Control of Florida Beggarweed *(Desmodium tortuosum)* in Peanuts *(Arachis hypogaea)* with Chloramben[1]

G. Wehtje* And R.B. Reed[2]

ABSTRACT

Experiments were conducted in 1983 and 1984 to evaluate control of Florida beggarweed *[Desmodium tortuosum* (SW) DC.] in peanuts *(Arachis hypogaea* L.) with chloramben (3-amino-2,5-dichlorobenzoic acid) applied at 2.2 kg ai/ha at ground cracking; and chloramben (with crop oil concentrate included at 2 L/ha) applied at either 0.6, 1.1, 2.2, or 3.4 kg ai/ha, at either 30, 45, 60, 75, or 90 days after planting (DAP). Maximum control (as indicated by weed weight at harvest) was achieved with the ground-cracking treatment, and with postemergence applications of 2.2 kg/ha, or higher applied at 30 DAP. Later applications resulted in progressively less control. Peanuts were tolerant to all rates evaluated, as indicated by yield and grade, provided the application was either before or after the flowering and pegging period (45 to 60 DAP). Growth chamber studies indicated that a spreader-sticker type adjuvant (i.e. a petroleum or vegetable based oil-surfactant blends) was essential for acceptable postemergence activity. Comparisons of autoradiograms prepared from peanuts and Florida beggarweed plants where ^{14}C-chloramben had been applied to the foliage and thin layer chromatographic analysis of foliar extracts indicated that the relative tolerance of peanuts could be attributed to the combined effects of limited absorption and translocation, as well as the enhanced ability of peanuts to convert the absorbed chloramben to a non phytotoxic *N*-glucosyl conjugate.

Key Words: Surfactants, herbicide metabolism.

Florida beggarweed is one of the most troublesome weeds in peanuts in Alabama, Georgia, and Florida (3). Florida beggarweed, a non-nodulating legume can grow to 2.5 m in height thereby towering above the peanut canopy. While yields are not seriously affected by a light to moderate infestation, i.e. populations up to approximately 8 plants/m^2 (2), denser stands can be very competitive (8). Research by Hauser *et al.* (10) revealed that each Florida beggarweed plant per 10 m^2, when allowed to compete for the entire season, reduced peanut yields 15.8 to 30.2 kg/ha. Infestations are not readily visible until late in the season when this weed grows above the peanut canopy. However, most plants that eventually penetrate the canopy germinated no later than 6 weeks after peanut emergence (8). Consequently, if peanuts were maintained weed free for 4 to 6 weeks after planting, they remained weed free for the remainder of the season (9).

Control of Florida beggarweed is generally achieved by cultivation or herbicide applications at ground cracking or soon thereafter, perferably when the Florida beggarweed is in the seedling stage (6,7). Ground cracking refers to the period between when the peanut hypocotyls first push or 'crack' through the soil surface and the appearance of the first leaf. Dinoseb [alkanolamine salt of 2-(1-methylpropl)-4,6-dinitrophenol] applied at ground cracking alone or in combination with naptalam (sodium salt of 2[(1-naphthalenylamino) carbonyl]benzoic acid provided 93% control. Control increased to 100% with repeated early postemergence treatments (7). Efficiency of these treatments was influenced by weather; control with both herbicides was reduced markedly with cool temperatures.

Few options, after the ground-cracking stage, are available for the control of this weed species in peanuts. Although attempting control after 6 weeks would be of minimal benefit in reducing weed-crop competition, it is considered desirable since uncontrolled plants impede fungicide applications and harvest, and serve as a future source of weed seed. Postemergence applications of chloramben mixed with a surfactant (type not specified) have provided effective Florida beggarweed control with neligible peanut injury (11). Swann (12) evaluated Florida beggarweed control and peanut yields as influenced by chloramben (2.2 kg ai/ha) applied at several intervals after planting. Chloramben alone or with a crop oil concentrate (brand not specified) provided 90 and 63% control, respectively, when applied 6 weeks after planting. Later applications were less effective. No crop injury or yield suppression was reported.

The relative tolerance of some species to chloramben has been attributed to the ablility to form benign conjugates, primarily *N*-glucosyl chloramben (13,14,15). However, this research was conducted with seedlings of several species of crops and weeds with the roots exposed to nutrient solutions containing chloramben to simulate preemergence activity. It is unknown whether a comparable phenomenon is the basis for the observed selectivity between peanuts and Florida beggarweed to foliar applied chloramben.

