



Florida Department of Agriculture & Consumer Services  
**BOB CRAWFORD, Commissioner**

May 31, 1995

Please Respond To:  
 Division of Plant Industry  
 P.O. Box 147100/1911 SW 34 St.  
 Gainesville, Florida 32614-7100  
 Phone: 904-372-3505/Fax: 904-955-2300

Mr. William Metterhouse  
 Executive Director  
 Interstate Pest Control Compact (IPCC)  
 National Association of State  
 Departments of Agriculture (NASDA)  
 Suite 1020  
 1156 15th Street Northwest  
 Washington, D.C. 20005

Dear Bill,

Please find enclosed an interim report issued by Dr. David Patterson, USDA/ARS, regarding the Tropical Soda Apple Ecological Range Study he is conducting at the Duke University Phytotron. This report should serve to meet the first progress reporting requirement requested in the Cooperative Agreement between the IPCC and the Florida Department of Agriculture and Consumer Services (FDACS).

This progress report is late due to a delay in execution of the subcontract between Duke University and FDACS. However, the research project is now underway and on track for completion by December of 1995 at which time I will send you a final report on this segment of the tropical soda apple control investigations funded by the IPCC.

I have also requested a progress report from Dr. Jeff Mullahey covering the tropical soda apple control research underway at the University of Florida, Institute of Food and Agricultural Sciences. Upon receipt, I will forward a copy of this report to you to satisfy the progress reporting requirements on the remainder of the IPCC Cooperative Agreement funded projects. Please contact me if you have any questions.

Sincerely,

BOB CRAWFORD  
 COMMISSIONER OF AGRICULTURE

  
 Richard Gaskalla  
 Director

RG/bsm



ADM.

Botany Dept. Phytotron  
Duke Univ. Box 90340  
Durham, NC 27708-0340  
Phone (919) 660-7409  
FAX (919) 660-7425  
August 12, 1994

APR 10 1995

D.H.I.

Subject: Interim Report on Tropical Soda Apple-FDACS Contract 2522

To: Richard Gaskalla  
Director, Division of Plant Industry  
Florida Department of Agriculture and Consumer Services

From: David T. Patterson  
Plant Physiologist-USDA

Experiments are being conducted at the Duke University Phytotron to determine the response of tropical soda apple (TSA) vegetative growth and reproductive development to temperature and photoperiod. The objective of the study is to evaluate the environmental factors potentially limiting the distribution of TSA in the U. S. Preliminary results have been presented at the 1995 annual meeting of the Weed Science Society of America and at a meeting of the Southern Plant Board with USDA/APHIS/ARS. A copy of the abstract for the WSSA meeting is attached.

The results to date may be summarized as follows:

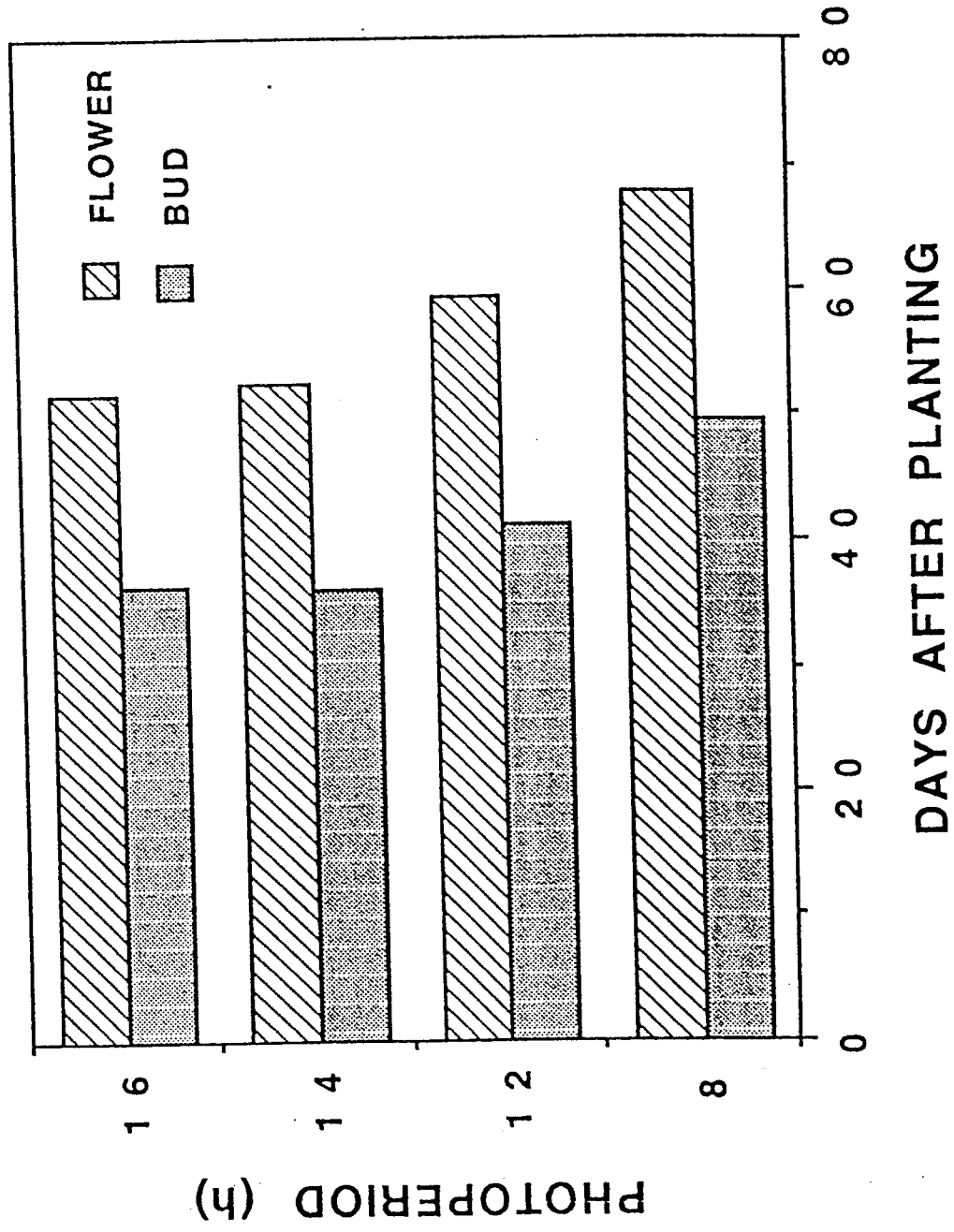
**PHOTOPERIOD:** There is no evidence that photoperiod or daylength will affect the potential range of TSA in the U. S. At favorable temperatures (30/25 C day/night) and photoperiods of 12 to 16 h, TSA produced flower buds within 35 to 40 days after germinated seeds were planted (Figure 1). Open flowers appeared after 50 to 60 days. Reproductive development was delayed about 7 days in a shorter 8 h photoperiod.

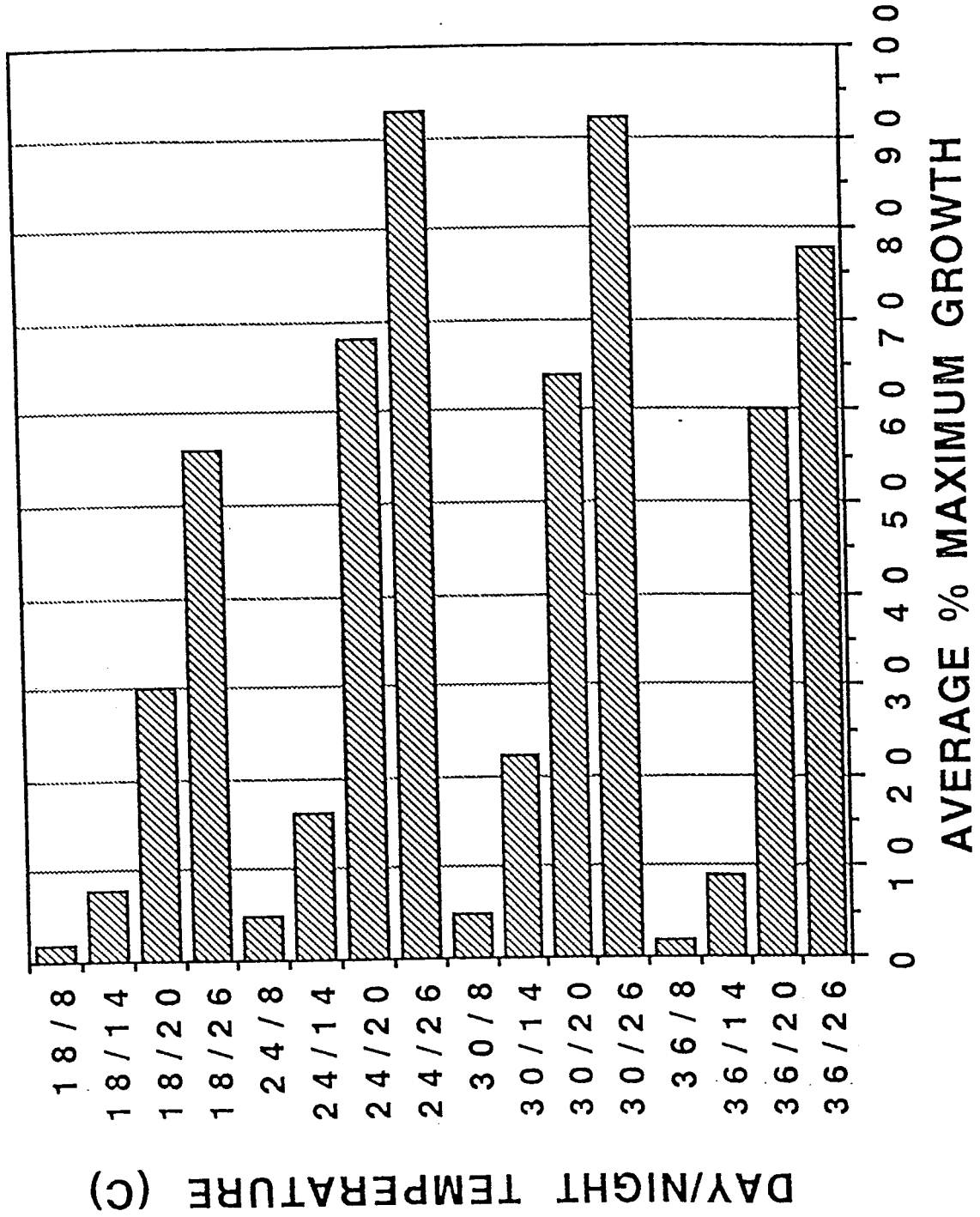
**TEMPERATURE:** TSA is very sensitive to temperature during vegetative growth (Figure 2). Night temperature affects growth more than day temperature. Even at temperatures unfavorable to vegetative growth, TSA eventually produced flowers (Figure 3). Time from planting to flowering ranged from 45 - 50 days at 24/26 or 30/26 C day/night to 105 days at 18/14 C day/night.

