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BALLOONVINE

Biology and Control in Soybeans

CONTENTS

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BIOLOGY AND CONTROL IN SOYBEANS

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INTRODUCTION

BALLOONVINE (*Cardiospermum halicacabum* L.) is a problem weed for soybean [*Glycine max* (L.) Merr] producers, particularly those producing certified seed. The Alabama Crop Improvement Association has annually rejected, over the past 5 years, an average of 1,100 acres of soybeans from certified seed production because of balloonvine infestations.[2]

Mechanical separation of balloonvine seed from soybean seed is difficult because of their similar sizes, shapes, textures, and densities *(4)*. Therefore, standard seed cleaning facilities fail to adequately remove the balloonvine seed, yielding seed beans contaminated with balloonvine seed. This is unacceptable since it perpetuates the weed problem.

One type of seed processing equipment has been effective in separating the two seeds. It utilizes an electric, light-sensitive eye. Unfortunately, it is slow and the machine with a single-eye unit costs in excess of $5,000.[3] Hand separation is

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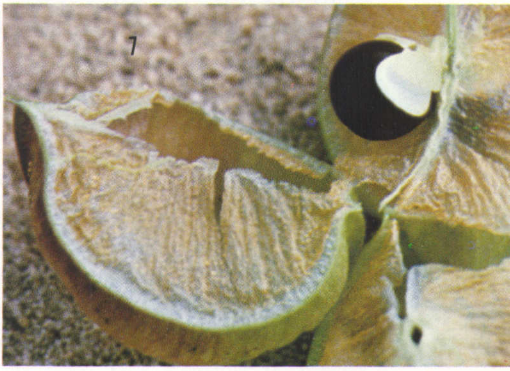
FIG. 1. Balloonvine and soybean seed; note similarity in seed sizes and shape. FIG. 2. A young balloonvine plant approximately 20 days after emergence. FIG. 3. Balloonvine plants showing flowers and seed pods. The plants are supported by soybeans. FIG. 4. Axillary tendrils enable balloonvine plants to climb on other plants.

FIG. 5. Balloonvine flowers are small, white, and about the size of a pencil eraser. FIG. 6. Balloonvine infesting a field in the Black Belt. FIG. 7. The balloonvine fruit is a 3-chambered capsule; note immature green seeds and inflated capsules. FIG. 8. Mature balloonvine seed pod that has ruptured and exposed the seed.



also effective, but it is a slow and costly process. Because balloonvine cannot be readily removed from soybean seed, it has been designated as a noxious weed in Alabama and other Southern States.

Classification, Description, and Distribution

Balloonvine is reported to have originated in Mexico or Central America and is considered an ornamental escape. As early as 1820, it was reported to have been abundant in central Oklahoma *(2)*. A member of the soapberry family *(Sapindaceae)*, it grows as a summer annual in the Southern United States, mainly in areas of intensive soybean production *(5,6)*. It has also been found along fence rows, around old home sites, and in areas subject to frequent flooding. In Alabama, infestations of balloonvine have been observed along the Alabama, Cahaba, and Tennessee rivers. Occasional infestations have been found in pastures in north-central counties. No infestations have been found in the Wiregrass area.

Balloonvine is a diminutive, shrubby, many-branched plant. Unlike many other vines, axillary tendrils provide support for this climbing plant. Stems are from 3 to 6 feet in length. The trifoliolate leaves are biternately divided into lanceolate segments, coarsely lobed, and weakly pubescent. White flowers, appearing in the early summer, are irregular with four sepals and four petals. There are eight anthers and three filiform stigmas. The inflorescences are arranged as cymes of three to five flowers. The resulting green capsular fruit is inflated, pubescent, and obovoid, containing one seed for each of its three locules *(7)*.

The seed of balloonvine are spherical and approximately 3.6 millimeters in diameter. Seed size varies and appears to be dependent upon growing conditions. Balloonvine seed number 4,500 to 5,500 per pound, which makes it similar in size to soybean seed (2,700 to 3,700 per pound). The balloonvine seed testa is black with a white heart-shaped area around the hilum *(7)*. Because of the shape and coloration of the seed, the plant is sometimes referred to as the "8-ball weed" *(1)*, figures 1-8.

Germination and Seed Longevity

Intact, mature balloonvine seed germinate poorly. This has been attributed to a hard and thick seedcoat. In an earlier work, Heit *(4)* showed that germination was only 30 percent after 4 weeks. Some seed required 4 to 6 years to germinate. For these reasons, once balloonvine is introduced into an area, its survival is virtually assured. Heit also found that consistent and rapid germination of balloonvine seed was obtained by scarification in concentrated sulfuric acid for 30 minutes.

Chemical Control

Until now, little information has been generated on the growth and development of balloonvine, let alone the control practices needed in soybeans. In 1976, Oliver *et al.* (unpublished data, University of Arkansas) found that preemergence treatments of metribuzin, early postemergence over-the-top applications of bentazon, and postemergence directed treatments of RH-2915, linuron +2, 4-DB, or metribuzin +2,4-DB all provided excellent (95 percent) balloonvine control in soybeans. Street *et al.* *(8)* also found that paraquat or 2,4-DB applied postemergence provided 70 percent balloonvine control.

MATERIALS AND METHODS

This bulletin summarizes the results of a series of balloonvine biology and control experiments conducted over 4 years (1977-80) at the Alabama Agricultural Experiment Station, Auburn University. Experiments were conducted at the Main Station, the E. V. Smith Research Center, and the Black Belt Substation, located at Auburn, Shorter, and Marion Junction, respectively.

The purposes of these experiments were: to identify germination, growth, and reproductive characteristics of balloonvine, determine competitive effects with soybeans, and evaluate methods of control in soybeans.

Germination Tests

Response of balloonvine to moisture stress, temperature, scarification, and oxygen concentration was determined in several laboratory experiments. Experiments were conducted in dark, thermostatically-controlled incubators, unless indicated otherwise. The seed were placed in 3-inch diameter petri dishes on two sheets of germination matting paper. Seed were recorded as germinated when the radicle had reached a length of 2 millimeters. A completely randomized design was used and all experiments were repeated.

Moisture stress

Aqueous solutions with osmotic potentials of 0, −2, −4, −6, and −8 bars were readied by dissolving appropriate amounts of polyethylene glycol in a quart of distilled water. Balloonvine and soybeans were moistened with 2 teaspoons of the appropriate solutions. Germination counts were made every 2 days for 14 days. Naked balloonvine seed (seed coats removed) were also tested. Germination was evaluated after 3 days.

Temperature

Thermostatically-controlled incubators were set at 59°, 68°, 77°, 86°, 95°, and 104°F. Petri dishes containing the acid-scarified balloonvine seed were placed in incubators at the designated temperatures. Germination was determined daily for 7 days.

Scarification

Balloonvine seed were scarified in concentrated sulfuric acid for 1, 2, 3, and 4 hours. Germination was evaluated daily for 7 days.

Oxygen

The effect of oxygen on balloonvine germination was determined using continuous gas flow and acid-scarified balloonvine seed. Either compressed N_2 (nitrogen gas), compressed air, or compressed O_2 (oxygen gas) was used to establish oxygen levels of 0, 21, and 100 percent, respectively. Seed were placed in 1-inch diameter petri dishes supported by a cylinder above the 1 pint of distilled water in the 1-quart, wide-mouth jar. Each dish contained germination matting paper and a cotton wick extending into the water to maintain seed moisture. Jars were sealed with stoppers having air inlet and outlet holes. Air flow was approximately 5 milliliters per minute, figure 9. A controlled environment chamber with an alternating 86°F day and 68°F night temperature and a 14-hour day was used. Germination was recorded after 3 days.

