ECONOMIC ASSESSMENT OF DICLOSULAM AND FLUMIOXAZIN IN STRIP- AND CONVENTIONAL-TILLAGE PEANUT

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ABSTRACT

Experiments were conducted in Lewiston, NC in 1999 and 2000 and Rocky Mount, NC in 1999 to evaluate weed management systems in strip- and conventional-tillage peanut. The peanut cultivars grown were 'NC 10C', 'NC 12C', and 'NC 7', respectively. Weed management systems consisted of different combinations of preemergence (PRE) herbicides including diclosulam and flumioxazin plus commercial postemergence (POST) herbicide systems. Dimethenamid plus diclosulam or flumioxazin PRE controlled common lambsquarters, eclipta, and prickly sida at least 91%. Both diclosulam and flumioxazin provided variable control of three morningglory species (59 to 91%), but bentazon plus acifluorfen POST was required for >90% control. Only diclosulam systems controlled yellow nutsedge 90% late season. Annual grass control required clethodim late POST, regardless of tillage system. Dimethenamid plus diclosulam or flumioxazin PRE produced equivalent yields and net returns with no significant differences between the two PRE options. Both systems produced higher yields and net returns than dimethenamid regardless of the POST herbicide option. The tillage production system did not influence weed control of eight weeds, peanut yields, or net returns. The addition of diclosulam or flumioxazin to dimethenamid PRE improved weed control compared to dimethenamid PRE alone.

INTRODUCTION

Historically, peanut has been grown as a conventionally planted crop utilizing production systems of primary and secondary tillage operations resulting in a friable, residue free, flat or slightly raised seedbed (Samples, 1987). These operations require considerable fuel, labor, and time. Increasing economic inputs and concerns for declining soil organic matter, subsoil compaction, water stress damage, and sandblasting have led to interest in alternative tillage options, such as strip-tillage productions systems (Troeh et al., 1991). Strip-tillage peanut and cotton (*Gossypium hirsutum* L.) hectarage is increasing across North Carolina and the Southeastern Coastal Plain. Since peanut are often grown in rotation with cotton more farmers will be inclined to follow strip-till cotton with a strip-till peanut production system.

In strip-tillage systems, primary tillage is replaced by herbicides applied preplant to control emerged weedy vegetation; preplant incorporated herbicides are replaced by preemergence (PRE) herbicides, and herbicide band applications to the drill and cultivation are replaced by broadcast herbicide applications maintaining the same objectives of controlling weeds without injuring the crop (Patterson et al., 1994a). There are many advantages for utilizing strip tillage production systems including: (1) water conservation and reduction of sand blasting on sandy soils, (2) elimination of seedbed preparation reduces tillage operations and the number of trips made across the field, and (3) soil tilth and water-holding capacity are improved over time (Bradley, 1995). Strip-tillage production systems work well where soils are prone to develop a hardpan or plow layer that impedes root growth or pegging (process where gynophore grows down into the soil after fertilization) (Sholar et al., 1995).

The ultimate goal is to reduce economic inputs while maintaining equivalent yields. Several studies conducted in the Southeastern United States have identified strip tillage production practices that have produced yields equivalent to conventional-till peanut (Colvin et al., 1988; Colvin et al., 1986; Wilcut et al., 1987). However, since the late 1980's a number of changes have occurred in herbicide options in peanut including the cancellation or withdrawing of dinoseb and naptalam registrations. Additionally, concerns about alachlor-treated peanut have eliminated this herbicide from use in U. S. peanut production (Bridges et al., 1994; Wilcut et al., 1995). Furthermore, new registrations of herbicides since the late 1980's include clethodim, diclosulam, dimethenamid, imazapic, imazethapyr, paraquat, and pyridate. Data for weed management systems for strip tillage remains limited for peanut compared with other agronomic crops (Colvin et al., 1986; Colvin et al., 1985; Wilcut et al., 1987; Worsham, 1985). Diclosulam has recently been registered for PPI and PRE use in peanut (Anonymous, 2000) and flumioxazin was registered in April 2001.