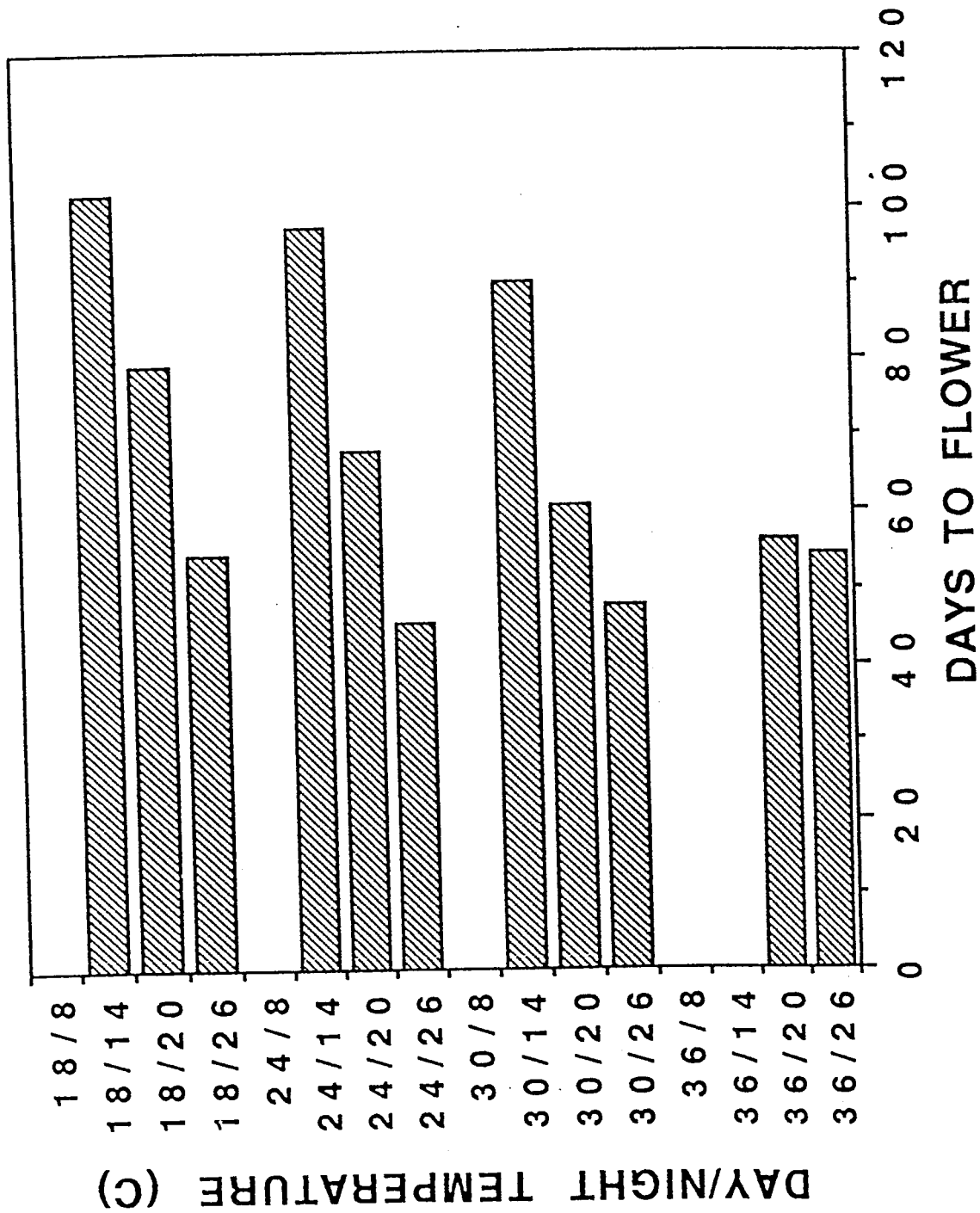
**PREDICTION OF GROWTH OF TSA AT DIVERSE U. S. SITES:** Based on the data of Figure 2, a regression equation was calculated to relate % maximum growth of TSA to effective day and night temperature (Figure 4). The regression equation then was used to estimate growth during the months of March through November at diverse sites throughout the southern U. S. These predictions are shown in Figures 5 through 9. Temperature conditions favorable for the growth of TSA occur throughout the Southeast and South, from the Carolinas through East Texas. Further west, available moisture may limit TSA.

**FUTURE WORK:** The photoperiod experiment is being repeated to confirm the results. A second temperature experiment is now underway to provide data to improve the precision of the estimates of TSA growth throughout the U. S. This experiment also will allow better definition of the influence of night temperature TSA growth.

**PRELIMINARY CONCLUSIONS:** TSA can be expected to continue its range expansion. Much of the South and Southeast probably are vulnerable to invasion by TSA.







## PREDICTION OF GROWTH OF TROPICAL SODA APPLE

-GREW PLANTS FOR 100 DAYS IN 16 DAY/NIGHT TEMPERATURE REGIMES RANGING FROM 15/8 C (58/46 F) TO 33/26 C (91/79 F).

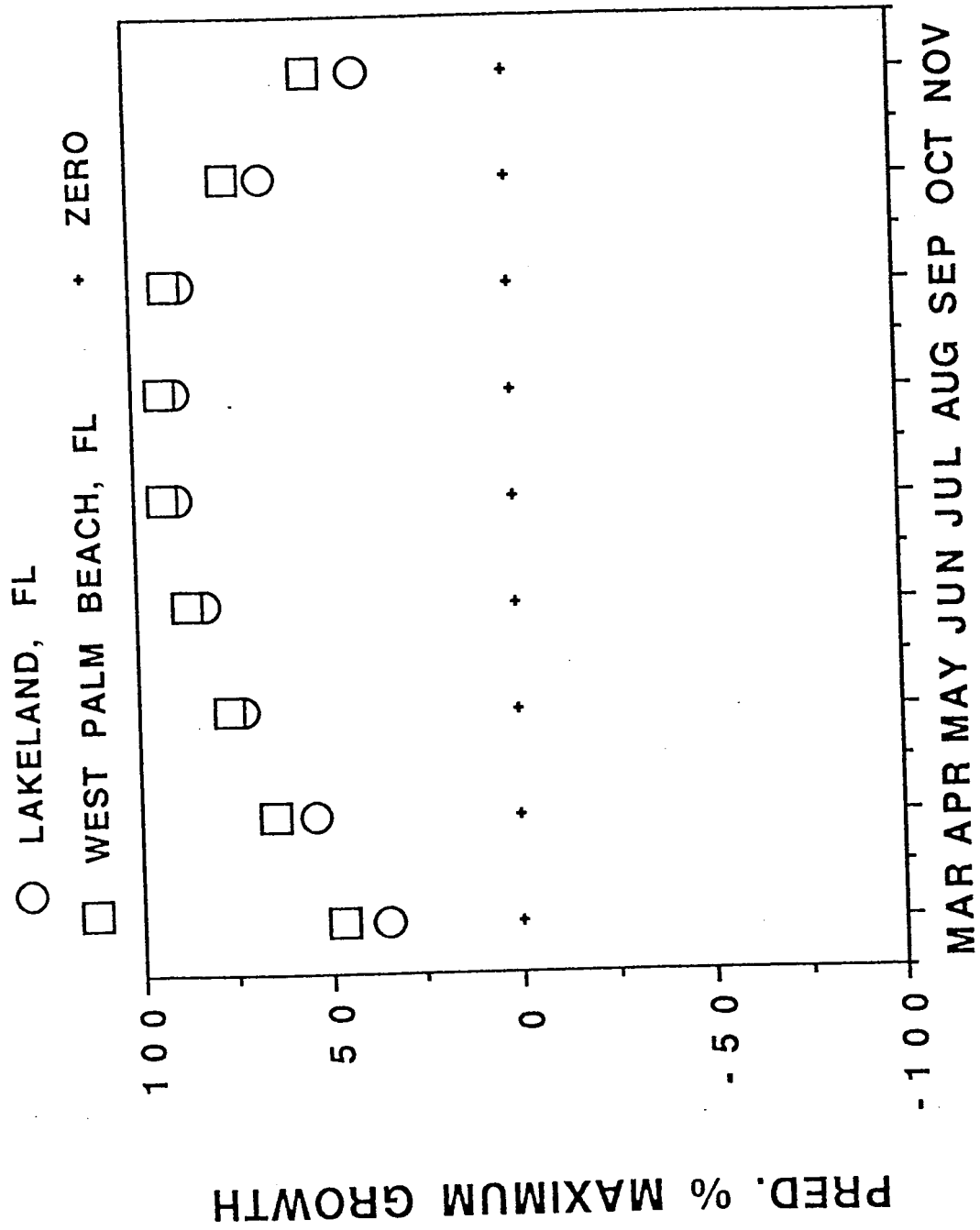
-DETERMINED GROWTH AT EACH TEMPERATURE AS A PERCENT OF THE MAXIMUM GROWTH ACHIEVED.