Growth and Development

Several experiments were conducted in a greenhouse or growth chamber to determine the response of balloonvine seed to planting depth, soil pH, and soil P and K. Field experiments were conducted to study balloonvine biology and competition with soybeans. All experiments were replicated and repeated.

Planting depth

Balloonvine and soybeans were planted at ⅓-, 1-, 2⅓-, 3½-, and 4¾-inch depths in a Marvyn loamy sand and a Houston clay soil held by 1-quart cartons. Cartons were subirrigated to minimize soil crusting and compaction. Cartons were placed in a controlled environment chamber with a 14-hour day and alternating temperatures of 86°F days and 68°F nights. Emergence was recorded after 1 day and every 2 days thereafter for 14 days.

Soil pH

Harselle sandy loam from the Sand Mountain Substation, Crossville, with a pH of 4.9, was used in this study. Selected soil pH levels of 5.9, 6.3, and 6.9 were established by adding $Ca(OH)_2$ to the original soil. Fumigation with methyl bromide, appendix table 1, was used to reduce the nematode population. Scarified balloonvine seed and soybeans were planted 1 inch deep in 3.3 pounds of soil held by styrofoam cups. Seedlings were thinned to three per cup after 14 days. Cups received 0.2 gram NH_4NO_3 biweekly. Plant dry weights were measured after 45 days.

Experiments were conducted in air conditioned greenhouses from June through September 1977. In the first test, temperatures averaged 104°F maximum days and 74°F minimum nights. The second test had average temperatures of 99°F days and 68°F nights.

Soil P and K

Three soil P levels (14, 42, and 73 pounds per acre) were established by adding $CaHPO_4$-$2H_2O$ to Marvyn loamy sand obtained from the Agronomy Farm in Auburn, Alabama. Three soil K levels (16, 40, and 140 pounds per acre) were established by adding KC1 to the soil.

Scarified balloonvine and soybean seed were planted 1 inch deep in 2.2 pounds of soil held in individual cups. Seedlings were thinned to three per cup after 10 days. Two weeks after planting, all cups received 0.2 gram NH_4NO_3. After 26 growing days, plant dry weights were obtained.

Biology

Biology studies were initiated on the Auburn University Agronomy Farm where scarified balloonvine seed were planted at 2-week intervals starting April 11 in 1977 and April 10 in 1978. Plantings continued through September of each year. Plots were fertilized at planting according to soil test recommendations. Each plot was 45 square feet with five plants per plot, supported with a wire mesh. Carbofuran and carbaryl were used to control nematodes and foliar feeding insects, respectively. Urea was applied twice as a sidedressing supplying 50 pounds per acre N each time. Irrigation was used as needed.

Dates of emergence, plant heights at 5 weeks, dates of flowering, and seed production were recorded for the five plants.

Competition With Soybeans

The effect of full season balloonvine competition with Ransom soybeans was determined at the Black Belt Substation, Marion Junction, in 1977 and 1979 (1978 abandoned). A split-plot design was used with soybean row spacings as the main plots and weed densities as sub-plots. Soybean seed were planted June 27, 1977, and May 17, 1979, in 24- and 36-inch rows. Plots were five rows x 33 feet in length.

Scarified balloonvine seed were planted 4 inches to right of the two center rows. Balloonvine plants were thinned to give densities of 0, 2, 4, 8, 16, 32, and 40 plants per 33 feet of row.

Fertilizer was applied as recommended by soil test results. Alachlor (1.5 pounds per acre) and carbaryl (1.8 pounds per acre) were used to control annual grasses and armyworm (*Laphygma frugiperda* Smith), respectively.

A self-propelled small plot combine was used to harvest the two center rows of each plot. Balloonvine seed were hand separated from the soybean seed and counted, after which the soybean seed were weighed.

Herbicide Evaluation

Soil-applied Herbicides

In 1977 and 1979, responses of balloonvine and Ransom soybeans planted at two depths were determined to preplant incorporated (PPI) and preemergence (PRE) applied herbicides.

Paired, 15-inch-wide rows of acid-scarified balloonvine and soybean seed were planted at ¾- and 2⅓-inch depths in a Marvyn loamy sand. Plots, 25 square feet, were arranged in a split-plot design with four replications. Herbicides were applied with a compressed-air, tractor sprayer and, where appropriate, were incorporated with a tandem-disc harrow operating at a 4-inch depth. Visual evaluations were made to determine activity of the herbicides on balloonvine and soybeans. These and other visual evaluations were based on a scale of 0 to 100 percent, where 0 = no effect and 100 = complete kill.

Foliar Applications: Herbicides, Rates, and Times of Application

Effects of herbicides applied postemergence, (Post Test I) on balloonvine were determined in 1978 at the E. V. Smith Research Center, Shorter. Herbicides normally applied as postemergence over-the-top (POT) or postemergence directed spray (PDS) treatments were all applied POT in single and double applications.

Acid scarified balloonvine seed were planted in a Norfolk loamy sand. Plots were two, 36-inch wide rows, 20 feet long, arranged in a split-plot design containing four replications. Applications were made with a compressed-air, tractor-mounted sprayer.

Timing for postemergence herbicide applications to balloonvine was determined in tests conducted during 1978 (Post Test II) and 1979 (Post Test III) at the E. V. Smith Research Center. Acid-scarified balloonvine seeds were planted in paired 15-inch-wide rows. Plots, 25 square feet, were arranged in a split-plot design with four replications. Applications were made with a compressed-air, tractor-mounted sprayer or a CO_2 backpack sprayer. Treatments were applied to balloonvine plants 3, 7, 18, and 27 inches tall.

Foliar Applications: Acifluorfen and Bentazon Rates and Frequency

To determine the effectiveness of multiple postemergence applications of herbicides for balloonvine control, two separate tests were initiated in 1978. Acifluorfen and bentazon were evaluated in Post Test IV and Post Test V, respectively. Rates, times, and numbers of applications were variables in these studies, appendix table 2.

In 1978, an area of Norfolk loamy sand was overseeded with acid-scarified balloonvine seed. Bragg soybeans were planted on July 18 in this area at the E. V. Smith Research Center. Plots were four, 36-inch-wide rows, 20 feet long, arranged in a randomized complete block design. Applications were made with either a compressed-air, tractor-mounted sprayer or a CO_2 backpack sprayer.

In 1979, the acifluorfen test was repeated (Post Test VI). On May 11, Bragg soybeans were planted in the area overseeded with acid-scarified balloonvine. Treatments were applied as in 1978. Plots were four 36-inch-wide rows, 25 feet in length. The right two rows of each plot were cultivated June 19. The test was repeated in 1980 (Post Test VII).

Balloonvine Control Systems

From the results of previous herbicide experiments, a herbicide system test (System Test I) was initiated in 1979 to find which combinations provide the best selective balloonvine control in soybeans. Methods, rates of application, and combinations evaluated are given in appendix table 3.

At the E. V. Smith Research Center, Bragg soybeans were planted in a Norfolk loamy sand. The area had been overseeded with acid-scarified balloonvine. A randomized complete block design with four replications was used. Plots were four 36-inch-wide rows, 25 feet in length. The right two rows of each plot were cultivated once.

