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ENH1202

UF-T3 and UF-T4: Two Sterile *Lantana camara* Varieties[1]

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Lantana camara plants are commonly grown in containers, hanging baskets, and landscapes. They are valued for their bright flower color, butterfly attraction, tolerance to harsh environmental conditions, low maintenance requirements, and ease of propagation and production (Schoellhorn 2004). Many existing *L. camara* varieties are highly fertile, producing a significant amount of fruit, seeds, and viable pollen that lead to weedy or invasive behaviors when grown in tropical and subtropical regions (FLEPPC 2011; Langeland et al. 2008). A genetic sterilization program was initiated in 2004 at the University of Florida's Institute of Food and Agricultural Sciences (UF/IFAS) to develop sterile *L. camara* varieties with much-reduced or eliminated invasive potential. Breeding, selection, and testing efforts during the last several years resulted in the development and release of UF-T3 and UF-T4 lantana varieties in late 2011 (Czarnecki et al. 2012). The UF/IFAS Invasive Plants Working Group reviewed the research data on these varieties and concluded that UF-T3 and UF-T4 would not likely be invasive weed problems and could be recommended for commercial production and landscape use in Florida.

Origin

UF-T3 and UF-T4 were derived from a cross between 'Dallas Red' and UF breeding line LAOP-9 and from a cross between 'Carlos' and breeding line LAOP-9, respectively. 'Carlos' and 'Dallas Red' are unpatented commercial *L. camara* varieties with yellow/pink and yellow/red flowers, respectively. Breeding line LAOP-9 was selected from the open-pollinated progeny of 'Lola', an unpatented commercial *L. camara* variety with yellow flowers.

Both UF-T3 and UF-T4 are triploids, which contain three sets of chromosomes in their cells, while 'Lola' and LAOP-9 are diploids, and 'Carlos' and 'Dallas Red' are tetraploids, which contain two and four sets of chromosomes, respectively.

Plant, stem, leaf, and flower characteristics

UF-T3 plants are multistemmed shrubs with a mounding growth habit (Fig. 1). New stems are light green, square, and covered with soft hairs but not prickles; old stems are round, light brown, and smooth with few hairs. Leaves are opposite and simple with petioles ½–1 inch long and light green. Mature leaf blades are ovate, 2½–4 inches long, and 1½–2 ½ inches wide with serrated margins (30–60 teeth), a broadly truncated base, and an acute apex. The upper leaf surface is green and covered with soft hairs. Inflorescences (flower clusters) are umbels, 1½–2 inches wide across the top and bearing 25–30 flowers. Inflorescence peduncles (flower stalks) are yellow green and 1½–3 inches long. UF-T3 flowers are multicolored and bright yellow upon opening, then turn to bright orange (Fig. 2). Inflorescences rarely bear fruit.

UF-T4 plants are multistemmed shrubs with a mounding growth habit (Fig. 3). Young stems are light green, square,

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Figure 1. A single UF-T3 lantana plant propagated by cutting, grown in a soilless mix for 50 days, and grown outdoors in the ground bed for 70 days.
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Figure 3. A single UF-T4 lantana plant propagated by cutting, grown in a soilless mix for 50 days, and grown in the field for 70 days.
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Figure 2. UF-T3 lantana flowers and inflorescences grown outdoors in ground beds in full sun.
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Figure 4. UF-T4 lantana flowers and inflorescences grown outdoors in ground beds in full sun.
Credits: University of Florida/IFAS

and covered with soft hairs but no prickles; old stems are round, light brown, and smooth with few hairs. Leaves are opposite and simple with petioles ½–1 inch long and yellowish green. Mature leaf blades are ovate, 3–4 inches long, and 2–3 inches wide with serrated margins (40–60 teeth), a broadly truncated base, and an acute apex. The upper leaf surface is green and covered with soft hairs. Inflorescences are umbels, approximately 1½ inches wide across the top, and bear 25–31 flowers with light yellow peduncles 2–3 inches long. Flowers are light yellow upon opening and turn pinkish purple as flowers mature (Fig. 4). Inflorescences rarely bear fruit.