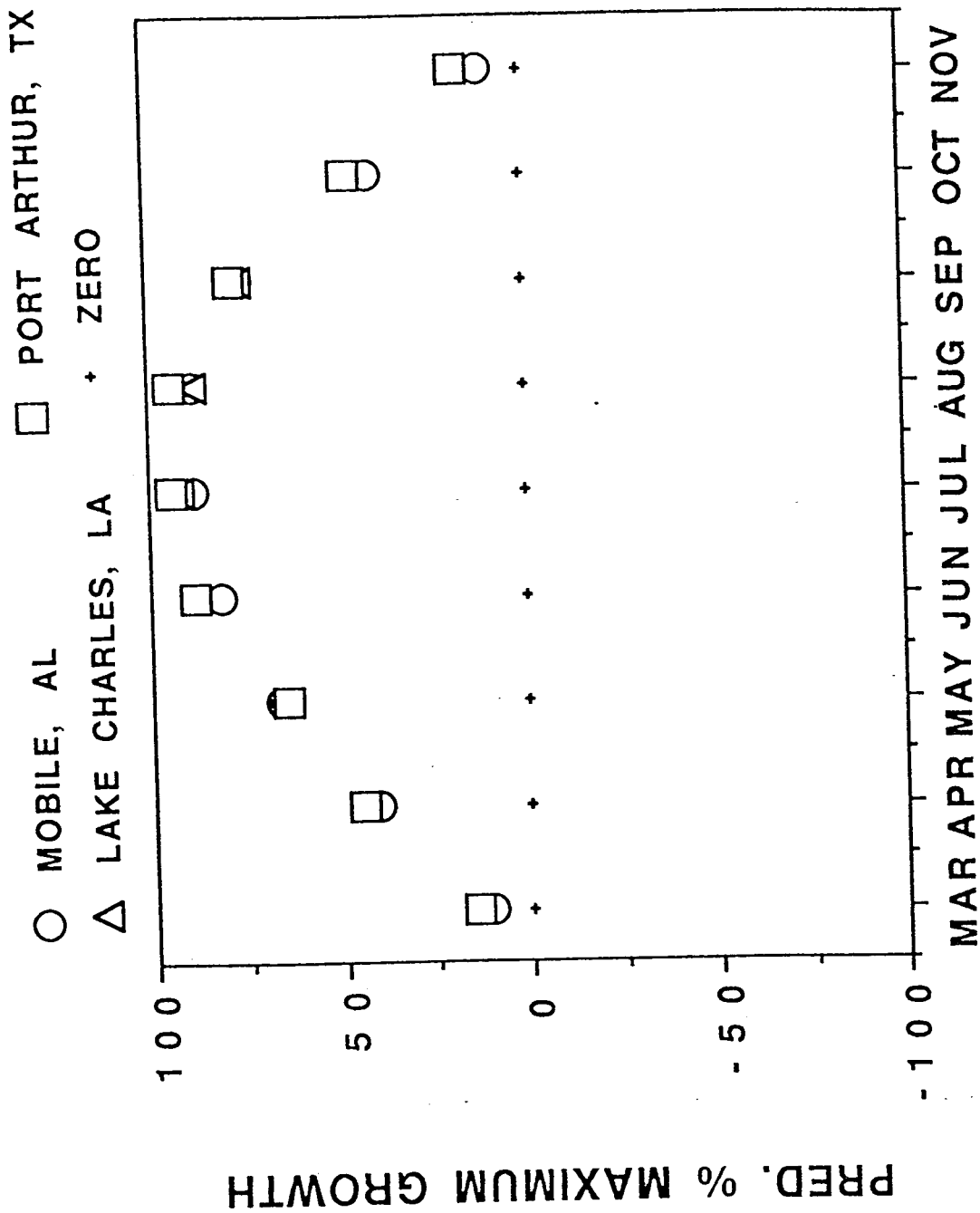
-CALCULATED A REGRESSION EQUATION RELATING PERCENT OF MAXIMUM GROWTH TO EFFECTIVE DAY AND NIGHT TEMPERATURE:

$$\% \text{ MAX} = 2.078(\text{EFF DAY C}) + 4.04(\text{EFF NIGHT C}) - 75.29$$

- THE REGRESSION EQUATION ACCOUNTED FOR 84 % OF THE OBSERVED VARIATION IN % MAXIMUM GROWTH ( $R^2 = 0.840$ ).

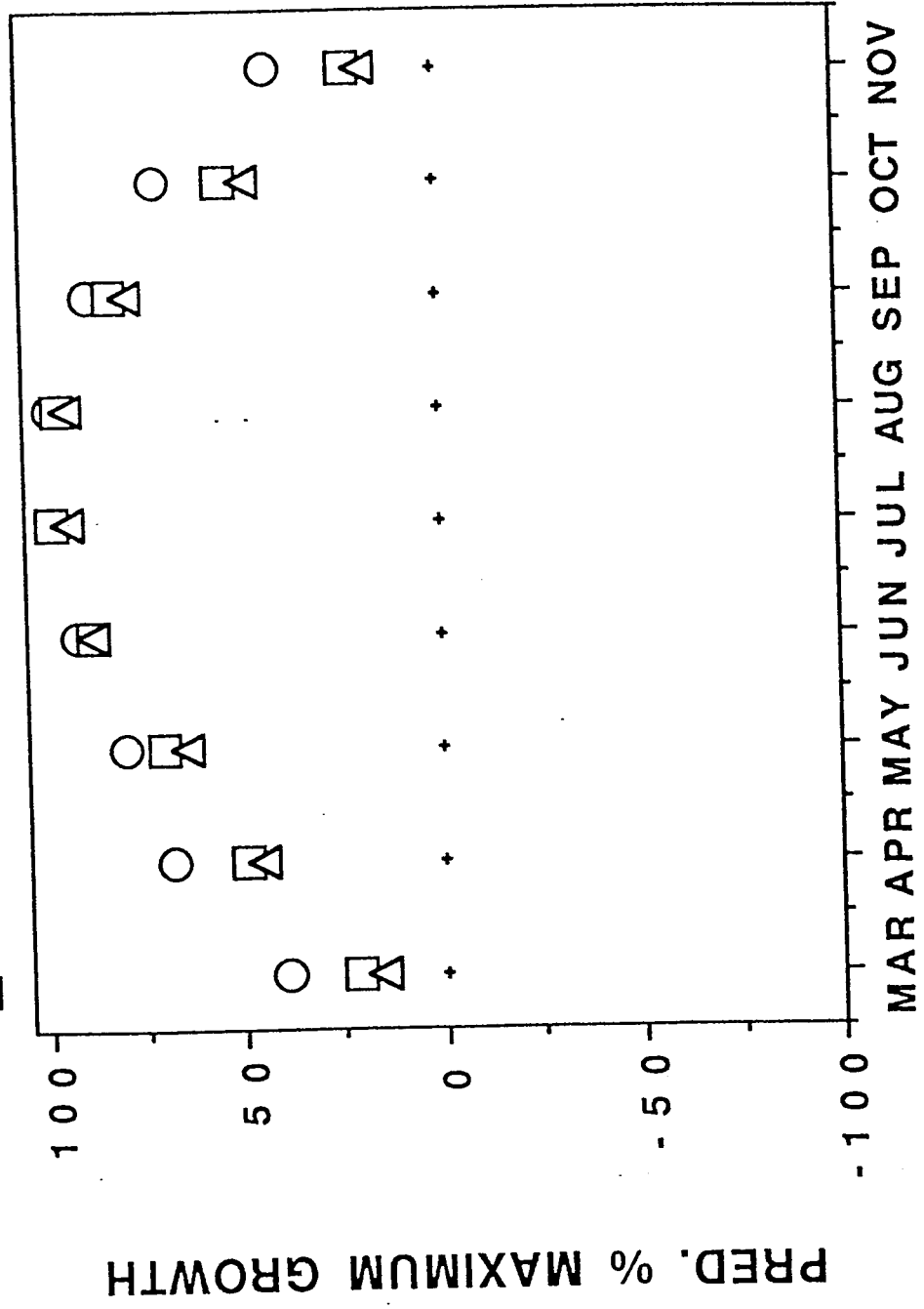
-USED THE REGRESSION EQUATION TO PREDICT % MAXIMUM GROWTH AT SELECTED LOCATIONS IN THE UNITED STATES FOR THE MONTHS OF MARCH THROUGH NOVEMBER, BASED ON THE AVERAGE EFFECTIVE DAY AND NIGHT TEMPERATURE FOR EACH MONTH AT EACH LOCATION.