Incorporation of herbicides was done immediately after application with a tandem disc-harrow operating at a 4-inch depth. Treatments were applied with either a compressed-air, tractor-mounted sprayer or a CO_2 backpack sprayer. Soybeans were harvested November 15 with a self-propelled plot combine. Balloonvine seed were hand separated from the harvested soybeans and counted.

The same test (Systems Test II) was repeated in 1980. Soybeans were planted May 27 and harvested November 21.

RESULTS AND DISCUSSION

Germination Tests

Scarification

Maximum germination of balloonvine was obtained with 3 hours of acid scarification, while a decline in germination occurred with both the 2- and 4-hour treatments, table 1. Balloonvine is 100 percent hard seed, which 1-hour acid scarification did not measurably affect. Heit *(4)*, however, reported maximum germination of balloonvine seed with 30-minute acid scarification. Variations in seedcoat thickness may be responsible for the difference in the scarification time reported. Seedcoat thickness variations may also have been responsible for the low germination of only 55 percent. En-

TABLE 1. INFLUENCE OF ACID SCARIFICATION ON BALLOONVINE GERMINATION

Acid scarification	Germination						
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Hr.				*Pct.*			
1	0a[1]	0a	0a	0a	0a	0a	0a
2	13bc	27b	37b	43b	46bc	46bc	46b
3	15c	35b	41b	46b	52c	54c	55c
4	10b	27b	36b	40b	42b	44b	46b

[1]Means within columns followed by the same letter are not significantly different at the .05 probability level by Duncan's Multiple Range Test (DMRT).

vironmental conditions at seed ripening have been shown to affect seedcoat thickness and composition, which could directly affect scarification time. In any case, these data suggest that balloonvine could persist for an undetermined length of time, once in the soil. This is supported by Heit *(4)* who showed that balloonvine seed could persist in soil for 6 years.

Oxygen

As the oxygen content increased from 0 to 21 percent, germination of balloonvine seed increased 36 percent, table 2. Scarified balloonvine seed germination, however, was doubled as oxygen increased from 21 to 100 percent. This increase was not likely because of seedcoat limiting oxygen intake; however, oxygen has been shown to increase germination by decreasing inhibitor concentrations by oxidation. These data imply that germination of balloonvine seed generally occurs in the surface few inches, 1 or 2 inches in coarse textured soils and the top inch in heavier clays.

TABLE 2. EFFECT OF OXYGEN LEVELS ON BALLOONVINE GERMINATION AFTER THREE DAYS

Oxygen	Germination
Pct.	*Pct.*
0	0a[1]
21	36b
100	74c

[1]Means followed by the same letter are not significantly different at the .05 probability level (DMRT).

Moisture Stress

Germination of soybean seed was reduced from 98 percent at 0 bars osmotic potential to 26 percent at −2 bars and 6 percent or less at −4 to −8 bars, respectively. Balloonvine seed, however, were even more sensitive to moisture stress with no germination occurring at osmotic potentials of −2 bars and less, table 3. When balloonvine seedcoats were removed

TABLE 3. EFFECTS OF MOISTURE STRESS ON BALLOONVINE AND SOYBEAN GERMINATION

Osmotic potential	Germination			
	Day 1	Day 3	Day 5	Day 7
Bars	Pct.			
	Soybean			
0	49a[1]	96a	98a	98a
-2	0b	12b	20b	26b
-4	0b	3c	5c	6c
-6	0b	1c	1d	1d
-8	0b	1c	1d	1d
	Balloonvine			
0	5a	21a	27a	29a
-2	0b	0b	0b	0b
-4	0b	0b	0b	0b
-6	0b	0b	0b	0b
-8	0b	0b	0b	0b
	Naked balloonvine			
0	—	92a	—	—
-2	—	78b	—	—
-4	—	74b	—	—
-6	—	29c	—	—
-8	—	15d	—	—

[1]Means within a column and within a species followed by the same letter are not significantly different at the .05 probability level (DMRT).

and naked embryos exposed to the solutions, germination occurred at all levels of osmotic stress. Germination of naked embryos decreased from 92 percent at 0 bars to 15 percent at −8 bars. The extreme sensitivity of balloonvine to moisture stress appears to be an effect of the seedcoat rather than a physiological requirement of the embryo. The seedcoat or embryo could contain an inhibitor(s) which leaches out under favorable moisture conditions but remains in the seed when placed in a non-leaching condition, such as decreased osmotic potential solutions. These data certainly suggest that balloonvine will be more a problem in soils containing abundant surface moisture, such as those in the Black Belt area and bottom soils in the Gulf Coast area and those along rivers and other surface water sources. Similarly, sprinkler irrigation may increase balloonvine weed problems.

Temperature

Optimum balloonvine seed germination occurred at 95°F. On day 2, germination at 77°, 86°, and 104°F was similar, but by day 3, each 10°F increase in temperature from 59° to 95°F increased germination, while a 10°F increase in temperature above 95°F by day 4 reduced germination to that obtained at 68°F, table 4. Germination of balloonvine seed in Alabama could, therefore, occur from early April through September,

TABLE 4. EFFECT OF TEMPERATURE ON BALLOONVINE GERMINATION

Temperature	Germination					
	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
°F	Pct.					
59	0a[1]	2a	4a	4a	5a	5a
68	4b	7b	15b	17b	18b	19b
77	14c	22d	26c	27c	27c	29c
86	22c	45e	50d	54d	56d	56d
95	43d	60f	61e	65e	69e	70e
104	11c	13c	15b	15b	17b	17b

[1]Means within columns followed by the same letter are not significantly different at the .05 probability level (DMRT).

with maximum germination during the warmer summer months. This suggests that balloonvine would be more a problem with late planted soybeans or vice versa with early planted soybeans.

Growth and Development

Planting depth

Soybeans and balloonvine did emerge when planted at a depth of 4¾ inches; however, maximum emergence occurred at the ⅓- and 1-inch depths in both soil types, table 5. The two soils in this study, a sandy loam and clay, did not cause a differential response to depth of planting, hence data were combined. Each increase in depth of planting beyond 1 inch reduced soybean emergence; balloonvine emergence at 1 and 2⅓ inches was similar. Balloonvine emergence at a depth of ⅓ to 3½ inches was substantially lower than that obtained with soybeans. These data indicate that soybeans can emerge faster than balloonvine and establish a competitive advantage. However, plants that emerge from deep in the soil

TABLE 5. BALLOONVINE AND SOYBEAN EMERGENCE AS AFFECTED BY PLANTING DEPTH

Planting depth	Emergence			
	Day 2	Day 4	Day 6	Day 8
In.	*Pct.*			
	Balloonvine			
1/3	0a[1]	3a	23a	27a
1	0a	2a	16a	21ab
2 1/3	0a	0a	10b	17b
3 1/2	0a	0a	0c	2c
4 3/4	0a	0a	0c	1c
	Soybean			
1/3	1a	77a	89a	91a
1	0a	78a	84a	87b
2 1/3	0a	23b	57b	60b
3 1/2	0a	0c	11c	20c
4 3/4	0a	0c	0d	1d

[1]Means within a column and within a species followed by the same letter are not significantly different at the .05 probability level (DMRT).

(to 4¾ inches) are less likely to be controlled with preemergence applied herbicides, especially those primarily absorbed by the roots. Balloonvine escapes will then have to be controlled with additional weed control inputs.

Soil pH

Both balloonvine and soybean growth were affected by soil pH. Reduced growth of soybeans occurred at pH 4.9 in Trial II, table 6. However, balloonvine was more sensitive, having reduced growth at pH 5.9 (Trial I) and pH 6.3 (Trial II). These data may help explain why balloonvine is more prevalent in the Black Belt soils since many of these soils are alkaline in nature. Likewise, Alabama's Coastal Plain soils generally have pH levels below 6.9, where balloonvine grew best.