The objectives of this study were, 1) to evaluate Florida beggarweed control, and peanut yield and grade, as influenced by rate and time of postemergence applications of chloramben (tank mixed with an appropriate adjuvant); 2) to evaluate Florida beggarweed response to chloramben as influenced by adjuvants other than a crop oil concentrate; 3) to compare the efficiency of postemergence applications of chloramben to the standard ground-cracking treatments; and 4) to determine if the tolerance of peanuts to chloramben could be attributed to differential absorption, translocation and/or conjugate formation.

Materials and Methods

Field experiments. Field experiments were conducted in 1983 and 1984 at the Wiregrass Substation of the Alabama Agriculture Experiment Station located near Headland, Alabama. The soil was a Dothan sandy loam (Plinthic Paleudults) heavily infested with Florida beggarweed. Prior to planting, the test area was plowed once and disked twice. Benefin [*N*-butyl-*N*-ethyl-2,6-dinitro-4-(trifluoromethyl)benzenamine] tank mixed with vernolate (*S*-propyl dipropylcarbamothioate) was applied as a preplant incorporated treatment over the entire area at 1.7 and 2.9 kg/ha, respectively. Previous experience of the authors has indicated that this treatment provides excellent

[1]Published as Alabama Agricutural Experiment Station Journal series paper 3-85774.

[2]Asst. Prof. Dep. Agron. and Soils, and Res. Assoc. Res. Data Anal. Alabama Agric. Exp., Auburn Univ., Auburn Univ., AL 36849.

control of the pertinent grass species, but has no effect on Florida beggarweed. Florunner peanuts were sown at a rate of 130 kg/ha in rows spaced 92 cm apart during the first week of May of both years. Herbicide treatments were chloramben applied at 0.6, 1.1, 2.2, or 3.4 kg/ha at either 30, 45, 60, 75, or 90 days after planting. Individual treatments consisted of single applications representing all possible combinations of the aforementioned variables. Two additional treatments, considered standards for the contral of Florida beggarweed, were included. The first treatment was a mixture of alachlor [2-chlor-*N*-(2,6-diethylphenyl)-*N*-(methoxymethyl)acetamide] and Dyanap[R] (a 1:2 commercially prepared mixture of dinoseb and naptalam), which was applied at ground-cracking at a rate of 3.4 and 5.0 kg/ha, respectively. The second was chloramben (2.2 kg/ha), also applied at ground cracking. Nontreated weedy and weed-free checks were also included. All treatments were assigned to plots 3.7 m (4 rows) by 6.1 m. Experimental design was a randomized complete block with four replications. Herbicides were applied with a tractor-mounted compressed air sprayer (operating at 220 kPa) in a volume of water equivalent to 140 L/ha. All postemergence chloramben treatments included Agridex[R] at 1% v/v[3]. Two rows of each plot were maintained weed free by weekly hoeings so that yields from this portion of the plot would not be influenced by weed competition, but only by the herbicide treatments. Florida beggarweed was harvested from the weed infested portion of all plots prior to peanut harvest to obtain the total fresh weight. Peanuts were harvested at approximately 130 days after planting using conventional peanut harvesting equipment. Peanuts from each plot were weighed, (weed free portion only) a sample was shelled, and the percentage of sound mature kernels (SMK value) was determined (5). Peanuts in the weed infested portion of the plots were not weighed since the roots of any non controlled weeds would sufficiently inhibit harvest so that accurate determinations of yield could not be made. All data were subjected to analysis of variance. Data from the postemergence treatments were analyzed as a factorial of 4 rates by 5 times of application. Data from the standard treatments and all the postemergence treatments with chloramben at 2.2 kg/ha were analyzed separately and means separated by Duncan's multiple rage test at the 5% level of probability.

Growth chamber studies. Four to six Florida beggarweed seedlings were grown in 0.8 L styrofoam cups filled with potting soil (sandy loam, sand, peat (1:1:1, v/v/v). Plants were kept in a growth chamber with a 14 h photoperiod with a PPFD of 550 uE·m-2·s-2. Day and night temperatures were 31 and 23 C, respectively. Plants when 10 cm tall were treated with chloramben (2.2 kg/ha) tank mixed with several adjuvants at rates of either 1.6, 0.8, 0.4, 0.2, or 0% (v/v). Adjuvants were Prime Oil II (vegetable based oil)[4], Agridex[R] (petroleum based oil), X77[5], and Triton Ag 98[6] (both nonionic surfactants). Each treatment was replicated 3 times. Treatments were applied with a moving belt type sprayer in a volume of water equivalent to 140 L/ha. Control of the Florida beggarweed was rated 10 days later. A completely randomized design with 4 replicates was used. The entire experiment was conducted twice and the results averaged.