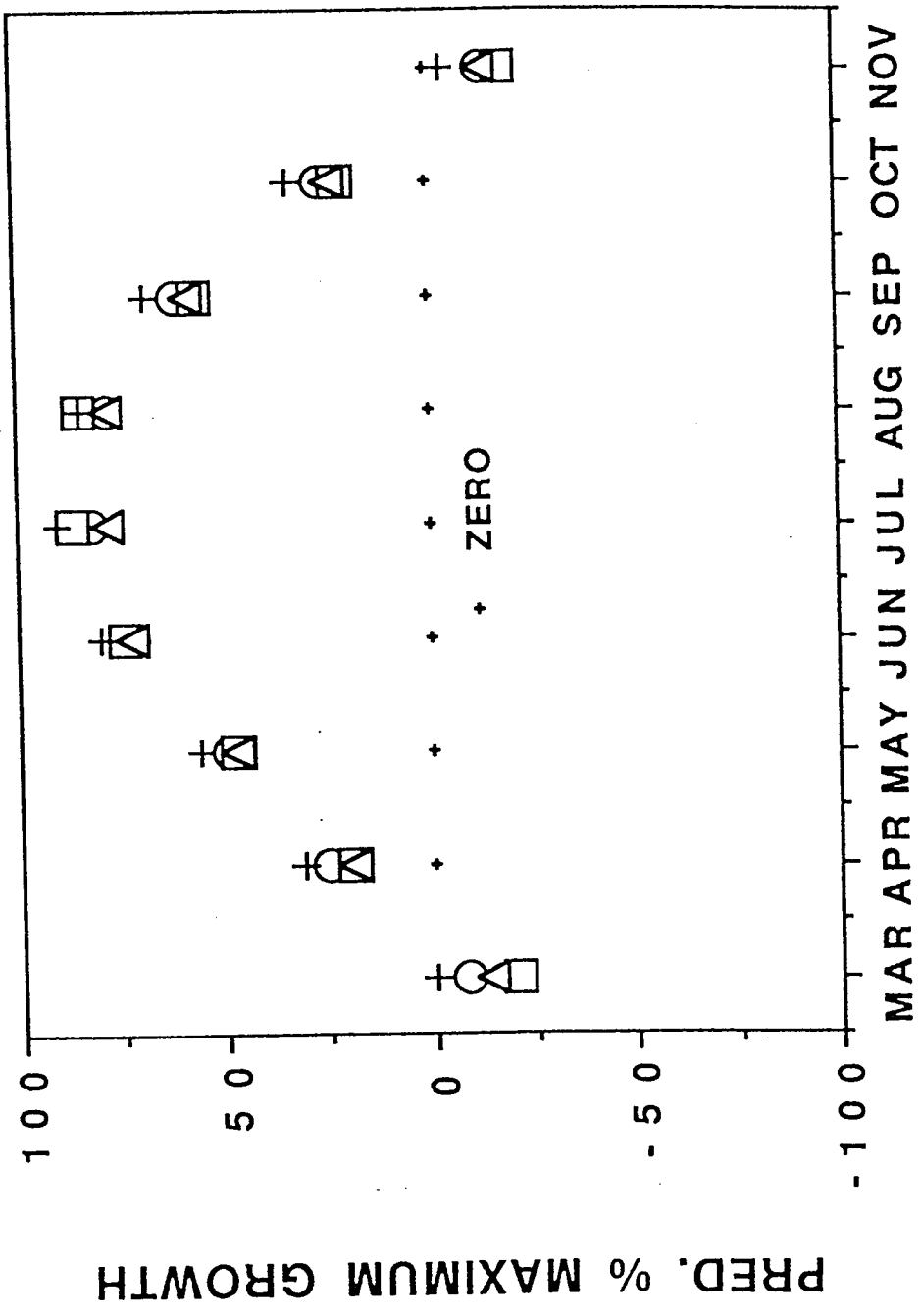


○ BROWNSVILLE, TX    △ PORT ARTHUR, TX

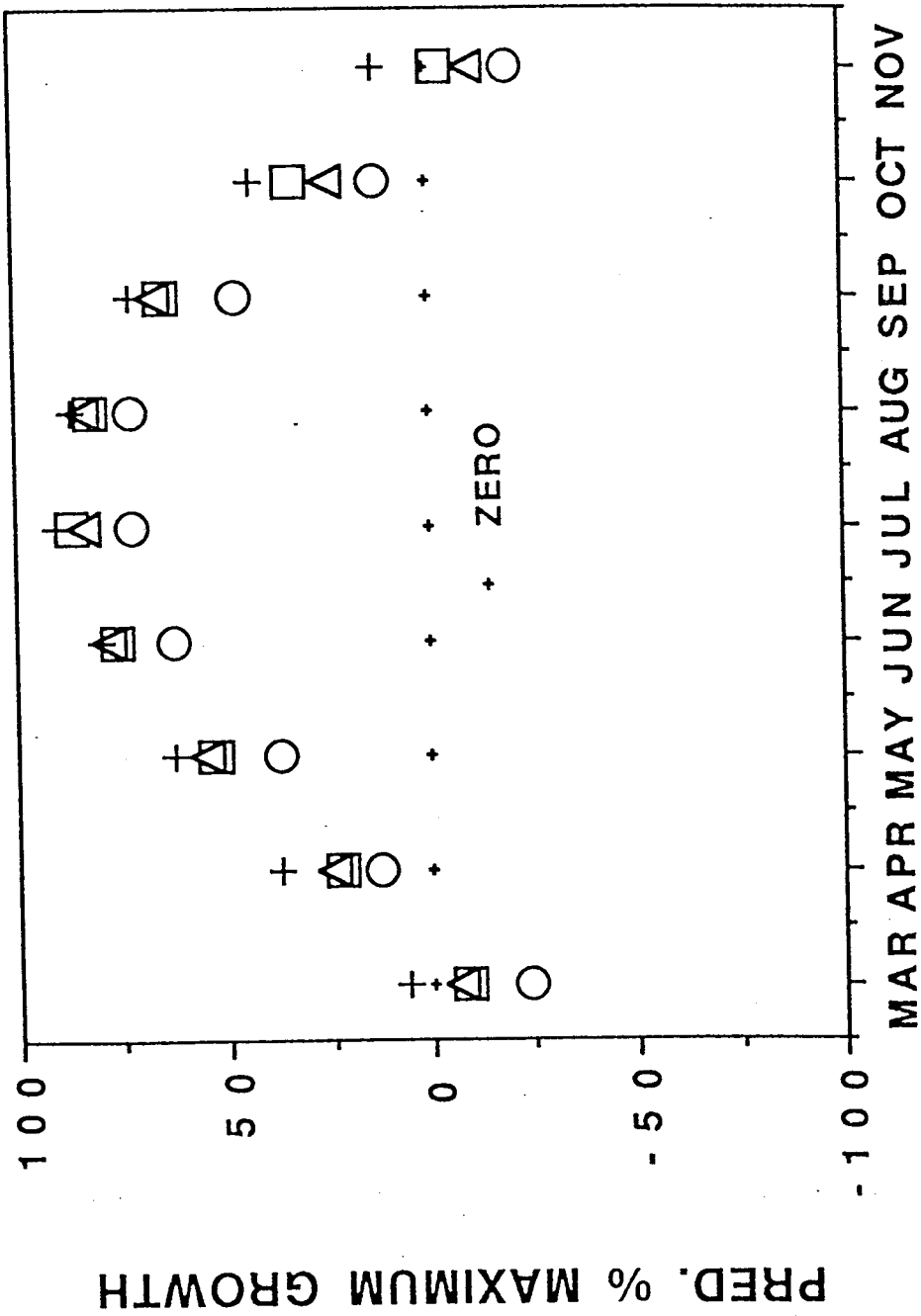
□ HOUSTON, TX    + ZERO



△ ATHENS, GA    + JACKSON, MS  
 ○ BIRMINGHAM, AL    □ LITTLE ROCK, AR



○ RALEIGH, NC    △ COLUMBIA, SC  
 □ WILMINGTON, NC    + CHARLESTON, SC





Florida Department of Agriculture & Consumer Services  
BOB CRAWFORD, Commissioner

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Division of Plant Industry  
P.O. Box 147100/1911 SW 34 St.  
Gainesville, Florida 32614-7100  
Phone: 904-372-3505/Fax: 904-955-2300

July 17, 1995

Mr. William Metterhouse  
Executive Director  
Interstate Pest Control Compact  
National Association of State  
Departments of Agriculture  
Suite 1020  
1156 15th Street Northwest  
Washington, D.C. 20005

Dear Bill,

Please find enclosed with this letter an interim report issued by Dr. Jeff Mullahey, Associate Professor, Range Science, Institute of Food and Agricultural Sciences, University of Florida, covering the control investigations underway for tropical soda apple. This report serves as the first progress report required under the Cooperative Agreement between the IPCC and the Florida Department of Agriculture and Consumer Services.

This progress report fulfills the first year reporting under the cooperative agreement as the ecological range of tropical soda apple interim report from Dr. David Patterson has been previously submitted (May 31, 1995). Please advise if you have any questions.

Sincerely,

BOB CRAWFORD  
COMMISSIONER OF AGRICULTURE

A handwritten signature in cursive script, appearing to read "Richard Gaskalla".

Richard Gaskalla  
Director

RG/bsm

xc: Mr. Doug Hadlock, letter only



Institute of Food and Agricultural Sciences  
Southwest Florida Research and Education Center

PO Drawer 5127  
Immokalee, FL 33934  
Tel. (813) 657-5221  
Fax (813) 657-5224

July 14, 1995

Mr. Richard Gaskalla, Director  
Division of Plant Industry, FDACS  
P.O. Box 147100/1911 SW 34 St.  
Gainesville, FL 32614-7100

ADM.

JUL 17 1995

D.P.I.

Dear Richard:

Per the contractual services agreement for FDACS Contract #2572 which involves research on tropical soda apple (*Solanum viarum*), enclosed is the first progress report covering projects funded by this contract. Project summary reports involve research in the areas of chemical control, reproductive physiology, survivability of tropical soda apple (TSA) in the rumen, and biological control. A second progress report will be sent by December 1995. If you need additional information please contact me.

Sincerely,

J. Jeffrey Mullahey,  
Associate Professor, Range Science

## Effect of rate and season of application of Remedy on tropical soda apple control (Hendry Co., 1993-94).

J. Jeffrey Mullahey and P. Mislevy, Univ Florida, IFAS

### SPRING APPLICATION

Treatment	Control (%) of mowed TSA plants			Control (%) of non-mowed TSA plants		
	30d	60d	90d	30d	60d	90d
1. 1 pt Remedy	51	70	55	23	12	12
2. 2 pt Remedy	69	60	50	53	25	25
3. 3 pt Remedy	81	61	61	82	63	39
4. Check	0	0	0	0	0	0
LSD (0.05)	26	53	54	29	37	44

Mowed on Feb. 22, 1993 and sprayed on June 9, 1993

### FALL APPLICATION

Treatment	Control (%) of mowed TSA plants			Control (%) of non-mowed TSA plants		
	30d	60d	90d	30d	60d	90d
1. 1 pt Remedy	37	96	96	41	75	66
2. 2 pt Remedy	52	85	97	46	81	91
3. 3 pt Remedy	61	92	97	54	86	87
4. Check	0	13	4	17	26	16
LSD (0.05)	32	27	8	17	19	28

Mowed on Oct. 1, 1993 and sprayed on Nov. 12, 1993

#### Comments:

In the spring of 1993, we had a frost (4-21-93) the day we were to spray. We waited 6 weeks for the TSA plants to recover before spraying. The plants did not appear to be normal, there was abnormal leaf pattern, color, heights, etc. We had to spray because plants were in the first flower stage. I feel that the abnormal plant development negatively affected the efficacy of Remedy. Our fall control was excellent, even on non-mowed plants. This study is currently being repeated.