TABLE 6. BALLOONVINE AND SOYBEAN GROWTH AS AFFECTED BY SOIL PH

Soil pH	Relative yield[1]	
	Balloonvine	Soybeans
	Trial 1	
5.9	78a	85a
6.3	94b	93a
6.9	100b	100b
	Trial 2	
4.9	18a	41a
5.9	36b	89b
6.3	42b	94b
6.9	100c	100b

[1]Means within a column followed by the same letter are not significantly different at the .05 probability level (DMRT).

Soil P and K

Balloonvine and soybean plants responded similarly at low (13 pounds per acre) and medium (42 pounds per acre) levels of P, and with 100 percent relative yield for both at the medium level, table 7. The high P level (73 pounds per acre), however, reduced balloonvine growth but did not affect soybeans. Soybean response to K levels was greater than balloonvine. Maximum relative yield of soybeans occurred at the medium K level (39 pounds per acre) while balloonvine produced maximum relative yield at the low K level (16 pounds per acre). The high level of K (140 pounds per acre) reduced yield of balloonvine the same as the high P level. These inhibitory responses cannot be explained. It appears that manipulating soil P and K levels would be of no value in trying to combat this weed. It is doubtful that P could be manipulated anyway since the majority of soils in Alabama are medium to

TABLE 7. INFLUENCE OF SOIL P AND K LEVELS ON BALLOONVINE AND SOYBEAN GROWTH

Soil test level	Relative yield	
	Balloonvine	Soybean
Lb./acre		
Phosphorous		
13	79a[1]	77a
42	100b	100b
73	80a	94ab
Potassium		
16	83a	67a
39	100a	90b
140	55b	100b

[1]Means within the same column for an element followed by the same letter are not significantly different at the .05 probability level (DMRT).

high in P already, and a significant change would take many years. If the reduced growth of balloonvine to high levels of P and K was not an anomaly, then perhaps maintaining soil P and K levels in the high range might be of some benefit.

Biology

Planting of scarified balloonvine seed on biweekly intervals from early April through September during 1977 and 1978 showed that emergence was initially slow, table 8. The April plantings required 9 to 15 days for five balloonvine plants to emerge during the 2-year period. As temperatures warmed, emergence time was reduced to 4 to 7 days, beginning with the last planting date in May and continuing through the same planting date in September. Plant growth, as measured by height 5 weeks after planting, was greatest for the June through July plantings. Flowering appeared to be day-length responsive. The average number of days to first flower was 49, 46, 38, 35, 27, and 27 for plantings made in April, May, June, July, August, and September, respectively. Balloonvine seed production decreased from 14,980 per plot (5 plants) in 1977 and 13,020 in 1978 for the initial plantings to zero for the August 29, 1977, and September 11, 1978, plantings. This means that control of balloonvine will generally need to last through August to prevent soybean seed contamination with balloonvine seed. These data also show that balloonvine is well adapted for growth and reproduction in the Southern States.

TABLE 8. GROWTH RESPONSE OF BALLOONVINE TO PLANTING DATES, AUBURN UNIVERSITY AGRONOMY FARM, 1977-78

Planting date		Emergence of five plants		First flowering		Plant height 5 weeks after planting (in.)		Seed produced per 5 plants	
1977	1978	1977	1978	1977	1978	1977	1978	1977	1978
		Days after planting							
4/11	4/10	9b[1]	15a	35	63	4fg	2ef	14,890a	13,020a
4/25	4/24	10a	13b	42	54	4fg	4ef	16,260a	12,500a
5/09	5/08	8c	15a	56	46	6ef	4ef	12,750b	11,450ab
5/23	5/22	7d	4f	49	33	8de	13bc	—	10,350ab
6/06	6/05	7d	6de	42	38	11b	14b	7,700c	9,210bc
6/20	6/19	5f	6de	35	38	12b	17a	5,230d	6,490cd
7/04	7/03	5f	6de	35	38	17a	13bcd	3,740d	5,840d
7/18	7/17	5f	7d	35	31	13b	14b	1,930e	4,410d
8/01	7/31	5f	6de	28	26	8cd	12bcd	270e	720e
8/05	8/14	4g	6de	28	26	18a	11cd	160e	480e
8/29	8/28	5f	6de	28	24	10bc	10cd	0e	320e
9/12	9/11	6e	5e	28	29	4fg	5e	0e	0e
9/26	9/25	7d	12c	—	—	2g	2f	0e	0e

[1]Means within a column followed by the same letter are not significantly different at the .05 probability level (DMRT).

Competition With Soybeans

No significant competitive differences were apparent among balloonvine densities when soybeans were planted in 24-inch rows (by regression analysis). Balloonvine competition was evident in some cases when soybeans were planted in 36-inch rows. Since differences were only slight, data are presented in tabular form, table 9. The number of balloonvine seed contaminating harvested soybeans was generally the same regardless of the number of balloonvine plants per 33 feet of row. However, the number of balloonvine seed found in a soybean sample could only be used to estimate the number of balloonvine seed produced since some seed had shattered before soybean harvesting. In all cases where balloonvine infested a plot, soybeans were contaminated with balloonvine seed. It is evident from these data that the major problem is soybean seed contamination, and balloonvine competition can be eliminated by planting in rows spaced 24 inches instead of the conventional 36 inches.

TABLE 9. INFLUENCE OF BALLOONVINE PLANT DENSITY AND ROW SPACING ON SOYBEAN YIELD AND BALLOONVINE SEED CONTAMINATION

Balloonvine density per 33 ft. of row	Soybean yield/acre		Number of balloonvine seed per lb. soybean	
	1977	1979	1977	1979
24-in. rows	*Bu.*	*Bu.*		
0	39a[1]	40b	0	0
2	41a	49a	3	6
4	38a	45ab	3	6
8	37a	44ab	4	6
16	37a	44ab	19	7
32	—	44ab	—	7
40	—	45ab	—	3
36-in. rows				
0	31a	40a	0	0
2	28a	39a	8	3
4	31a	37a	9	5
8	28a	35a	23	7
16	25a	35a	49	9
32	—	36a	—	5
40	—	36a	—	5

[1]Means within a row spacing and within a column followed by the same letter are not significantly different at the .05 probability level as judged by DMRT.

Herbicide Evaluation

Soil-applied Herbicides

Metribuzin provided the best control of balloonvine in 1977 and 1979, appendix table 4. Linuron generally provided acceptable control, while control with vernolate was marginal. In both years, balloonvine control showed a trend for higher control where balloonvine seed were planted at the 2⅓-inch depth. Soybean injury from metribuzin was less when applied preemergence versus preplant incorporated. Control was not complete for any soil-applied herbicide, suggesting that additional measures are needed to control balloonvine escapes.

Foliar Applications: Herbicides, Rates, and Times of Application

Acifluorfen provided the best control of balloonvine in both Post Test I and II, appendix tables 5 and 6. Linuron, 2,4-DB, metribuzin, and oxyfluorfen provided greater than 70 percent balloonvine control when applied postemergence (Post Test I). Control was more effective when application was made to 3- and 7-inch-tall balloonvine than when applied to balloonvine 18 and 26 inches tall.