Laboratory studies. Absorptions and translocation of chloramben in peanuts and Florida beggarweed were studied with autoradiography as described by Crafts and Yamaguchi (4). Peanuts and Florida beggarweed plant were grown in the growth chamber for 3 weeks as previously described. Single 10 uL drop, containing approximately 0.2 uCi of ^{14}C-chloramben (specific activity of 12.8 uCi/mg) and Agridex[R] (1.6% v/v), were placed on the youngest fully expanded leaf of both species. Plants were removed from the soil 48 h later and the roots washed with water. The treated leaf was washed first with 10 mL of methanol and then with 10 mL of water. Both liquids were forcefully ejected from a pipette onto the treated site so as to remove any herbicide that was simply adhered to the cuticle. Plants were flattened and dried in a plant press and glued to cardboard prior to exposure to X-ray film (Kodak X-Omot TL, Eastman Kodak G., Rochester, NY 14650).

Chloramben treated peanuts and Florida beggarweed plants (grown in the growth chamber as previously described) were analyzed for parent and metabolized chloramben by the techniques described by Stoller (15). Briefly, the foilage of both species was coated with an artist's paint brush with a 4 mg/mL chloramben solution that had been spiked with ^{14}C-chloramben (final specific activity of 0.15 uCi/m) and containing Agridex[R] (1.6% v/v). Forty-eight hours after treatment, 20-g portions of the treated foliage were homogenized in methanol (100 mL at 59 C) and the resulting solution passed through filter paper (Whatman No. 1). Extracts were eluted (gravity flow) through a forasil column (15 cm by 2 cm) and the radioactive containing fraction collected. Volume of extract was reduced to 1 mL with vacuum distillation (59 C). Extracts, as well as a chloramben standard were spotted on 20 by 20 cm precoated TLC plates (250 um, silca gel 60 F-254) and then developed in a mixture of n-butanol, ammonium hydroxide, and ethanol (2:1:1, v/v/v, respectively). The distance between the origin and the final wetting front was divided into 20 increments, which were individually removed and analyzed for radioactivity.

Results and Discussion

Field studies. Analysis of variance on the combined data revealed that Florida beggarweed control was significantly affected in a linear manner both chloramben rate and time of application, and by the interaction of these variables, (Table 1). Furthermore, the time of application by year, and rate by year, interactions were significant. Examination of the treatment means for each year reveals that control was generally enhanced with higher rates and earlier applications (Fig. 1). In 1983, chloramben rates of 2.2 and 3.3 kg/ha reduced the level of Florida beggarweed infestation by 92 and 85%, respec-

Table 1. Effects of rate and time of postemergence applications of chloramben on Florida beggarweed control, peanut yield, and SMK value. Partial summary of statistical analysis as pooled over 1983 and 1984.

Variable[a]	Florida beggarweed control[b]	Peanut yield[b]	Peanut SMK[b]
Rate	**(L)	-	*(C)
Time	**(L)	*(Q)	-
Rate X time	*	-	-
Year	-	-	-
Rate X year	*	-	-
Time X year	*	*	-
Rate X time X year	-	-	-

[b]* and ** indicate significance at the 5 and 1% level of probability, respectively. L, Q, and C indicate linear, quadratic, and cubic respectively.

[a]Rates were 0.6, 1.1, 2.2, and 3.4 kg/ha, times of application were 30, 45, 60, 75, and 90 days after planting. All treatments included Agridex[R] at 1% v/v.

[3]A blend of parafin based petroleum oil (87%) and polyoxy ethylated polyol fatty acids Leslers (13%) available from Helena Chemical Co. 5100 Poplar, Suite 3200, Memphis TN 38137.

[4]A blend of vegetable oils (90%) and alkylphenoxyl polyoxyalkylene ethers (10%). Available from Riverside chemical Co. P. O. Box 1828, Sioux City, IA 51102.

[5]A blend (proportions not specifed) of alkylarylpolyoxyethylene, glycols, free fatty acids and isopropanol. Available from Chevron Chemical Co. 575 Market St., San Francisco, CA 94105.

[6]Principal functional agents are alkyl aryl polyoxyethylene glycols. Available from Rohn and Haas Chemical Co. Independence Mall West, Philadelphia, PA 19105.