# Effect of cultural practices and herbicides on control of tropical soda apple (Hendry Co., 1993-94)

J. Jeffrey Mullahey and P. Mislevy, Univ. of Florida, IFAS

Herbicide Treatment	Cultural Practice	Control (%)	Total Grass Cover (%)		TSA ground cover (%)
		TSA Plants	0d	90d	365d
<b>Mowing</b>					
1.	Remedy 1 lb/A alone	99	71	62	5
2.	Remedy 1 lb/A + Karmex 2 lb/A	99	71	73	11
3.	Remedy 1 lb/A + Arsenal 8 oz/A	97	66	26	4
4.	Karmex 2 lb/A alone	99	59	70	5
5.	Arsenal 8 oz. alone	100	69	22	2
6.	Remedy 0.5 lb/A + 0.5 lb/A	100	65	64	7
7.	Remedy 1.0 lb/A + 2 qt. Hi-dep	100	78	83	9
8.	Control	77	58	64	6
<b>Chopping</b>					
1.	Remedy 1 lb/A alone	97	63	64	7
2.	Remedy 1 lb/A + Karmex 2 lb/A	97	63	65	8
3.	Remedy 1 lb/A + Arsenal 8 oz/A	100	64	34	0
4.	Karmex 2 lb/A alone	97	58	69	5
5.	Arsenal 8 oz. alone	92	67	24	0
6.	Remedy 0.5 lb/A + 0.5 lb/A	89	62	76	3
7.	Remedy 1.0 lb/A + 2 qt. Hi-dep	98	78	85	3
8.	Control	68	73	92	21
<b>Check</b>					
1.	Remedy 1 lb/A alone	60	66	66	7
2.	Remedy 1 lb/A + Karmex 2 lb/A	59	55	45	10
3.	Remedy 1 lb/A + Arsenal 8 oz/A	81	47	16	5
4.	Karmex 2 lb/A alone	43	61	61	31
5.	Arsenal 8 oz. alone	88	55	16	9
6.	Remedy 0.5 lb/A + 0.5 lb/A	56	43	42	5
7.	Remedy 1.0 lb/A + 2 qt. Hi-dep	71	34	45	15
8.	Control	46	39	36	34

Mowed and chopped on Sept. 3, 1993, sprayed on Oct. 22, 1993

Comments: Herbicide control was higher when TSA plants were mowed or chopped prior to spraying. TSA control with a herbicide ranged from 90-100% when combined with a cultural practice. However, most treatments had some TSA ground cover 1 year after application. A follow-up spot control program would be necessary. Mowing (64%) and chopping (92%) greatly increased grass ground

cover (90 d) compared to the control (36%). Grass ground cover (90 d), across all herbicide treatments, was higher from mowing (57%) or chopping (59%) compared to the check (41%). Mow TSA before spraying with a herbicide to improve chemical control and increase grass growth.

Effect of spot spraying various rates of Remedy on control of TSA in an oak hammock (Hendry Co., 1994-95).

Jeff Mullahey, University of Florida, IFAS

Objective: to determine the effect of rate of Remedy on control of TSA in hammock areas, and to determine the number of herbicide applications needed to eradicate TSA from the hammock area.

Methods: sprayed 7 rates (0, 0.25, 0.5, 1, 1.5, 2, and 3%) of Remedy herbicide on mature TSA plants in an oak hammock on August 28, 1994. Plot size is 6' x 20' with 4 replications. Total number of TSA plants per plot were recorded prior to spraying and then at 30, 60, 90, 150, 210, 270, 330 and 365 days. Percent control of TSA is calculated based on the number of TSA plants at day 0.

Treatment	Control (%) of TSA Plants		
	30	60	90
Check	21	25	42
0.25% Remedy	53	100	100
0.50% Remedy	85	98	100
1.00% Remedy	100	100	100
1.50% Remedy	100	100	100
2.00% Remedy	100	100	100
3.00% Remedy	100	98	100

Preliminary results indicate that TSA plants in shaded areas like oak hammocks are more susceptible to Remedy herbicide. Apparently, lower rates will successfully control TSA in hammocks compared to TSA plants in pastures. We currently recommend a 1% Remedy solution in pastures.

Using a color dye with the Remedy is helpful to insure that all plants are sprayed. Repeated herbicide applications will be necessary because of new plants from TSA seed. This study will be repeated during 1995.

Experiment title: Mow-double spray study.

Faculty participants: P. Mislevy and J.J. Mullahey

**Approach:** The purpose of this experiment is to determine the influence of single and double herbicide applications at 0, 0.5, and 1.0 lb/A active Triclopyr (Remedy®) on mowed and non-mowed tropical soda apple control. Initial herbicide application was applied 60 d after mowing followed by a second application 30 d later.

Percentage ground cover (GC) of TSA photosynthetic area of adult plants and seedlings were determined at the time of herbicide application and on 30 d intervals.

**Results:** Influence of herbicide rate, application (single or double), and mowing on TSA control after 120 d.

Remedy treatment	TSA			
	Non-mow	Mow	Non-mow	Mow
lb/application	-----adult plants, % control----		-----seedlings, % GC-----	
0.5	36	84	<1	<1
0.5 + 0.5	70	94	1	1
1.0	58	81	<1	<1
1.0 + 1.0	60	83	<1	<1
Control	0	0		

Data indicates mowing plants to a 3 in. stubble will require 50 to 60 d of regrowth before plants flower.

Seedlings require about 120 d growth from germination before plants develop flowers.

**Experiment title:** Clipping spray study

**Faculty participants:** P. Mislevy and J.J. Mullahey

**Approach:** The purpose of this experiment is to determine the influence of single and multiple (3) TSA mowings followed by herbicide applications on TSA control. Mature tropical soda apple plants were mowed 1, 2, or 3 times to a 3 in. stubble at 60 d intervals and sprayed with 0, 0.5, and 1.0 lb/A of Triclopyr (Remedy®).

Percentage adult TSA control and number of seedlings developed following clipping alone and with various herbicide treatments.

**Results:** A single clipping of adult TSA plants followed by herbicide treatment after 60 d regrowth resulted in 95 and 93% control from 0.5 and 1.0 lb/A Remedy®, respectively after 180 d. Clipping plants twice at 60 d intervals followed by herbicide treatment resulted in 98 and 100% control from 0.5 and 1.0 lb/A Remedy®, respectively. Clipping TSA plants 3 times at 60 d intervals followed by herbicide treatment resulted in 100% control for both the 0.5 and 1.0 lb/A Remedy® treatment. Seedling development from all three clipping-herbicide treatments was about zero after 180 d. Three clippings alone to a 3 in. stubble, at 60 d intervals with no herbicide, resulted in 80% TSA control.

Project Title: Reproductive physiology of tropical soda apple

Objective: Determine the effect of environmental factors on germination of tropical soda apple.

Investigators: R. U. Akanda, J.J. Mullahey, and D.G. Shilling

Numerous laboratory and greenhouse studies have been initiated to study the effect of light, temperature, and water on germination of TSA. In addition, seed dormancy is being investigated. Results to date are included in the following graph.

# Factors Affecting Germination of Tropical Soda Apple (*Solanum viarum*)

R. U. Akanda, J. J. Mullahey, and D. Shilling

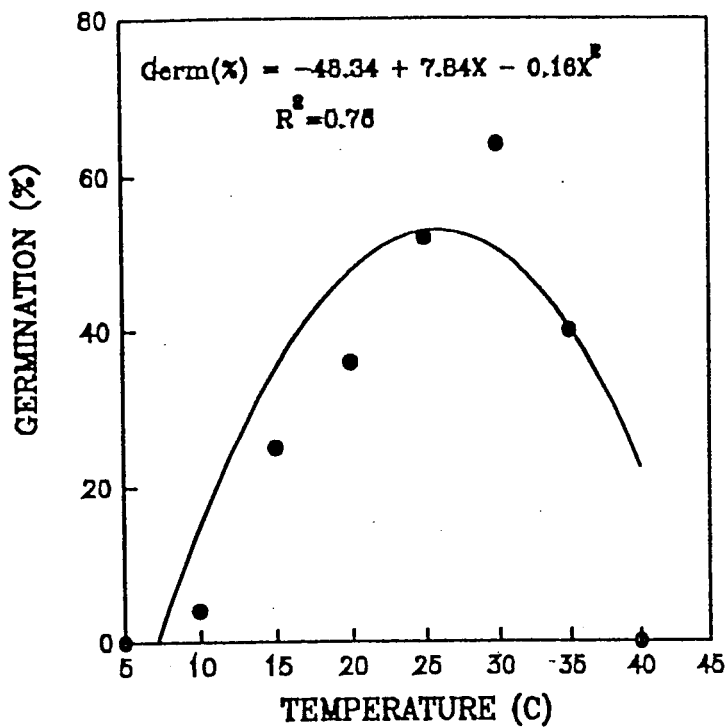


Fig. Effect of temperature (C) On germination of tropical soda apple.

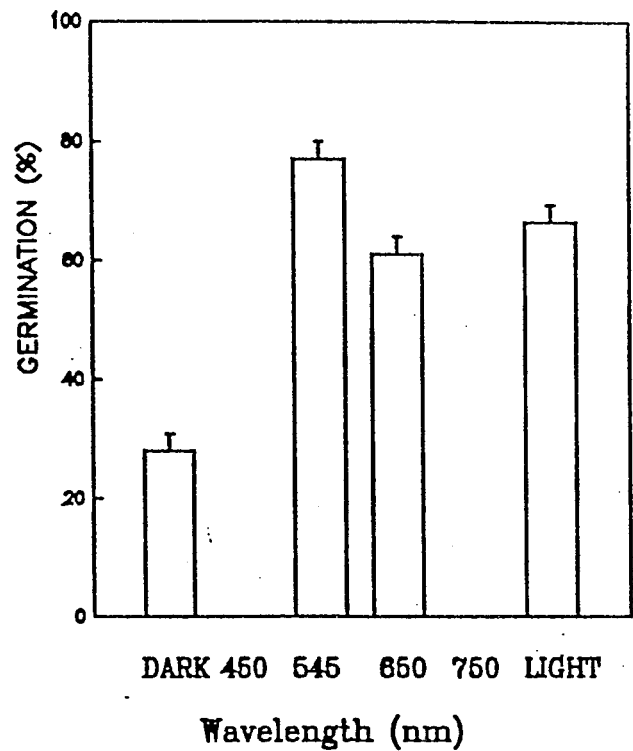


Fig. Effect of light and light quality on germination of TSA. LSD (0.05).