Male sterility

Previous studies have shown that pollen stainability is a good indicator of lantana's male fertility (or sterility) and hybridization potential with Florida native lantana, *Lantana depressa* (Czarnecki 2011; Czarnecki, Deng, and Clark 2008; Dehgan and Guy, n.d.). Three pollen-staining experiments (Experiments 1, 2, and 3) were conducted to determine the pollen stainability of UF-T3 and UF-T4. The commercial variety 'Pink Caprice' was included in the experiments as a check. Fresh anthers were collected from the plants grown at the UF/IFAS Gulf Coast Research and Education Center (GCREC) on 24 September 2009

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(Experiment 1) and 16 November 2009 (Experiment 2) and from plants grown at the UF/IFAS Indian River Research and Education Center (IRREC) on 6 October 2009 (Experiment 3). In each staining experiment, three inflorescences were collected per plant and three to four anthers were isolated from each inflorescence, resulting in 48–72 anthers for any given variety (two plants per replicate and three replicates). Collected anthers were stained in a commercial cotton blue solution (Eng Scientific, Inc. Product No. 6730, Clifton, NJ) overnight at 150°F. Stained pollen grains were observed under a microscope (400×, BH-2, Olympus, Tokyo). Well-developed, fully and deeply stained pollen grains were counted as stainable, while unstained, partially stained, or abnormally shaped pollen grains were counted as unstainable (aborted).

The average pollen stainability of UF-T3 and UF-T4 from three experiments was 5.1% and 3.2%, respectively, while the pollen stainability of 'Pink Caprice' was 65.6% (Table 1). Thus, the male fertility of UF-T3 and UF-T4 was reduced by greater than 90% from that of 'Pink Caprice'. The high level of male sterility was consistent over time and among experiments.

Female sterility

Previous studies have indicated that the primary factors determining lantana's female fertility (or sterility) are fruit (seed) production per peduncle and seed germination (Czarnecki 2011; Dehgan and Guy, n.d.) and that a female fertility index (FFI) could be derived by multiplying fruit production per peduncle and seed germination (Czarnecki 2011).

Four experiments were conducted simultaneously at the IRREC in Ft. Pierce, the GCREC in Balm, the Plant Science Research and Education Unit (PSREU) in Citra, and the North Florida Research and Education Center (NFREC) in Quincy to determine the fruit production of UF-T3 and UF-T4. The experimental design in Ft. Pierce and Balm was a randomized complete block with three blocks. Each plot within a block at these sites consisted of two plants of the same variety and one *L. depressa* plant (mixed planting) with 6-foot spacing. The same experimental design and the same number of blocks were used in Quincy and Citra, except that *L. depressa* plants were not installed in any of the plots (pure planting) because *L. depressa* does not occur naturally in north Florida. At each experimental site, 'Pink Caprice' was included as a "resident species" taxon. This variety is commercially produced and prolific in fruit (and seed) production (Czarnecki, Deng, and Clark 2008). 'Pink Caprice' plants were installed at least 150 feet away from UF-T3 and UF-T4 plants.

Lantana plants were approximately 7 weeks old. Raised ground beds were fumigated at least 3 weeks before planting and covered with white-on-black plastic or landscape fabric. Transplanting was completed the week of 5 May 2009. Each plant was top dressed with approximately 15 grams of the controlled-release fertilizer Osmocote® (15-9-12, 12–14 months) and irrigated through drip tapes twice a week for 2 hours per irrigation event.

Fruit production per peduncle: Every 4 weeks, beginning in late July 2009 until mid-December 2009, 20 peduncles were harvested randomly from each of the plants grown at the four experimental sites, and fruit on each peduncle was counted. A total of six harvests were made for each plant at each experimental site. Thus, 120 peduncles were examined for each lantana variety in each experimental plot during a given harvest, and 2,880 peduncles were examined across the four experimental sites through six harvests (20 peduncles per plant × 2 plants within a block × 3 blocks × 4 sites × 6 harvests) for each variety.