Diclosulam is a soil-applied herbicide belonging to the triazolopyrimidine sulfonanilide family developed for weed control in soybean (*Glycine max* L.) and peanut (Bailey et al. 1999; Barnes et al. 1998). Previous research has shown diclosulam PRE to control a variety of broadleaf weeds in soybean and peanut while exhibiting excellent tolerance to diclosulam (Bailey et al. 1999, 2000; Baughman et al. 2000; Dotray et al. 2000; Main et al. 2000; Prostko et al. 1998; Sheppard et al. 1997).

Flumioxazin is an N-phenyl phtalimide herbicide that inhibits protoporphy-rinogen oxidase (Anderson et al. 1994; Hatzios 1998; Yoshida et al. 1991). Previous research has shown flumioxazin PRE to control Florida beggarweed, morningglories, and prickly sida in Georgia (Wilcut 1997). Flumioxazin PRE controls common lambsquarters, common ragweed, and jimsonweed with good crop tolerance (Wilcut et al. 2000). However, in Texas and Georgia, flumioxazin has failed to control yellow nutsedge, sicklepod, and annual grasses consistently (Grichar and Colburn 1996; Wilcut 1997).

The recent increase in reduced-tillage peanut production on the mid-Atlantic and Southeastern Coastal Plain and the lack of data concerning weed management in reduced-tillage systems necessitates additional research. Therefore, studies were conducted to evaluate weed management systems with diclosulam and flumioxazin PRE for weed control in strip- and conventional-tillage peanut production, and to evaluate peanut response, yield potential and economic returns to peanut in these two tillage systems.

MATERIALS AND METHODS

Field experiments were conducted at the Upper Coastal Plain Research Station located near Rocky Mount, NC in 1999 and at the Peanut Belt Research Station located near Lewiston-Woodville, NC in 1999 and 2000 to evaluate weed management systems in strip- and conventional-tillage peanut. Soils were a Norfolk loamy sand (fine-loamy, siliceous, thermic Typic Kandiudults) with 1.0% organic matter and a pH 5.9 each year at Lewiston and a Rains fine sandy loam (fine-loamy, siliceous, thermic Typic Paleaquults) with 1.1% organic matter and a pH 5.8 at Rocky Mount. These experimental sites are representative of the major peanut-producing areas of North Carolina.

Peanut cultivars included 'NC 10C' and 'NC 12C' at Lewiston, NC in 1999 and 2000 and 'NC 7' at Rocky Mount, NC in 1999. These cultivars are among the more widely planted in North Carolina (Spears, 2000). Peanut was planted 2 in deep at 107 to 116 lb ac^{-1} in 36-in rows into corn (*Zea mays* L.) stubble in 1999 and into cotton stubble in 2000 at Lewiston. Peanut was planted in wheat at

Rocky Mount in 1999. Seeding rates were typical for North Carolina according to state extension recommendations (Jordan, 2000). Pest management programs other than herbicide programs were based on Cooperative Extension Service recommendations (Bailey 2000, Brandenburg 2000).

Weed species evaluated at two or more locations included common lambsquarters, eclipta, entireleaf morningglory, ivyleaf morningglory, pitted morningglory, prickly sida, purple nutsedge, and yellow nutsedge. At the time of early postemergence (EPOST) and POST applications, broadleaf weeds were in the one- to seven-leaf stage while yellow nutsedge was 6 to 10 in tall, with densities ranging from 3 to 10 plants per species m^{-2}. EPOST treatments were applied 7 to 10 days after peanut emergence and POST treatments were applied approximately 2 wk after EPOST treatments. These application timings are typical of commercial postemergence systems in peanut (Wilcut, 1991; Wilcut et al. 1994).

