 2010]) under a master-license agreement with the Florida Foundation Seed Producers, 3913 Hwy 71, Greenwood, FL 32443. It is protected by a trademark filed under the denomination of 'Aloha Seashore Paspalum' with registration number 3080442 that was filed and granted in 2007. In 2005, a plant patent was submitted with the assigned application number 11/188,229. It continues to await review. Breeder stock is maintained at the Everglades Research and Education Center, 3200 East Palm Beach Rd., University of Florida, Belle Glade, FL 33430–8003. Breeder and foundation stocks are also maintained by Environmental Turf under the guidelines of the

Table 4. The rate of development, longevity, and fecundity of the greenbug aphid feeding on five different varieties of seashore paspalum.

Variety	Rate of development†	Longevity‡	Fecundity§
	mean ± SE		
Aloha	8.20 ± 0.10	16.30 ± 1.70	14.60 ± 2.70
SeaIsle 1	8.20 ± 0.20	24.90 ± 2.20	29.10 ± 3.80
SeaDwarf	7.60 ± 0.20	26.10 ± 2.80	38.30 ± 3.70
SeaGreen	7.90 ± 0.20	26.60 ± 3.40	34.00 ± 4.10
SeaWay	7.60 ± 0.30	29.40 ± 3.00	38.40 ± 6.00

†Rate of development is defined as the number of days to reproductive maturity.

‡Longevity is the average life expectancy measured in days.

§Fecundity is a measure of the reproductive rate and based on offspring count.

Table 5. Weight gain for the tropical sod webworm after 4 d of feeding on six different varieties of seashore paspalum.

Variety	Weight gain	Range	
	Mean ± SE	Low	High
	mg		
Aloha	50.90 ± 4.76	24.10	68.70
SeaIsle 1	56.27 ± 2.76	43.20	73.80
SeaDwarf	51.14 ± 3.86	29.50	70.60
SeaGreen	58.38 ± 5.33	24.40	78.80
SeaWay	51.61 ± 3.81	32.70	70.00
Sea Wolf	30.43 ± 4.47	12.50	55.10

Southern Seed Certification Association, Inc., P.0. Box 2619, Auburn, AL 36831 (www.ag.auburn.edu/ssca [verified 7 Sept. 2010]). Samples were deposited with the National Center for Genetic Resources Preservation (NCGRP), ARS-USDA, and are held at the ARS Plant Genetic Resources Conservation Unit, 1109 Experiment St., Griffin, GA 30223. Unless otherwise negotiated, samples of Aloha are available for research purposes only, and request should be directed to the Everglades Research and Education Center, Institute of Food and Agricultural Sciences, University of Florida or to Environmental Turf, Inc. Sublicenses for commercial production purposes are available from Environmental Turf, Inc. and Florida Foundation Seed Producers, Inc.

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