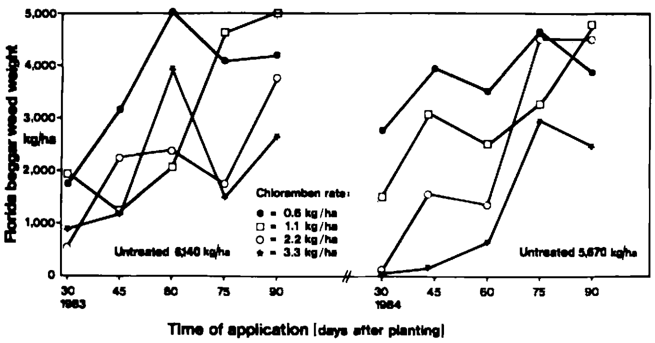

Fig. 1. Influence of chloramben rate and time of application for Florida beggarweed control in peanuts as determined by fresh weed weight at the end of the season.

tively, relative to the untreated control. In 1984, these same rates resulted in a 98 and 99% reduction, respectively. The relative poor control achieved with treatments applied at 75 days after planting in 1983 can probaly be attributed to 2.0 cm of rain that fell within 24h after application which apparently washed the herbicide from the Florida baggarweed foliage.

Peanut yield was significantly affected in a quadratic manner by time of chloramben application; the time of application by year interaction was also significant. Inspection of the yields for each year as influenced by time of application (Table 2) reveals that chloramben applied

Table 2. Peanut yield as influenced by time of postemergence chloramben aapplication, averaged over all rates, 1983-1984.

Time of application	Yield[b] 1983	1984
	(kg/ha)	(kg/ha)
30 DAP[a]	3700	4070
45 DAP	3540	3780
60 DAP	3420	3280
75 DAP	3620	3420
90 DAP	3570	3630
untreated-weed free	3490	3850

[a]DAP=Days after planting.

[b]Regression of yield on time in 1983 was nonsignificant (P=0.05). In 1984, regression analysis provided the following equation: yield = 5,792 - 71.5(DAP) + 52.7 X 10^{-2} $(DAP)^2$, (P 0.0029).

at 60 DAP (1983) and 60 to 75 DAP (1984) reduced yield relative to earlier and later application. The majority of flowering and pegging occurs during this period (1). Data indicate that peanuts are tolerant to all rates evaluated provided application is before or after the major flowering pegging period. The SMK value was significantly affected in a cubic manner by rate. In addition, there was a significant difference between years. However, the SMK for the individual treatments for 1983 ranged from 68.3 to 73.7%; the average was 69.7%. In 1984 the range was 75.2 to 78.5%, with an average of 76.3%. The ranges in values would be of limited economic importance, and none of the treatments affected the SMK value relative to the untreated control (69.8% in 1983 and 77.0% in 1984).

Within the selected treatments, maximum control of Florida beggarweed was achieved with chloramben applied at ground cracking or 30 DAP (Table 3). Alachlor + Dyanap[R] applied at ground cracking significantly reduced the level of infestation relative to the untreated check, however this treatment was not as effective as the aforementioned chloramben treatments. Chloramben applied later than 30 DAP provided progressively less control. However, all of these later-applied treatments did reduce the level of infestation relative to the untreated control. Since the critical weed-free period extends to approximately 50 days after planting (8), late application of chloramben could be justified only as a harvest aid. None of the selected treatments significantly reduced yields relative to the weed-free check (Table 3).

Table 3. Control of Florida beggarweed, peanut yield, and SMK value as influenced by selected treatments.

Treatments	Florida beggarweed fresh weight[b]	Peanut yield[b]	Peanut sound mature kernels[b]
	(kg/ha)	(kg/ha)	(SMK%)
Chloramben-ground cracking	100 e	3730 ab	71.8 a
Chloramben-30 DAP[a]	320 de	3870 a	73.4 a
Chloramben-45 DAP	1880 c	3860 a	74.8 a
Chloramben-60 DAP	1890 c	3030 b	73.6 a
Chloramben-75 DAP	3340 b	3690 ab	74.0 a
Chloramben-90 DAP	4130 b	3570 ab	73.6 a
Alachlor+Dyanap[R]	1643 cd	3730 ab	72.6 a
Untreated weed free	0 e	3770 ab	73.3 a
Untreated weedy	5902 a	-------	------

[a]DAP= Days after planting.

[b]Means followed by same letter are equivalent according to Duncan's multiple range test at the 5% probability level.