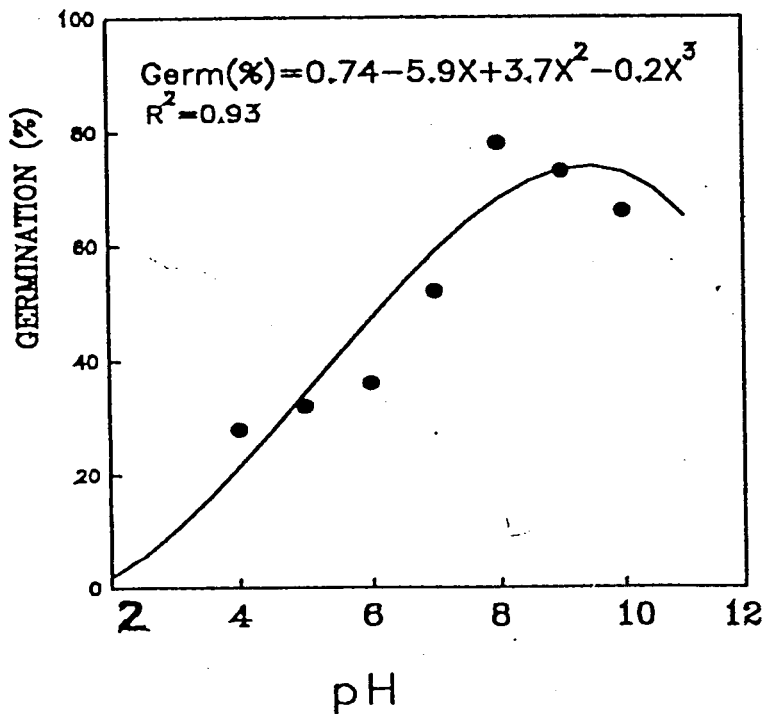


Fig. Effect of pH on germination of TSA

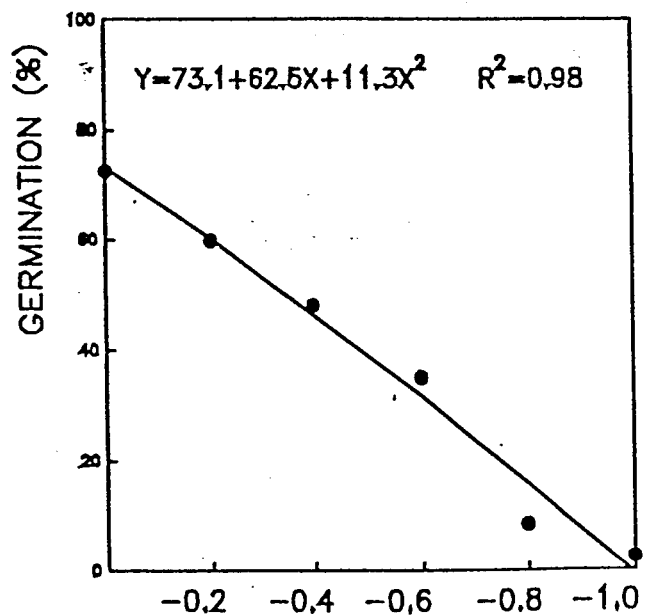


Fig. Effect of water stress (MPa) on germination of TSA at 30/20 C.

# TROPICAL SODA APPLE SEED SURVIVABILITY IN CATTLE

Bill Brown, Jeff Mullahey, and Paul Mislevy  
University of Florida, Institute of Food and Agricultural Sciences,  
Ona and SWFREC

- OBJECTIVES:
- 1) To determine tropical soda apple (TSA) seed survivability in the rumen
  - 2) To determine rumen retention time, rate of passage, and seed survivability of TSA seed collected in feces.
  - 3) To develop recommendations for how long cattle need to be held, prior to movement, to insure that cattle are not contaminated with viable TSA seed.

## MATERIALS AND METHODS:

### Phase 1- Seed survivability in the Rumen: A Laboratory Technique

Tropical soda apple seed were placed in the rumen fluid containing in-vitro digestion tubes for 24-144 hours. Seed were removed every 24 hours and after the last sampling period (144 hours), seed germination was determined for all the seed in an incubator. Experimental design was a randomized complete block with five replications containing 100 seed per tube (30 tubes per experiment). The experiment was repeated twice (see next figure for results).

### Phase 2- Rumen retention time, rate of passage, and seed survivability

Approximately 300,000 to 400,000 TSA seed will have to be collected to conduct the experiment. Place 30,000 TSA seed in the rumen cannulated animal and collect feces for up to 14 days. Seed will be placed in the rumen at 7:00 a.m. on day one and feces collected 24 hours. A marker will be fed daily to estimate total fecal production. With each sampling event, feces will be collected and sieved over a 5 gallon bucket. Samples will then be placed in 250 ml beakers, water added, and the seed will be decanted. Remaining solids will be placed on filter paper to remove seed. Seed will be germinated in an incubator.

Approximately 5 rumen cannulated steers will be used for the study. The experiment will be repeated at least twice. Rate of passage and seed survivability will be calculated. Restricted forage diet will consist of bahia or similar quality hay. During the experiment, 4 temporary laborers will be needed to harvest TSA fruit and extract seed, assist in fecal collection and seed separation. In addition to the hourly labor help, a person who supervises the project will have to be hired. All seed germination work will be worked at the AREC in Immokalee.

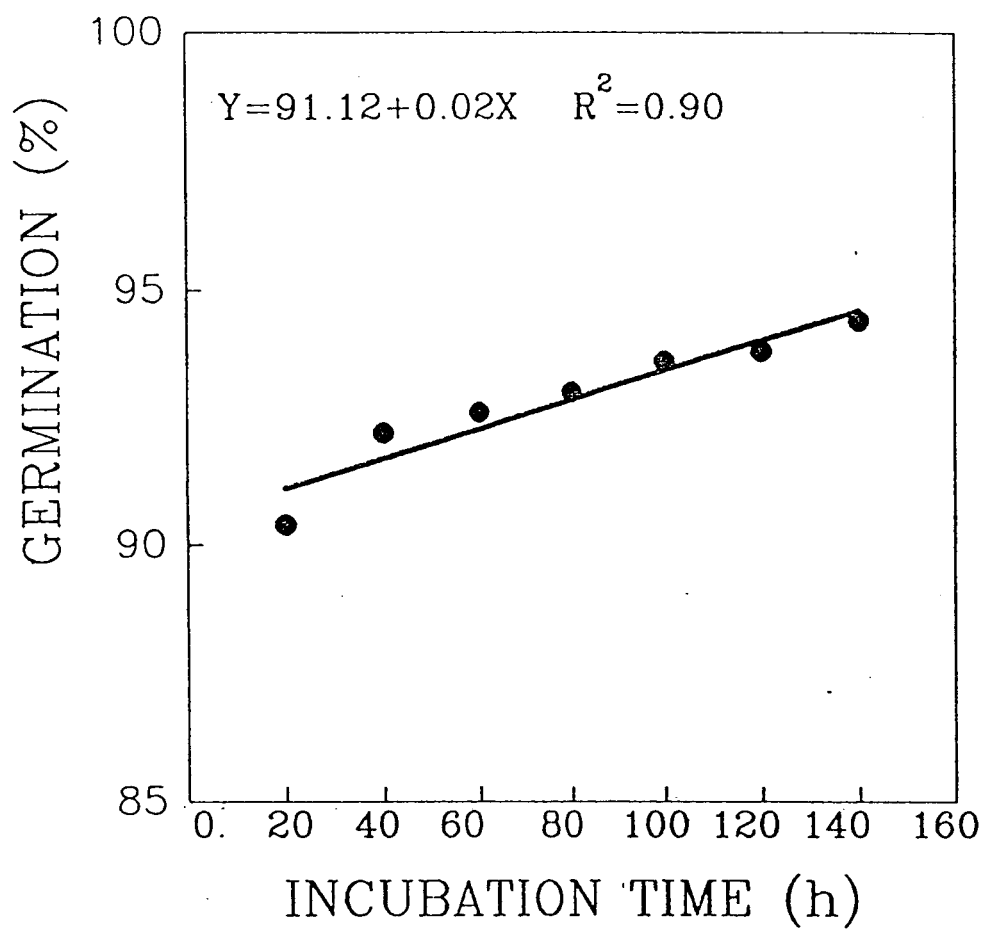


Fig. TSA seed germination as affected by time of digestion.

\*R. U. Akanda, J. J. Mullahey, and W. F. Brown. University of Florida, SWFREC, Immokalee, and AREC, Ona.

# BIOLOGICAL CONTROL OF TROPICAL SODA APPLE

Submitted by

Robinson A. Pitelli, Weed Ecology and Control, Faculty of Agriculture and Veterinary Sciences,  
University of the State of Sao Paulo, Jaboticabal, SP, BRAZIL

Dale H. Habeck, Entomology & Nematology Department, University of Florida, Gainesville, FL 32611  
and

R. Charudattan, Plant Pathology Department, University of Florida, Gainesville, FL 32611

Tropical soda apple (*Solanum viarum*) is native to southern Brazil, Argentina, Paraguay, and Uruguay. In its native range, tropical soda apple is not considered a weed, and our observations have suggested that environmental and biotic factors may be involved in relegating the plant to be a minor status in the local flora. Our goal is to find suitable classical and inundative biological control agents through surveys in Brazil and Florida and to identify environmental and biotic factors that might be limiting to the productivity and spread of tropical soda apple in southern Brazil. The specific objectives of the project are:

- I. To determine the distribution and ecology of tropical soda apple in southern Brazil.
- II. To survey for insects and pathogens attacking tropical soda apple in Brazil and Florida.
- III. To determine the identity, biology, and specificity of potentially useful agents.
- IV. To assess the effects of selected organisms on tropical soda apple under controlled conditions.