Paraquat at 0.625 lb ai ac^{-1} was applied to all plots three weeks before planting to control existing vegetation. Diclosulam was evaluated with registered preemergence (PRE) and POST herbicides. The PRE herbicide options included: 1) dimethenamid alone at 1.25 lb ai ac^{-1}, dimethenamid plus diclosulam at 0.024 lb ai ac^{-1}, dimethenamid plus flumioxazin at 0.063 lb ai ac^{-1}, or no soil-applied herbicide treatment. Postemergence herbicide options included: 1) bentazon at 0.25 lb ai ac^{-1} plus paraquat at 0.125 lb ai ac^{-1} EPOST followed by a pre-packaged mixture[1] of acifluorfen at 0.25 lb ai ac^{-1} plus bentazon at 0.5 lb ai ac^{-1} POST, 2) paraquat EPOST followed by a pre-packaged mixture of acifluorfen plus bentazon POST at the aforementioned rate, and 3) no POST herbicide treatment. A nonionic surfactant[2] (NIS) at 0.25% (v/v) was included in all EPOST and POST treatments and in the paraquat burndown treatment in strip-tillage. The paraquat burndown treatments served as the untreated check for visual evaluations of weed control and crop injury. Clethodim late POST at 0.125 lb ai ac^{-1} plus crop oil concentrate[3] at 1% (v/v) was needed for all treatment combinations for adequate season-long control of annual grasses including broadleaf signalgrass (*Brachiaria platyphylla* (Griseb.) Nash), goosegrass (*Eleusine indica* L. Gaertn.), and large crabgrass (*Digitaria sanguinalis* L. Scop.). This treatment was needed to facilitate harvest as the fibrous root systems of annual grasses interfere with digging and harvesting operations (Wilcut et al. 1994a). Plot size was four 36-in rows that were 20-ft in length. The experimental design was a randomized complete block with each block replicated three times. A split-plot treatment arrangement with main plot tillage and subplot herbicide program was utilized to facilitate tillage and planting.

Visual estimates of weed control were recorded early (mid-June) and late in the season (late August) just prior to harvest. Weed control and peanut injury based on leaf discoloration and biomass reduction as compared to the untreated control, was visually estimated on a scale of 0 (no injury symptoms) to 100 (complete death of all plants or no plants present) (Frans et al., 1986). Peanut injury was visually estimated 3 weeks (mid-June) after application of PRE herbicides and again 3 weeks (mid July) after POST herbicides. Weed control of common lambsquarters, eclipta, entireleaf morningglory (*Ipomoea hederacea* var. *integruiscula* Gray), ivyleaf morningglory (*Ipomoea hederacea* (L.) Jacq.), pitted morningglory (*Ipomoea lacunosa* L.), prickly sida, and yellow nutsedge, was visually estimated early (mid June) and late (late August) season. Since late season weed control influenced peanut yield and harvest efficiency, only late season evaluation of weed control will be presented (Wilcut et al., 1994). The center two rows of each plot were harvested in mid-October of each year using conventional harvesting equipment.

Economic Analysis.

An enterprise budget developed by the North Carolina Cooperative Extension Service (Brown, 2000) that included operating inputs, fixed costs, and peanut yield value was modified to represent the various weed management programs. Adjustments to operating costs included crop seed and technology fees, herbicide application and incorporation costs, and herbicides and adjuvant costs. The production costs included cultural and pest management procedures, equipment and labor, interest on operating equipment, harvest operations including drying and hauling, and general overhead costs. Cost of seed, technology fee, herbicides, and adjuvants were based on averages of quoted prices from two local agricultural suppliers. Costs of application were \$4.28 per application, based on computer models developed by the Department of Agriculture and Resource Economics at North Carolina State University. Chemical costs ac^{-1} were as follows: clethodim at \$4.84 ac^{-1}, crop oil concentrate at \$0.95 ac^{-1}, dimethenamid at \$16.14 ac^{-1}, bentazon at \$4.09 ac^{-1}, paraquat at \$7.82 ac^{-1}, pre-packaged mixture of acifluorfen plus bentazon at \$12.80 ac^{-1}, diclosulam at \$21.99 ac^{-1}, flumioxazin at \$9.93 ac^{-1}, and NIS at \$0.56 ac^{-1}. Herbicide system costs represent the sum of all application, herbicide, and adjuvant costs (Table 6). Net returns were calculated by multiplying yield/ha by 100% of the price support (\$0.30 lb^{-1}) and subtracting total production costs for each treatment.