Foliar Applications: Acifluorfen and Bentazon Rates and Frequency

Multiple applications of bentazon (Post Test V) applied over-the-top failed to control balloonvine at any rate or frequency, appendix table 7. However, multiple acifluorfen applications (Post Tests IV, VI, VIII) provided excellent balloonvine control with minimal soybean injury, table 10. Acceptable control, however, was obtained only when balloonvine seed were not found in the harvested soybeans. During 1978 (Post Test IV), when favorable weather conditions existed for postemergence applied herbicide activity, two acifluorfen applications at 1 pound per acre provided complete control. Results were less favorable in 1980 (Post Test VII) under the droughty conditions which also depressed soybean yields. Soybean yields were only occasionally adversely affected by acifluorfen.

Herbicide Systems

Visual evaluations and balloonvine seed counts showed that vernolate and metribuzin were the most effective preemergence applied treatments for both years, with 1979 results generally better than 1980. However, all these herbicides failed to provide complete control, tables 11 and 12. Control was markedly increased when postemergence applied treatments were included with the preemergence herbicides. Complete balloonvine control was accomplished with the following herbicide systems and should be considered by producers:

Table 10. Effects of Multiple Acifluorfen Applications on Balloonvine Control, Soybean Yield, and Balloonvine Seed Contamination, E. V. Smith Research Center, 1978-1980[1]

Treatment	Rates active[3]	Visual rating[2]						Ballonvine seed count		Soybean yield	
		Balloonvine control			Soybean injury						
		1978	1979	1980	1978	1979	1980	1979	1980	1979	1980
Times	*Lb./acre*		*Pct.*			*Pct.*		*No./acre*		*Bu/acre*	
Weedy check	—	0i[5]	0e	0g	0	0c	0b	74,291a	28,826a	25a-d	7e
Hand-hoed check	—	100a	94abc	100a	0	3bc	0b	526b	0c	32a	12a-d
7[4]	0.25	10hi	90a-d	71de	0	3bc	9ab	2,146b	5,182bc	22d	11a-d
7	0.5	45c-g	85cd	65ef	0	3bc	5ab	4,818b	15,061b	23bcd	12a-d
14	0.25	10hi	85cd	90abc	0	3bc	8ab	5,628b	1,255e	29a-d	11a-d
14	0.5	29d-i	90a-d	90abc	0	0c	20a	2,955b	1,012c	29a-d	9b-e
14	0.75	28d-i	90a-d	93abc	0	3bc	11ab	1,053b	3,765bc	27a-d	11a-d
14	1.0	35d-h	95abc	93abc	0	3bc	0b	526b	1,336e	28a-d	10a-d
28	0.5	13ghi	79d	55f	0	3bc	8ab	7,490b	9,109bc	25a-d	10a-d
28	1.0	18f-i	91a-d	78b-e	0	0c	6ab	1,741b	12,348bc	26a-d	11a-d
7; 11	0.25	75abc	87a-d	86a-d	0	0c	8ab	0b	5,506bc	24a-d	12a-d
7; 15	0.25	33d-i	86bcd	91abc	0	0c	15ab	2,389b	2,470bc	28a-d	10a-d
14; 18	0.25	50c-f	88a-d	88a-d	0	5abc	5ab	1,336b	4,130bc	30abc	13ab
14; 22	0.25	23e-i	85c-d	81b-e	0	3bc	0b	3,482b	6,032bc	30abc	14a
14;18	0.5	95a	98ab	93abc	0	11a	9ab	0b	2,713bc	29a-d	11a-d
14; 22	0.5	71abc	92a-d	87a-d	0	3bc	15ab	810b	810c	28a-d	8de
14; 26	0.5	76abc	95abc	95ab	0	0c	16ab	1,862b	1,053c	23cd	8de
14; 30	0.5	60bcd	96abc	100a	0	4abc	10ab	1,053b	0c	28a-d	13ab
14;18	1.0	100a	99a	100a	0	5abc	19ab	0b	0c	25a-d	12a-d
14; 22	1.0	93a	98ab	91abc	0	9ab	3ab	0b	283c	28a-d	12a-d
14; 26	1.0	88ab	98ab	93abc	0	5abc	15ab	0b	1,053c	26a-d	9b-e
14; 30	1.0	93a	99a	99a	0	3bc	15ab	0b	65c	24a-d	10a-d
7; 11; 15	0.25	90ab	94abc	76cde	0	5abc	6ab	3,077b	9,757bc	27a-d	12a-d
14; 18; 22	0.25	70abc	91a-d	87a-d	0	3bc	14ab	0b	2,510bc	26a-d	11a-d
14; 18; 26	0.25	50c-f	91a-d	100a	0	9ab	16ab	1,336b	0c	31ab	13ab
14; 22; 26	0.25	54cde	95a-c	90abc	0	5abc	4ab	1,053b	4,858bc	29a-d	11a-d

[1]Plots were not cultivated.
[2]Evaluations made at soybean maturity just before harvest.
[3]Rates used for each treatment.
[4]Days after balloonvine emergence.
[5]Means within a column followed by the same letter are not significantly different at the .05 probability level (DMRT).

TABLE 11. BALLOONVINE CONTROL AS AFFECTED BY HERBICIDE SYSTEMS VISUALLY EVALUATED IN OCTOBER, E.V. SMITH RESEARCH CENTER, 1979-1980

Postemergence treatment	Preemergence treatment[1]									
	None		Vernolate		Metribuzin		Linuron		Oxyfluorfen	
	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980
	Pct.									
None	0g[2]	5e	83abc	64cd	78a-d	47d	35f	65bcd	38ef	40d
Hand-hoed	93ab	75abc	—	—	—	—	—	—	—	—
Cultivated	63cd	77abc	—	—	—	—	—	—	—	—
Acifluorfen (POT E)[3]	—	—	99a	100a	83abc	84abc	71bcd	91ab	86ab	99a
Acifluorfen (POT E); acifluorfen (POT L)	—	—	99a	95a	100a	92ab	84abc	96a	95ab	95a
Acifluorfen (POT E); metribuzin + 2,4-DB (PDS)	—	—	100a	98a	100a	95a	98a	100a	99a	100a
Acifluorfen (POT E); linuron + 2,4-DB (PDS)	—	—	100a	100a	100a	96a	100a	100a	97a	99a
Acifluorfen (POT E); oxyfluorfen (PDS)	—	—	100a	98a	100a	96a	98a	98a	97a	99a
Acifluorfen (POT E)	63cd	88abc	—	—	—	—	—	—	—	—
Acifluorfen (POT E); acifluorfen (POT L)	97a	86abc	—	—	—	—	—	—	—	—

[1]Plots were not cultivated except for the cultivation treatment.
[2]Means within a year followed by the same letter are not significantly different at the .05 probability level (DMRT).
[3]POT E = over-the-top, early; POT L = over-the-top, late; PDS = post-directed spray.