We are making good progress on all of the objectives as follows.

**Surveys:** R. Charudattan made a 3-week trip to Brazil in October 1994 to survey for and collect pathogens of tropical soda apple and other weeds of importance to Florida. In addition, several surveys were made in Florida in areas where tropical soda apple is widely distributed. Approximately 62 cultures were isolated from these surveys and are being tested in Gainesville to identify prospective biocontrol agents. Included in this group are species of *Alternaria*, *Colletotrichum*, *Curvularia*, *Fusarium*, *Helminthosporium*, *Phomopsis*, and *Verticillium*. The fungi were tested for pathogenicity by spraying tropical soda apple seedlings with spores or mycelial fragments ( $10^6$  units/ml of 0.05% solution of Triton X-100) until runoff. Also screened were five strains of *Pseudomonas solanacearum*, the causal agent of the bacterial wilt of several solanaceous plants, and five strains of *P. syringae* pathovar *tabaci*, the causal agent of the wildfire disease of tobacco. The bacteria were tested by applying suspensions of cells ( $10^8$  cfu) in 0.25% Silvet L-77 (polyalkyleneoxide modified heptamethyltrisiloxane) as foliar sprays till runoff or by injecting directly into stems ( $10^8$  cfu in 0.1 M phosphate buffer) at four leaf axils per plant. The test plants were raised from seeds, and seedlings were transplanted into a commercial potting mix in 10-cm diam pots; the seedlings were 10 to 15 cm tall (4 to 6 leaves; 45 days postgermination) when inoculated. The fungal-sprayed plants were incubated in darkness for a minimum of 18 h at 100% relative humidity before transferring to the greenhouse; the bacterial-sprayed plants were not subjected to the humidity-treatment and were inoculated and kept in the greenhouse. The experiments were replicated and included appropriate controls. None of the fungi produced any disease; therefore, all were regarded to be nonpathogenic to tropical soda apple. The *P. syringae* pathovar *tabaci* stains were also nonpathogenic when sprayed or injected. The foliar application of *P. solanacearum* strains did not also produce any disease. However, two of the five *P. solanacearum* strains, both originally from tomato, were highly pathogenic when injected into tropical soda apple stem and induced a typical wilt disease characterized by

massive foliar chlorosis and necrosis followed by plant death. The disease developed four days after bacterial injection, and 100% of the inoculated seedlings were killed within a week. Koch's postulates have been fulfilled, confirming this first record of susceptibility of *S. viarum* to *P. solanacearum*. The potential benefits from the use of this pathogen must be weighed carefully against possible increased risk to solanaceous vegetable crops. Therefore, further work in progress to characterize the *P. solanacearum*-tropical soda apple system will include a thorough risk analysis.

Host range of *P. solanacearum* towards 31 plant species in Solanaceae, including five cultivars of tomato and two cultivars of pepper was determined. Five strains of the pathogen were tested by injecting bacterial cell suspensions into stems of greenhouse-grown seedlings. Plants were rated for symptoms of wilting and death, partial shoot kill, or no reaction using a rating system as indicated under Table 1. The results indicated that the strains differed in their specificity to different species and cultivars, confirming the possibility finding strains that may be restricted in host range to tropical soda apple (Table 1).

Dr. Julio Medal, a postdoctoral associate of D.H. Habeck, made six trips to Brazil in 1994-95 to collect insects associated with tropical soda apple. Several potential biological control insects were found that may prove to be useful. Since we have no permit to bring tropical soda apple insects into Florida quarantine, all observations have been in the field in Brazil and Florida. In Florida, the only insects commonly occurring on tropical soda apple are the tobacco hornworm, the tobacco budworm, and the Colorado potato beetle. Several leaf-feeding insects as well as a fruit-feeding caterpillar have been found in Brazil and should receive further study. Efforts are underway to secure adequate funding for this work and to locate Brazilian cooperators.

From surveys conducted in 1994-95, Dr. Robinson Pitelli has established that tropical soda apple is widespread in southeastern Brazil, but populations of this plant are under strong environmental selection pressure. Often the plants are scattered in distribution, with only a few plants in each location and with the populations typically separated by great distances. Frequently, the plants are small, with few small leaves, and subject to attacks by a wide variety of pathogens and insects, especially by leaf-eating and sucking insects.

To understand the natural control of tropical soda apple populations, a fruit collection was made in several sites in Brazil (in Taiuva, SP; Taiacu, SP; Divinolândia, SP; and Cascavel, PR) and in Paraguay (Capitan Miranda). All fruits on plants found in a location were collected, from about 200 plants in all four locations.

When only healthy fruits were considered, it was possible to estimate the number of seeds based on fruit diameter. Fruits showing symptoms of fruit-borer damage were examined; using the value of fruit diameter, it was possible to estimate the number of unblemished seeds that fruit should have. By matching this number with actual number of apparently healthy seeds, it was possible to estimate the influence of fruit-borer damage on seed production. It was not possible to determine how many seeds were damaged directly by the insect or secondary attack of opportunistic microorganisms. The fruit borer was identified as *Neoleucinodes elegantalis*, an important pest of tomatoes.

From this data, it was possible to estimate that the damage caused by this insect, direct or indirectly, reduced seed production in tropical soda apple between 47% and 93%. It was also possible to say that this insect is one of the main factors regulating tropical soda apple populations and its expansion in Brazil.

In another experiment, 50 tropical soda apple seedlings were transplanted with 1 m x 1.5 m spacing and examined frequently to collect ripe fruits and to determine the plant's phenology in terms of fruit setting and seed release, and to analyze the damage by insects. At this time, the plants are completing the life cycle and the results are being monitored.

A greenhouse experiment was carried out to study the influence of soil pH on growth of tropical soda apple. Although, white-fly attack had partially hindered the plant growth, it was possible to estimate that plant response to soil pH is significant. However, this does not fully explain the plant's distribution in

Brazil. Apparently, tropical soda apple grows better in a pH range of 5.5 to 6.5. The plant response to phosphorus levels was inconsistent, probably due to a differential white-fly attack or differential plant susceptibility to the insect.

Two experiments were set up to study the growth and nutrient uptake of tropical soda apple. However, these experiments were rejected because of heavy white-fly damage.

There are some places, such as backyards and near cattle- management facilities, where the plant grows more vigorously and the insect attack is sparse. It is possible that the plant's growth is related to soil organic-matter content. This possibility will be investigated next.

In the coming year, experiments will be carried out under field conditions, where white-fly attack is minimal and chemical control is effective. Some facilities are being built to conduct these studies under semi-controlled conditions.

**Personnel:** In addition to the PIs named above, **Mr. James T. DeValerio**, Senior Biologist, Plant Pathology Department, University of Florida, **Dr. Julio Medal**, Postdoctoral Associate, Entomology & Nematology Department, University of Florida, and **Mr. Alexandre Bezutte** and **Mr. Ricardo Rossetto**, Faculty of Agriculture and Veterinary Sciences, University of the State of Sao Paulo, Jaboticabal, BRAZIL are involved in various aspects of this project. However, it should be noted that these individuals are supported by funds outside of this FDACS-DPI-sponsored project.

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Table 1. Host Range of *Pseudomonas solanacearum* Strains Screened Against Solaneceous Plants

Host		Cultivar	Host Reaction to Strain No.			
10Q	H2		UF #	W2	W4	10
<u>Capsicum annuum</u>		Pepper Sweet Bell	LS	R	R	M S
	R					
<u>Capsicum annuum</u>		Pepper Perrano	R	R	R	H S
	R					
<u>Lycopersicum esculentum</u>		Tomato Supersteak	HS	R	R	HS R
<u>Lycopersicum esculentum</u>		Tomato Manalucie	HS	R	R	HS R
<u>Lycopersicum esculentum</u>		Tomato Celebrity	HS	R	R	HS R
<u>Lycopersicum esculentum</u>		Tomato Bradley	HS		R	R HS
	R					
<u>Lycopersicum esculentum</u>		Tomato Betterboy	HS		R	R HS
	R					
<u>Solanum aculeatis</u>			13	R		
<u>Solanum americanum</u>			12			R
<u>Solanum anguivi</u>			11	R	LS	HS
<u>Solanum atropurpureum</u>			10			MS
<u>Solanum aviculare</u>			9	MS	LS	HS
<u>Solanum aviculare</u>			8	LS	LS	HS
<u>Solanum capsicoides</u>			7	LS	R	HS
<u>Solanum caripense</u>			6	LS		HS
<u>Solanum ciliatum</u>			5	MS		
<u>Solanum elaeagnifolium</u>			4	MS		HS
<u>Solanum ferox</u>			3	R		LS HS
<u>Solanum gilo</u>			2	R		
<u>Solanum gilo</u>			1	MS		LS HS
<u>Solanum incanum</u>			14	MS	R	HS
<u>Solanum incanum</u>			26	MS	R	HS
<u>Solanum laciniatum</u>			28	MS		HS
<u>Solanum laciniatum</u>			27	MS		HS
<u>Solanum linnaeanum</u>			30	MS	R	HS
<u>Solanum linnaeanum</u>			29	LS	LS	MS
<u>Solanum macrocarpon</u>			31	MS	LS	MS
<u>Solanum mammosum</u>			33			MS
<u>Solanum mammosum</u>			32	MS	R	MS
<u>Solanum melongena</u>			34	LS	LS	LS
<u>Solanum melongena</u>			35	MS		HS
<u>Solanum nigrum</u>			37	LS		R HS
<u>Solanum nigrum</u>			36	HS		R HS
<u>Solanum nodiflorum</u>			38			LS
<u>Solanum pseudocapsicum</u>			24	LS	R	HS
<u>Solanum quinquangulare</u>			25	MS		HS
<u>Solanum rostratum</u>			15	R	R	HS
<u>Solanum sessiliflorum</u>			16	LS		HS
<u>Solanum sisymbriifolium</u>			17	LS		HS
<u>Solanum sisymbriifolium</u>			18	R	R	HS
<u>Solanum spinosissimum</u>			19	MS	R	HS
<u>Solanum stramonifolium</u>			20	MS	R	HS
<u>Solanum suaveolens</u>			21	MS		MS
<u>Solanum suaveolens</u>			22	R		MS

R = resistant; LS = slightly susceptible; MS = moderately susceptible; HS = highly susceptible when inoculated by stem injection with the bacterial suspension.