'Pink Caprice' produced the greatest number of fruits in the study (Table 2). Each peduncle produced an average of 1.143–22.838 fruits with an overall average of 10.451 across the four sites and six harvests. The number of fruits per peduncle on 'Pink Caprice' grown in Balm and Ft. Pierce ranged from 1.143 to 12.416, averaged to 6.783, while the number of fruits per peduncle on plants grown in Quincy and Citra was 7.150–22.838, averaged to 14.118, more than onefold greater.

The number of fruits UF-T3 produced per peduncle ranged from 0 to 0.074 and averaged to 0.019 across four experimental sites over 6 months (Table 2). The number of fruits per peduncle for UF-T4 ranged from 0 to 0.358 and averaged to 0.023 across the sites over 6 months (Table 2). These levels of fruit production represent greater than 99% reduction from the fruit production capacity of 'Pink Caprice'. UF-T3 and UF-T4 showed similarly low levels of fruit production regardless of whether they were planted purely (without *L. depressa* in Quincy and Citra) or interplanted with *L. depressa* (in Balm and Ft. Pierce).

Seed germination: Seeds from mature fruit collected from experimental sites were germinated at the IRREC. There were few seeds for UF-T3 and UF-T4, thus seeds from different harvests at each site were combined before germination. Seeds were germinated in transparent polystyrene germination boxes containing two sheets of germination

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paper (Anchor Paper Company) moistened with nanopure water. Germination boxes were placed in temperature- and light-controlled chambers with cool-white fluorescent lamps. The germination condition was 12 hours of light at 77°F (photosynthetic photon flux was 22–30 µmol m^{-2} s^{-1} at shelf level) followed by 12 hours of dark at 59°F. Seed germination was monitored every other day for a period of 60 days. An additional 5–10 mL of nanopure water was added to the germination boxes as needed. A seed was considered germinated when radicle emergence (embryonic root) was 2.0 mm or greater.

'Pink Caprice' seeds germinated readily with an average germination percentage of 63.3 (Table 3). Only a very small number of seeds could be collected from UF-T3 plants, and the germination percentage of the seeds averaged to 24.4. A total of 25 seeds were collected from 24 UF-T4 plants over 6 months, and none of the seeds germinated. UF-T4 seeds appeared abnormal and were likely not viable.

Female fertility index: The FFI for UF-T3 and UF-T4 was 0.005 and 0.000, respectively (Table 3). These indices were less than 0.1% of the 'Pink Caprice' FFI (6.615), indicating an extremely high level of female sterility in UF-T3 and UF-T4.

Hybridization potential with *L. depressa*

Two hand-pollination experiments were performed in the greenhouse at GCREC in fall 2009 and spring 2010 to assess the ability of UF-T3, UF-T4, and 'Pink Caprice' to cause fruit set on *L. depressa* flowers. Stock plants were grown in plastic containers filled with a commercial soilless mix amended with a controlled-release fertilizer (Osmocote®, 15-9-12, 8–9 months). Fresh anthers were collected from mature, unopened flowers of UF-T3, UF-T4, and 'Pink Caprice' and applied immediately to emasculated *L. depressa* flowers.

UF-T4 pollen did not cause any fruit set on *L. depressa* (Table 4). Pollination with UF-T3 pollen resulted in 2.8% fruit set on *L. depressa* flowers in the first experiment but no fruit set in the second experiment. Two seeds were obtained from *L. depressa* flowers pollinated with UF-T3, but the seeds did not germinate. 'Pink Caprice' pollen caused an average of 8.9% fruit set on *L. depressa* flowers. Seeds from *L. depressa* × 'Pink Caprice' had 10.0% germination. These results indicate that UF-T3 and UF-T4 do not readily hybridize with *L. depressa* or produce viable interspecific progeny.