However, a downward trend was evident when chloramben was applied at 60 DAP, while an upward trend was evident for chloramben applied at 45 DAP. None of the selected treatments significantly affected the SMK value.

Growth chamber studies. Chloramben applied postemergence (2.2 kg/ha) without an adjucant to growth-chamber grown Florida beggarweed provided only 18 to 20% control (Fig. 2). However, with the maximum level

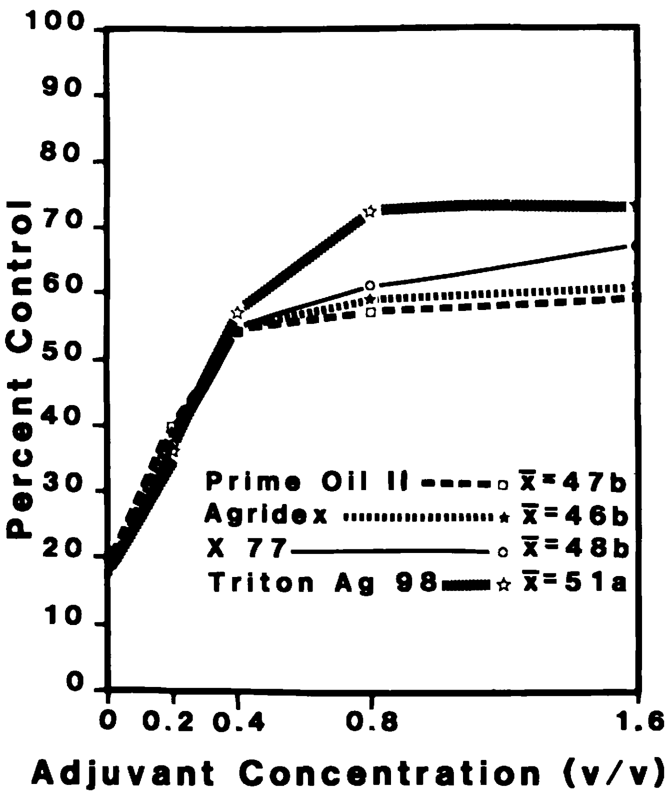

Fig. 2. Florida beggarweed control with chloramben (2.2 kg/ha) as influenced by various adjuvants and concentrations thereof.

of adjuvant (1.6% v/v) control reached 59 to 73%. Control was not markedly reduced unless adjuvant rates were reduced below 0.4% (v/v). Control averaged across all rates with Triton Ag 98[R] (51%) was statistically superior to the others, which were statistically equivalent.

Laboratory studies. Autoradiograms revealed that chloramben and/or chloramben metabolites were absorbed and translocated in both species (Fig. 3). However, the extent of absorption and translocation to metabolic sinks, such as immature leaves, terminal buds, and roots, appeared to be greater in Florida beggarweed.

Thin layer chromatographic analysis revealed that in both species radioactivity was localized in two spots with Rf values of 0.63 and 0.27. The first value was comparable to that of the chloramben standard (0.68). Swanson *et al.* (13,14) reported that the Rf values *N*-glucosyl chloramben was 0.23, which was approximately half the value they obtained for chloramben (0.45). Consequently, we concluded that our other site of radioactivity (Rf of 0.27) was *N*-glucosyl chloramben, and this was the only metabolite produced by either species as detected by this analysis. In subsequent trials, only the areas corresponding to parent and *N*-glycosly chloramben (visable under ultraviolet light) were removed and the amount of radioactivity determined. With the peanut (Table 4), a greater amount of the total radioactivity was recovered as *N*-glucosyl chloramben than as the parent material (79.8 versus 20.2%). Similar results were found for

Fig. 3. Representative autoradiograms of peanuts and Florida beggarweed plants 48 h after treatment with ^{14}C-chloramben, TL = treated leaf.

Table 4. Relative concentration of chloramben and *N*-glucosyl chloramben in the foliage of Florida beggarweed and peanuts 48 h after application.

	Precent of total radioactivity recovered[a]	
Plant	Chloramben	N glucosyl chloramben
Florida beggarweed	36.3	63.7
Peanut	20.2	79.8

[a]Differences between species were significant according to an F test (P=0.0005).

Florida beggarweed, however the difference was smaller, 63.7% as *N*-glucosyl chloramben compared to 36.3% chloramben. The tolerance of peanuts can be attributed to limited absorption and translocation, as well as greater ability to convert that which was absorbed to a benign conjugate.

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Accepted September 30, 1985