## Tropical Soda Apple, *Solanum viarum* Dunal: The Plant from Hell <sup>1</sup> (SOLANACEAE)

Nancy C. Coile <sup>2</sup>

**INTRODUCTION:** *Solanum viarum* Dunal, tropical soda apple, has recently made its presence known in Florida. The plant is prickly as are many other *Solanum* spp., so why would *Solanum viarum* be called "the plant from hell." The presence of this weed near Devils Garden, Hendry County, led to this new appellation. Another connection with hell is the common name "tropical soda apple" which is "Sodom apple" in British-speaking areas. Sodom is the biblical city noted for its wickedness. *Solanum viarum* has become the dominant vegetation in vast areas of the pastures in Glades, Hendry and Highlands counties.

The earliest record in Florida was collected from Glades Co. in 1988 (University of Florida Herbarium [FLAS]). David W. Hall, who identified the FLAS specimen, believes that *Solanum viarum* has been present in Florida since 1981 or 1982 (personal communication). Mullahey (1993) estimated that *Solanum viarum* has infested over 150,000 acres in Florida. The acreage may be higher (Patrick Hogue, Institute of Food and Agricultural Sciences [IFAS], Extension-Agent Highlands Co., personal communication).



Figures 1-3. *Solanum viarum* Dunal. Fig. 1) Tropical soda apple; 2) Flowers; 3) Immature to mature fruit (Photography credit: Jeffrey W. Lotz).

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How has this species, which is native to Brazil and Argentina, become a problem in Florida so rapidly? There are about 413 seeds per fruit and 125 berries per plant with germination exceeding 75% (Mullahey 1993). Although cattle avoid eating the prickly vegetation, their long tongues can reach into the foliage to pluck off the fruits. Cattle are apparently good vectors for spreading the seed through defecation. *Solanum viarum* is also present in hammocks where cattle retreat to rest. It occurs in ditch banks, citrus groves, sugar cane fields, watermelon fields and along roadsides. Wildlife, such as raccoons, deer and feral pigs, apparently also spread the seed. Birds have not yet been observed feeding on the fruits and may not be vectors for spread.

**DISTRIBUTION:** Originally native to Argentina and Brazil, *Solanum viarum* has spread into other parts of South America, Africa, India, Nepal, Caribbean, Mexico and Florida. It is thought that most Florida counties south of Lake County have been infested by this pest plant. Herbarium specimens at Division of Plant Industry Herbarium (PIHG) document *Solanum viarum* in Osceola (W. J. Shirley B93-172), Polk (J. E. Lindsay B93-180), Hendry (Coile 5936, 5937), Highlands (Coile 5938, 5939) and Alachua (Coile 5947) counties. The latter county is north of Lake Co.

**DESCRIPTION:** *Solanum viarum* is an herbaceous perennial which can persist if winters are mild. Plants grown in good conditions may reach 2 m (6 feet) in height; usually the plants are about 1 m (3 feet) tall. The stems are sturdy and have scattered small, hooked prickles. Leaves are alternate, simple, lobed; to 20 cm (8 inches) long; to 15 cm (6 inches) wide; and covered with fine soft hairs which give a velvety sheen to the leaves (Fig. 1). Rigid, yellowish prickles up to 20 mm ( $\frac{3}{4}$  inch) are scattered along the midvein and the secondary veins on both surfaces of the leaf blade and are more concentrated on the petiole (leaf stalk). The flowers are in small terminal clusters. The calyx is five-lobed and has tiny prickles on the surface; corollas are white, with five, recurved petals; anthers are cream-colored and surround the single pistil (Fig. 2). Immature fruits are pale-green with dark-green veining (appear like a tiny striped watermelon). Mature fruits are a dull medium-yellow, leathery-skinned, about 2 to 3 cm (up to  $1\frac{1}{2}$  inches) across (Fig. 3). The pulp band is narrow, pale-green, mucilaginous and scented. Seeds are numerous, flat, bitter and mucilaginous.

**MAY BE CONFUSED WITH:** World-wide there are over 1400 species of *Solanum* (Mabberly 1987). In India, *S. viarum* has been confused with *S. khasianum* C.B. Clarke (Babu and Hepper 1978). In Florida, the prickly species are: *S. capsicoides* Allioni, *S. carolinense* L., *S. dimidiatum* Raf., *S. houstonii* Dunal, *S. rostratum* Dunal, *S. sisymbriifolium* Lam., *S. torvum* Sw. and *S. viarum* Dunal.

*Solanum capsicoides* may be listed as *S. aculeatissimum* Jacq. or as *S. ciliatum* Lam. in older references (Kartesz and Kartesz 1980). Common names are soda apple, cockroach berry, Devil's apple, love-apple and berenjena (Perkins and Payne 1978; Standley 1923). The distribution is Texas, southern U.S., Bermuda, West Indies and tropical America (Correll and Johnston 1970). The stems are densely covered with broad-based, hooked, yellowish prickles, in contrast to *S. viarum* which has scattered prickles. The fruits are persimmon-red while *S. viarum* has yellow fruits which are slightly larger. *Solanum capsicoides* may grow in the same pastures as *S. viarum*, but in comparatively small numbers.

*Solanum carolinense*, or horse-nettle, was originally native to the southeastern United States north to Virginia and Kentucky. It is now distributed north to Ontario and westward (Gleason and Cronquist 1991). This weed of disturbed areas has lavender to white flowers about 2 cm ( $\frac{3}{4}$  inch) wide. The prickles are not as long as those of *S. viarum*. Plants may reach 1 m (3 feet) in height, but are usually much shorter.

*Solanum dimidiatum*, originally of Kansas, Arkansas and Texas (Gleason and Cronquist 1991), has now spread to south Georgia and North Florida (Clewell 1985; Small 1933; Wunderlin 1982). Commonly called western horse-nettle, this species is distinguished by its purple corolla with a green eye. The fruit is pale yellow and the plant is clothed with stellate hairs (Correll and Johnston 1970).

*Solanum tampicense* (called *S. houstonii* in the earlier edition of this circular) is a newly discovered pest plant in Florida. Wunderlin *et al* (1993) note that *S. houstonii* Dunal is a homonym of the 1807 *S. houstonii* Martyn and is thus illegitimate. The common names for this species are Tampico soda apple and wetland soda apple. Standley (1923) uses the following common names: aijicon, huistomate, or huevo de gato.

*Solanum tampicense* is distributed from Mexico, West Indies, British Honduras (Gentry and Standley 1974) and now Florida. The leaves of *S. tampicense* differ markedly from *S. viarum*: (1) being more elongate (to 16 cm long) and narrower (2.2 to 5.5 cm) wide; (2) lacking straight prickles but having curved prickles on both leaves and stems. The plants are straggly and clamber onto other plants. Mark L. Runnals (personal communication) observed that plants along the Peace River (near Arcadia) attained a height of 15 feet. The fruits are arranged in lateral clusters opposite the leaves, small (to 8.5 mm across), and red. The sites observed in Florida are along rivers and in cypress stands. The presence of this alien species may imperil natural areas of the state.

***Solanum rostratum***, with common names of buffalo bur, Kansas-thistle and mala mujer (Correll and Johnston 1970) is native to the Great Plains (Gleason and Cronquist 1991) and is an occasional weed in Florida. It is not likely to be confused with *S. viarum* because the leaves resemble a watermelon leaf (are pinnatifid) and are covered with stellate hairs and many straight prickles. The extremely prickly calyx covers the fruits entirely.

***Solanum sisymbriifolium***, introduced from South America (Clewell 1985), occurs in the Panhandle and Central Florida. Unlike *S. viarum*, it has pinnatifid leaves. There are glandular hairs on the leaves which give it the common name, sticky nightshade. The spiny calyx mostly covers the red berry; spines are not as dense as those of *S. rostratum*.

***Solanum torvum*** is a federally-listed noxious weed. Common names are bushy white solanum (Correll and Correll 1982) and susumber (Bird and Heinlein, no date; Gentry and Standley 1974). Leaf shape is highly variable: leaves may be lobed similar to those of *S. viarum*, unlobed, or oddly lobed. Both stems and leaves are covered with stellate hairs, and there may also be prickles which are straight or curved. The flowers are terminal and the petals are not recurved. Ripe fruits are yellow. Specimens, which were grown especially for their edible fruit, have been located in Florida.

**ECONOMIC IMPORTANCE:** *Solanum viarum* is difficult to control due to its: (1) prickly nature, (2) rapidly expanding range, and (3) tendency to form huge patches. This suggests that *S. viarum* will have a major economic impact in agricultural fields, orange groves and pastures. Natural areas are also at risk. Because of the displacement of native and preferred forage plants and the components of natural ecosystems, the Florida Department of Agriculture and Consumer Services is proceeding with a Rule Amendment to include *S. viarum* as a noxious weed.

*Solanum viarum* is grown in India as a source of steroids (Mullahey 1993). The glycoalkaloid solasodine which is present in the fruit is a precursor for the steroid diosgenin, which is used in contraceptives (Budavari 1989). Although it is not advised, I bit into a fruit as far as the seed cavity and immediately took the fruit out of my mouth. It is bitter and the mucilage sticks to the teeth. The bitter alkaloids of the solanine type (eg., solasodine) are poisonous to humans (Kingsberry 1964; Smith 1976).

**CONTROL MEASURES:** Careful vigilance to detect and remove *Solanum viarum* from pastureland before it proliferates is advisable. Research is underway at the IFAS Southwest Florida Research and Education Center toward controlling this pest plant. Moderate success in control has been observed by mowing the plants before they set fruit and following up with the application of an herbicide to the young seedlings. Reintroduction of seed from neighboring uncontrolled sites will require repeating control measures. Considerably more funds and research need to be directed towards understanding how to control this extremely pestiferous "plant from hell."

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