Propagation and pot plant production

UF-T3 and UF-T4 cuttings rooted well following the propagation procedures and under the greenhouse conditions that are typically used for lantana propagation. Rooted cuttings produced finished flowering potted plants within 4–6 weeks, depending on the temperatures set for the greenhouse and pot size.

Plant growth, performance, and flowering

UF-T3 and UF-T4 were evaluated for plant growth habit, performance, and flowering at the same time when fruiting data were collected in 2009 from the above-mentioned experiments in Ft. Pierce (USDA Hardiness Zone 9B, American Horticultural Society [AHS] Heat Zone 9–10), Balm (USDA Hardiness Zone 9A, AHS Heat Zone 10), Citra (USDA Hardiness Zone 8B, AHS Heat Zone 10), and Quincy (USDA Hardiness Zone 8B, AHS Heat Zone 9). UF-T3 and UF-T4 plants established well in the ground beds, developed a mounding growth habit, and produced an attractive canopy. The plants flowered profusely through the evaluation period. UF-T3 and UF-T4 landscape performance and flowering intensity ratings were equal to or better than those of 'Pink Caprice'.

Summary

Compared to 'Pink Caprice', the pollen stainability of UF-T3 and UF-T4 was reduced by 90% or more. These new triploid varieties did not cause fruit set or produce viable progeny when their pollen was hand applied to *L. depressa* flowers. Fruit production of these varieties was reduced by more than 99% and typically did not produce viable seeds. These varieties' high level of male and female sterility was stable from south Florida to north Florida, even with fertile *L. depressa* plants located in close proximity. These results indicate that UF-T3 and UF-T4 will not hybridize with *L. depressa* or produce viable interspecific progeny. UF-T3 and UF-T4 plants developed a mounding growth habit and performed and flowered better or comparably to 'Pink Caprice' in multisite replicated trials. UF-T3 and UF-T4 flowers are yellow/red and yellow/pink, respectively. With these attributes, UF-T3 and UF-T4 can serve as desirable candidates to replace male- and female-fertile *L. camara* varieties.

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Availability

The Florida Agricultural Experiment Station has applied for plant patents for UF-T3 and UF-T4, and propagation, production, and sale of these varieties are to be with a licensing agreement with the Florida Foundation Seed Producers, Inc., P.O. Box 309, Greenwood, FL 32443. Information about plant materials and propagation agreements can be obtained from the Florida Foundation Seed Producers, Inc. (http://ffsp.net/).

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Table 1. Pollen stainability of UF-T3, UF-T4, and 'Pink Caprice' grown outdoor in ground beds in full sun (2009)

Varieties	Pollen grains examined (no.)				Pollen stainability (%)			
	Experiment 1	Experiment 2	Experiment 3	Total	Experiment 1	Experiment 2	Experiment 3	Overall average
UF-T3	5,141	3,752	4,025	12,918	6.5	6.4	2.4	5.1
UF-T4	3,992	2,983	3,808	10,783	3.1	4.6	1.9	3.2
Pink Caprice	2,211	2,030	1,752	5,993	62.0	65.1	69.9	65.6

Note: Fresh lantana anthers were stained in a cotton blue staining solution overnight at 149°F before they were examined under a microscope. In Experiments 1 and 2, anthers were collected on 24 September 2009 and 16 November 2009 from plants (three blocks and two plants per block) at the University of Florida/IFAS Gulf Coast Research and Education Center, Balm, FL. In Experiment 3, anthers were collected on 6 October 2009 from plants (three blocks and two plants per block) at the University of Florida/IFAS Indian River Research and Education Center, Ft. Pierce, FL.