TABLE 12. BALLOONVINE SEED CONTAMINATING HARVESTED SOYBEANS AS AFECTED BY HERBICIDE CONTROL SYSTEMS, E. V. SMITH RESEARCH CENTER, 1979-1980

Postemergence treatment	Preemergence treatment[1]									
	None		Vernolate		Metribuzin		Linuron		Oxyfluorfen	
	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980
	No./acre									
None	84,494a[2]	16,154ab	6,356de	13,239ab	8,785de	2,105b	73,563ab	2,591b	50,972bc	5,506b
Hand-hoed	3,441de	0b	—	—	—	—	—	—	—	—
Cultivated	17,652de	10,972ab	—	—	—	—	—	—	—	—
Acifluorfen (POT E)[3]	—	—	0e	0b	15,101de	397b	7,287de	931b	4,089de	0b
Acifluorfen (POT E); acifluorfen (POT L)	—	—	0e	0b	0e	0b	4,737de	0b	2,065e	526b
Acifluorfen (POT E); metribuzin + 2,4-DB (PDS)	—	—	0e	0b	0e	0b	0e	26,640a	0e	397b
Acifluorfen (POT E); linuron + 2,4-DB (PDS)	—	—	0e	0b	0e	344b	0e	0b	0e	0b
Acifluorfen (POT E); oxyfluorfen (PDS)	—	—	0e	0b	0e	0b	0e	0b	0e	891b
Acifluorfen (POT E)	16,721de	526b	—	—	—	—	—	—	—	—
Acifluorfen (POT E); acifluorfen (POT L)	0e	3,603b	—	—	—	—	—	—	—	—

[1]Plots were not cultivated except for the cultivation treatment.
[2]Means within a year followed by the same letter are not significantly different at the .05 probability level (DMRT).
[3]POT E = over-the-top, early; POT L = over-the-top, late; PDS = post-directed spray.

System 1: vernolate—preplant incorporated; acifluorfen—postemergence over-the-top early; acifluorfen—postemergence over-the-top 2 to 3 weeks after the first application; System 2: same as System 1 except for a second postemergence application of metribuzin + 2,4-DB post-directed; System 3: same as System 1 except for a second postemergence application of linuron + 2,4-DB post-directed; System 4: same as System 1 except for a second postemergence application of oxyfluorfen + 2,4-DB post-directed; System 5: metribuzin—preemergence; acifluorfen—postemergence over-the-top early; acifluorfen—postemergence over-the-top 2 to 3 weeks after the first application; System 6: same as System 5 except for a second postemergence application of metribuzin + 2,4-DB post-directed; System 7: same as System 5 except for a second postemergence application of linuron + 2,4-DB post-directed; System 8: same as System 5 except for a second postemergence application of oxyfluorfen + 2,4-DB post-directed.

The choice of one of the above systems will depend on cost, application capabilities, and soil type. Vernolate will generally be a better choice for coarse textured soils, while metribuzin will fit more on medium to fine textured soils. Over-the-top broadcast applications are easier and faster, but more costly. Post-directed applications are generally cheaper but more time consuming.

The chemical intensity of these systems may be reduced with the addition of cultivation. Cultivation alone reduced balloonvine contamination by 79 percent in 1979 and 34 percent in 1980 when compared to the untreated check, table 12.

Soybean injury ratings showed little differences among herbicide systems, with crop injury of 31 percent or less, table 13. Injury of 30 percent or less is only slight injury.

Soybean yields in both years generally were not different from the hand-hoed treatment. Also, yields generally were not different from the untreated check. This again points out that balloonvine is not highly competitive with soybeans. Yields for 1980 were low because of dry weather, table 14.

TABLE 13. SOYBEAN INJURY TO HERBICIDE CONTROL SYSTEMS VISUALLY EVALUATED IN OCTOBER, E. V. SMITH RESEARCH CENTER, 1979-1980

Postemergence treatment	Preemergence treatment[1]									
	None		Vernolate		Metribuzin		Linuron		Oxyfluorfen	
	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980
	Pct.									
None	0b[2]	0e	14ab	4cde	20ab	4cde	0b	5cde	4ab	8cde
Hand-hoed	3ab	13b-e	—	—	—	—	—	—	—	—
Cultivated	0b	13b-e	—	—	—	—	—	—	—	—
Acifluorfen (POT E)[3]	—	—	10ab	0e	5ab	3de	3ab	6cde	5ab	21a-e
Acifluorfen (POT E); acifluorfen (POT L)	—	—	14ab	9b-e	14ab	18a-e	13ab	13b-e	25a	9b-e
Acifluorfen (POT E); metribuzin + 2,4-DB (PDS)	—	—	19ab	23a-e	16ab	26abc	9ab	39a	16ab	19a-e
Acifluorfen (POT E); linuron + 2,4-DB (PDS)	—	—	11ab	15b-e	9ab	31ab	0b	26abc	19ab	14b-e
Acifluorfen (POT E); oxyfluorfen (PDS)	—	—	3ab	3de	15ab	14b-e	0b	9b-e	15ab	11b-e
Acifluorfen (POT E)	5ab	24abc	—	—	—	—	—	—	—	—
Acifluorfen (POT E); acifluorfen (POT L)	8ab	10bcd	—	—	—	—	—	—	—	—

[1]Plots were not cultivated except for the cultivation treatment.
[2]Means within a year followed by the same letter are not significantly different at the .05 probability level (DMRT).
[3]POT E = over-the-top, early; POT L = over-the-top, late; PDS = post-directed spray.

TABLE 14. SOYBEAN YIELD RESPONSE TO HERBICIDE CONTROL SYSTEMS, E. V. SMITH RESEARCH CENTER, 1979-1980

Postemergence treatment	Preemergence treatment[1]									
	None[2]		Vernolate		Metribuzin		Linuron		Oxyfluorfen	
	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980
	Bu./acre									
None	27ab[3]	6c	26ab	12ab	25ab	13ab	32a	13ab	31a	14ab
Hand-hoed	29ab	14a	—	—	—	—	—	—	—	—
Cultivated	31a	13ab	—	—	—	—	—	—	—	—
Acifluorfen (POT E)[4]	—	—	35a	15a	28ab	13ab	35a	12ab	33a	13ab
Acifluorfen (POT E); acifluorfen (POT L)	—	—	18b	13ab	25ab	12ab	23ab	12ab	23ab	15a
Acifluorfen (POT E); metribuzin + 2,4-DB (PDS)	—	—	25ab	13ab	30ab	11ab	31a	9bc	29ab	12ab
Acifluorfen (POT E); linuron + 2,4-DB (PDS)	—	—	30ab	14ab	26ab	11ab	32a	10ab	34a	11ab
Acifluorfen (POT E); oxyfluorfen (PDS)	—	—	26ab	15a	30ab	12ab	32a	14ab	26ab	13ab
Acifluorfen (POT E)	28ab	11ab	—	—	—	—	—	—	—	—
Acifluorfen (POT E); acifluorfen (POT L)	27ab	12ab	—	—	—	—	—	—	—	—

[1]Plots were not cultivated except for the cultivation treatment.
[2]Yields are expressed at 11 percent moisture.
[3]Means within a year followed by the same letter are not significantly different at the .05 probability level (DMRT).
[4]POT E = over-the-top, early; POT L = over-the-top, late; PDS = post-directed spray.

SUMMARY

Balloonvine biology and control experiments were conducted from 1977 to 1980 to identify germination, growth, and reproductive characteristics; determine competitive effects with soybeans; and evaluate methods of control in soybeans.

Balloonvine seed, considered to be 100 percent hard seeded, needed 3 hours of harsh scarification with concentrated sulfuric acid to germinate. Also, adequate levels of moisture and oxygen were needed in the immediate environment for germination. All of these factors lead to the conclusion that persistence of balloonvine once introduced into a field is very likely.

Balloonvine was able to grow well under conditions favorable for soybean production. However, soybeans can obtain a competitive edge over balloonvine because of their rapid emergence. Balloonvine was not found to be competitive with soybeans even at densities of 40 plants per 33 feet of row.

Balloonvine was found to be sensitive to the soil-applied herbicides vernolate, metribuzin, and linuron, and foliar-applied herbicides acifluorfen, metribuzin, linuron, and 2,4-DB. Applications of acifluorfen (POT) were most effective when made approximately 2 weeks after balloonvine emergence.