Table 2. Fruit production of UF-T3, UF-T4, and 'Pink Caprice' grown outdoors in ground beds in full sun at four experimental sites in Quincy, Citra, Balm, and Ft. Pierce in Florida (2009)

Varieties	Experimental site	Type of planting[a]	Fruit per peduncle (no.) at the following weeks post planting[b]							Average across all sites over 20 weeks
			12	16	20	24	28	32	Average	
UF-T3	Quincy	Pure	0.008	0.000	0.008	0.000	0.000	0.033	0.008	0.019
	Citra	Pure	0.025	0.008	0.000	0.000	0.000	0.017	0.008	
	Balm	Mixed	0.000	0.017	0.074	0.033	0.017	0.016	0.026	
	Ft. Pierce	Mixed	0.025	0.033	0.025	0.025	0.042	0.033	0.031	
UF-T4	Quincy	Pure	0.000	0.000	0.000	0.125	0.000	0.358	0.081	0.023
	Citra	Pure	0.000	0.017	0.000	0.000	0.000	0.000	0.003	
	Balm	Mixed	0.000	0.017	0.016	0.008	0.000	0.000	0.007	
	Ft. Pierce	Mixed	0.008	0.008	0.000	0.000	0.000	0.000	0.003	
Pink Caprice	Quincy	Pure	7.150	22.838	20.825	17.000	11.138	11.275	15.038	10.451
	Citra	Pure	15.808	10.867	16.092	9.175	12.783	14.467	13.199	
	Balm	Mixed	1.143	10.683	12.415	4.226	8.883	7.532	7.481	
	Ft. Pierce	Mixed	5.067	6.608	9.525	8.000	4.583	2.733	6.086	

Note: Lantana plants were installed the week of 5 May 2009 at each of four experimental sites: Quincy (UF/IFAS North Florida Research and Education Center), Citra (UF/IFAS Plant Science Unit), Balm (UF/IFAS Gulf Coast Research and Education Center), and Ft. Pierce (UF/IFAS Indian River Research and Education Center).

[a]Pure planting = two plants of the same variety per plot without *Lantana depressa* plants; mixed planting = one *L. depressa* plant was installed between the two plants of the same variety.

[b]Fruit per peduncle values are means from 120 peduncles (three blocks or replicates, two plants per block, and 20 peduncles per plant), unless indicated otherwise.

Table 3. Seed germination (%) and female fertility index of UF-T3, UF-T4, and 'Pink Caprice' lantana (2009)

Varieties	Seeds in germination tests (no.)				Seed germination (%)					Average fruit per peduncle[a]	Female fertility index[b]
	Quincy	Citra	Balm	Ft. Pierce	Quincy	Citra	Balm	Ft. Pierce	Average		
UF-T3	---[c]	2	13	12	---	50.0	15.4	33.3	24.4	0.019	0.005
UF-T4	22	---	3	---	0	---	0	---	0	0.023	0.000
Pink Caprice	100	100	100	100	71.0	49.0	71.0	62.0	63.3	10.451	6.615

Note: Seeds were collected from plants grown at four sites (Quincy, Citra, Balm, and Ft. Pierce) and germinated for 60 days at the UF/IFAS Indian River Research and Education Center in 2009. Germination conditions were under 12 hours of photoperiod, 25°C (day) and 15°C (night), in germination boxes placed in growth chambers. A maximum of 100 seeds were placed in a germination box. Only limited numbers of seeds were available for UF-T3 and UF-T4.

[a]Average fruit production per peduncle values were copied from Table 2.

[b]Female fertility index = average fruit production per peduncle × seed germination (%) /100. [c] "---" indicates that no seeds were produced and collected during the 32-week growing season for germination tests.

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Table 4. Hybridization potential of UF-T3 and UF-T4 with *Lantana depressa* as compared to 'Pink Caprice

Varieties	*L. depressa* flowers pollinated (no.)		*L. depressa* fruit set (%)			Seed germination (%)
	Fall 2009	Spring 2010	Fall 2009	Spring 2010	Average	
UF-T3	64	114	2.8	0	1.4	0
UF-T4	133	107	0	0	0	0
Pink Caprice	305	93	1.6	16.1	8.9	10.0