Since balloonvine emerge and produce seed through August, emerge from depths to 4¾ inches, and potentially have longevity in the soil, systems providing season-long control are needed. This was provided by soil treatments of vernolate or metribuzin followed by acifluorfen (POT) and either metribuzin + 2,4-DB or linuron + 2,4-DB (PDS). A timely cultivation should further lengthen control.

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APPENDIX

APPENDIX TABLE 1. TRADE, COMMON, AND CHEMICAL NAMES OF CHEMICALS MENTIONED IN THIS BULLETIN

Trade name	Common name	Chemical name
Amiben	chloramben	3-amino-2,5-dichlorobenzoic acid
Basagran	bentazon	3-isopropyl-1*H*-2,1,3-benzothiadiazin-4(3*H*)-one 2,2-dioxide
Blazer 2L	acifluorfen	5-[2-chloro-(4-trifluormethyl)phenoxy]-2-nitrobenzoic acid
Butyrac 200	2,4-DB (amine salt)	4-(2,4-dichlorophenoxy)butyric acid
Cobex	dinitramine	N^4,N^4-diethyl-α,α,α-trifluoro-3,5-dinitrotoluene-2,4-diamine
Dowfume	methyl bromide	bromomethane
Dyanap	dinoseb + naptalam	2-*sec*-butyl-4,6-dinitrophenol + *N*-1-naphtylphthalamic acid
Furadan	carbofuran	2,3-dihydro-2,2-dimethyl-7-benzofuranylmethyl carbamate
Goal	oxyfluorfen	2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl) benzene
Lasso	alachlor	2-chloro-2′,6′-diethyl-*N*-(methoxymethyl) acetanilide
Lexone, Sencor	metribuzin	4-amino-6-*tert*-butyl-3-(methylthio)-*as*-triazin-5(4*H*)-one
Lorox	linuron	3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea
Paraquat CL	paraquat	1,1′-dimethyl-4,4′-bipyridinium ion
Premerge 3	dinoseb	2-*sec*-butyl-4,6-dinitrophenol
Prowl	pendimethalin	*N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine
Ronstar	oxadiazon	2-*tert*-butyl-4-(2,4-dichloro-5-isoproproxyphenyl)-Δ^2-1,3,4-oxadiazolin-5-one
Sevin	carbaryl	1-naphthyl-*N*-methylcarbamate
Surflan	oryzalin	3,5-dinitro-N^4,N^4-dipropylsulfanilamide
Tenoran	chloroxuron	3-[*p*-(*p*-chlorophenoxy)phenyl]-1,1-dimethylurea
Treflan	trifluralin	α,α,α-trifluoro-2,6-dinitro-*N*, *N*-dipropyl-*p*-toluidine
Vernam	vernolate	S-propyl dipropylthiocarbamate

APPENDIX TABLE 2. TREATMENT SCHEMES EVALUATED FOR FREQUENCY OF ACIFLUORFEN (POST TESTS IV, VI, VII) AND BENTAZON APPLICATIONS (POST TEST V), 1978-1980

Time-days after balloonvine emergence			Rates[1]	
application			Post Tests IV, VI, VII	Post Test V
1st	2nd	3rd	acifluorfen	bentazon
			Lb. active/acre	*Lb. active/acre*
7	—	—	0.0, 0.25, 0.5	0.5, 1.0
14	—	—	0.25, 0.5, 0.75, 1.0	0.5, 0.75, 1.0, 1.5
28	—	—	0.5, 1.0	0.75, 1.5
7	11	—	0.25	0.5
7	15	—	0.25	0.5
14	18	—	0.25	0.5
14	22	—	0.25	0.5
14	18	—	0.5	0.75
14	22	—	0.5	0.75
14	26	—	0.5	0.75
14	30	—	0.5	0.75
14	18	—	1.0	1.0
14	22	—	1.0	1.0
14	26	—	1.0	1.0
14	30	—	1.0	1.0
7	11	15	0.25	0.5
14	18	22	0.25	0.5
14	18	26	0.25	0.5
14	22	26	0.25	0.5

[1]All treatments contained a nonionic spray adjuvant at 0.25 percent v/v.

APPENDIX TABLE 3. HERBICIDE CONTROL SYSTEMS EVALUATED FOR BALLOONVINE CONTROL IN SYSTEMS TESTS I AND II

Treatments[1]					
PPI	PRE	Early POT	Late POT	Early PDS	Rates
					Lb. active/acre
Vernolate	—	—	—	—	2.5
Vernolate	—	Acifluorfen	—	—	2.5; 0.5
Vernolate	—	Acifluorfen	Acifluorfen	—	2.5; 0.375; 0.375
Vernolate	—	Acifluorfen	—	Metribuzin + 2,4-DB	2.5; 0.5; 0.25 + 0.25
Vernolate	—	Acifluorfen	—	Linuron + 2,4-DB	2.5; 0.5; 0.5 + 0.25
Vernolate	—	Acifluorfen	—	Oxyfluorfen	2.5; 0.5; 0.25
—	Metribuzin	—	—	—	0.375
—	Metribuzin	Acifluorfen	—	—	0.375; 0.5
—	Metribuzin	Acifluorfen	Acifluorfen	—	0.375; 0.375; 0.375
—	Metribuzin	Acifluorfen	—	Metribuzin + 2,4-DB	0.375; 0.5; 0.25 + 0.25
—	Metribuzin	Acifluorfen	—	Linuron + 2,4-DB	0.375; 0.5; 0.5 + 0.25
—	Metribuzin	Acifluorfen	—	Oxyfluorfen	0.375; 0.5; 0.25
—	Linuron	—	—	—	1.0
—	Linuron	Acifluorfen	—	—	1.0; 0.5
—	Linuron	Acifluorfen	Acifluorfen	—	1.0; 0.375; 0.375
—	Linuron	Acifluorfen	—	Metribuzin + 2,4-DB	1.0; 0.5; 0.25 + 0.25
—	Linuron	Acifluorfen	—	Linuron + 2,4-DB	1.0; 0.5; 0.5 + 0.25
—	Linuron	Acifluorfen	—	Oxyfluorfen	1.0; 0.5; 0.25
—	Oxyfluorfen	—	—	—	0.5
—	Oxyfluorfen	Acifluorfen	—	—	0.5
—	Oxyfluorfen	Acifluorfen	Acifluorfen	—	0.5; 0.375; 0.375
—	Oxyfluorfen	Acifluorfen	—	Metribuzin + 2,4-DB	0.5; 0.5; 0.25 + 0.25
—	Oxyfluorfen	Acifluorfen	—	Linuron + 2,4-DB	0.5; 0.5; 0.5 + 0.25
—	Oxyfluorfen	Acifluorfen	—	Oxyfluorfen	0.5; 0.5; 0.25
—	—	Acifluorfen	—	—	0.5
—	—	Acifluorfen	Acifluorfen	—	0.5; 0.5

[1]All postemergence applications contained a nonionic spray adjuvant at 0.25 percent v/v; PPI = preplant incorporated; PRE = applied to soil surface immediately after planting; POT = postemergence over-the-top; PDS = postemergence directed.

APPENDIX TABLE 4. RESPONSE OF BALLOONVINE AND SOYBEAN TO PLANTING DEPTH AND SOIL-APPLIED HERBICIDES, AUBURN UNIVERSITY AGRONOMY FARM, 1977 AND 1979

Treatment	Rates active	Visual rating[1]							
		Balloonvine planting depth				Soybean planting depth			
		1977		1979		1977		1979	
		3/4 in.	2 1/3 in.	3/4 in.	2 1/3 in.	3/4 in.	2 1/3 in.	3/4 in.	2 1/3 in.
	Lb./acre	*Pct. control*				*Pct. injury*			
Alachlor (PRE)	2.0; 4.0	36	35	51	57	3	13	44	30
Chloramben (PRE)	2.0; 4.0	0	0	9	4	6	14	55	55
Dinitramine (PPI)	0.375; 0.75	74	46	61	63	44	61	96	60
Dinoseb + naptalam (PRE)	1.5 + 3.0; 3.0 + 6.0	40	69	57	52	79	24	39	30
Linuron (PRE)	1.0; 2.0	75	75	67	71	44	34	43	45
Metribuzin (PPI)	0.375; 0.75	73	95	89	90	28	8	69	58
Metribuzin (PRE)	0.75; 1.5	94	85	85	87	10	11	51	23
Oryzalin (PRE)	1.0; 2.0	55	11	9	19	28	20	52	36
Oxadiazon (PRE)	1.0; 2.0	35	56	83	84	33	54	33	14
Pendimethalin (PRE)	0.5; 1.0	3	0	15	11	4	1	30	33
Trifluralin (PPI)	0.5; 1.0	24	56	18	26	1	23	45	30
Vernolate (PPI)	2.0; 4.0	40	68	53	60	10	43	37	24

[1]Ratings averaged over both herbicide rates.

APPENDIX TABLE 5. CONTROL OF BALLOONVINE WITH POSTEMERGENCE-APPLIED HERBICIDES, E. V. SMITH RESEARCH CENTER, 1978

Herbicide	Rates active	Visual rating[1]		
		Time of application[2]		
		Early	Late	Early + Late
	Lb./acre	*Pct. control*		
Acifluorfen[3]	0.5; 1.0	95	91	99
Bentazon	0.5; 1.0	9	18	20
Chloroxuron	1.0; 1.5	44	28	64
2,4-DB	0.1; 0.2	83	60	97
Dinoseb	0.5; 1.0	36	28	53
Dinoseb + naptalam	0.5 + 1.0; 1.0 + 2.0	13	23	48
Linuron	0.5; 1.0	77	51	85
Metribuzin	0.25; 0.5	77	46	93
Oxyfluorfen	0.25; 0.5	78	43	99

[1]Ratings averaged over both herbicide rates.

[2]Early applications made to 3-inch and late applications made to 15-inch-tall balloonvine.

[3]All herbicide treatments except dinoseb and dinoseb + naptalam received a nonionic spray adjuvant at 0.25 percent v/v.

APPENDIX TABLE 6. RESPONSE OF BALLOONVINE TO POSTEMERGENCE-APPLIED HERBICIDES IN POST TEST II AND POST TEST III, E. V. SMITH RESEARCH CENTER, 1978-1979

Herbicide	Rates active	Visual rating[1]							
		Balloonvine height at herbicide application							
		3 in.		7 in.		18 in.		26 in.	
		1978	1979	1978	1979	1978	1979	1978	1979
	Lb./acre	*Pct. control*							
Acifluorfen[2]	0.5; 1.0	96	87	70	75	77	51	48	71
Bentazon	0.75; 1.0	15	19	35	11	5	10	10	16
Chloroxuron	1.0; 1.5	58	20	68	24	21	26	22	23
2,4-DB	0.05; 0.1	34	47	43	35	41	36	18	56
Dinoseb	0.5; 1.0	18	39	15	16	18	30	27	46
Dinoseb + naptalam	0.5 + 1.0; 1.0 + 2.0	16	36	24	13	26	20	32	36

[1]Ratings averaged over both herbicide rates.

[2]All herbicide treatments except dinoseb and dinoseb + naptalam contained a nonionic spray adjuvant at 0.25 percent v/v.

APPENDIX TABLE 7. EFFECTS OF MULTIPLE BENTAZON APPLICATIONS ON BALLOONVINE, E. V. SMITH RESEARCH CENTER, 1978

Days after balloonvine emergence	Rates active	Balloonvine control[1]	
		9/08	10/31
	Lb./acre	*Pct.*	*Pct.*
Weedy check	—	0f	5def
Hand-hoed check	—	99a	85a
7	0.5	20c-f	23b-f
7	1.0	35bcd	30b-f
14	0.5	3ef	0b
14	0.75	5ef	5def
14	1.0	13def	18b-f
14	1.5	13def	10c-f
28	0.75	20c-f	3ef
28	1.5	41bcd	8def
7; 11	0.5	18c-f	15c-f
7; 15	0.5	20c-f	23b-f
14; 18	0.5	40bcd	13c-f
14; 22	0.5	28b-f	25b-f
14; 18	0.75	43bcd	35bcd
14; 22	0.75	30b-e	13c-f
14; 26	0.75	28b-f	23b-f
14; 30	0.75	43bcd	15c-f
14; 18	1.0	28b-f	40bc
14; 22	1.0	38bcd	48b
14; 26	1.0	28b-f	15c-f
14; 30	1.0	40bcd	23b-f
7; 11; 15	0.5	38bcd	40bc
14; 18; 22	0.5	48bc	33b-e
14; 18; 26	0.5	28b-f	8def
14; 22; 26	0.5	53b	40bc

[1]Means within a column followed by the same letter are not significantly different at the .05 probability level (DMRT).

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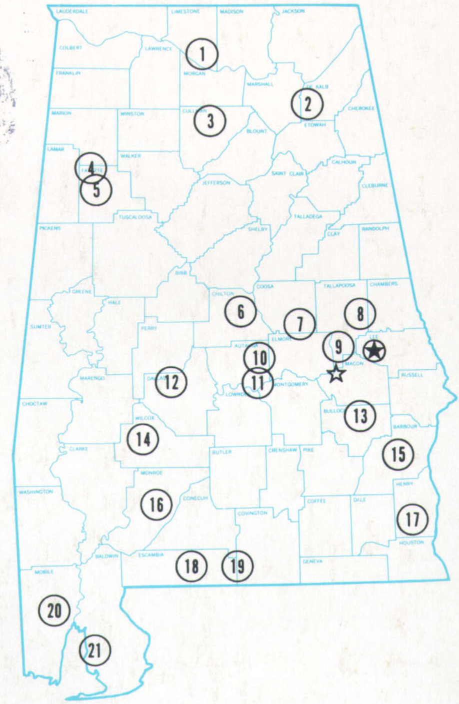

Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.
☆ E. V. Smith Research Center, Shorter.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Chilton Area Horticulture Substation, Clanton.
7. Forestry Unit, Coosa County.
8. Piedmont Substation, Camp Hill.
9. Plant Breeding Unit, Tallassee.
10. Forestry Unit, Autauga County.
11. Prattville Experiment Field, Prattville.
12. Black Belt Substation, Marion Junction.
13. The Turnipseed-Ikenberry Place, Union Springs.
14. Lower Coastal Plain Substation, Camden.
15. Forestry Unit, Barbour County.
16. Monroeville Experiment Field, Monroeville.
17. Wiregrass Substation, Headland.
18. Brewton Experiment Field, Brewton.
19. Solon Dixon Forestry Education Center, Covington and Escambia counties.
20. Ornamental Horticulture Field Station, Spring Hill.
21. Gulf Coast Substation, Fairhope.