Statistical Analysis.
Data were tested for homogeneity of variance by plotting residuals. An arcsine square-root transformation did not improve variance homogeneity, thus non-transformed data were used in analysis and presentation for clarity. Data from the non-treated control was deleted prior to analysis to stabilize variance since visually estimated weed control ratings were set to zero and peanut yield could not be harvested due to weed biomass interference with machinery. To recognize structure in the treatment arrangement, analysis of variance was conducted using the general linear models procedure in SAS (SAS, 1998) to evaluate the effect of various PRE herbicide systems (four levels) and postemergence herbicide options (three levels) on crop injury, weed control, and crop yield. Sums of squares were partitioned to evaluate location and year effects that were considered separate random variables. Main effects and interactions were tested by the appropriate mean square associated with the random variables (McIntosh 1983). Mean separations were performed using Fisher's protected LSD test at P=0.05.

RESULTS AND DISCUSSION

Peanut Response.
Injury at 2 weeks after planting at Lewiston 1999 was minimal with less than 8% for any PRE herbicide systems. However, at Rocky Mt. 1999 and Lewiston 2000, early season injury was noticeable with ranges from 0 to 25 and 0 to 15%, respectively. The same trend in injury was evident with the POST herbicides at the three locations. Most injury was transient, and 8% or less by the late injury rating (Table 1). Injury was expressed as stunting at the late evaluation. This level of stunting is not a concern with producers as excessive vine growth can lead to more disease problems and digging problems at harvest due to poor row definition (Young et al., 1982).

Weed Control.
Tillage did not influence weed control, except for eclipta, thus all weed control data excluding eclipta was pooled over tillage (Tables 2, 3, 4, and 5).

Annual grasses. When compared to non-treated plots, all herbicide treatments improved control of annual grass complex that included broadleaf signalgrass, goosegrass, large crabgrass, and Texas panicum (data not shown). Dimethenamid systems controlled these species better than systems that did not include dimethenamid. However control was 60% or less which would interfere with harvesting operations. Thus, clethodim late POST was needed for all weed management systems for adequate control (>95%) of annual grasses late season.

Yellow nutsedge. There was a significant treatment by location interaction for yellow nutsedge control thus data are presented separately by location. Dimethenamid PRE alone controlled yellow nutsedge 17 to 65% depending on location (Table 2). The additional use of paraquat EPOST fb acifluorfen plus bentazon POST to dimethenamid increased control only at one location. The further addition of bentazon plus paraquat EPOST fb acifluorfen plus bentazon POST increased control at two locations 19 to 73 percentage points. At all locations, yellow nutsedge control with dimethenamid plus diclosulam or flumioxazin PRE was better than control with only dimethenamid PRE. Both diclosulam and flumioxazin PRE controlled yellow nutsedge similarly. The addition of either POST systems to dimethenamid plus diclosulam or flumioxazin PRE did not increase yellow nutsedge control at any location.

Common lambsquarters. There was a significant treatment by location interaction, therefore, data are presented by location. Dimethenamid PRE controlled common lambsquarters 59% or less, while dimethenamid plus diclosulam or flumioxazin PRE controlled 78 to 99 with no differences in treatments (Table 2). The additional use of either POST system to dimethenamid PRE alone increased common lambsquarters control to at least 84% at all locations. Additional use of POST systems with diclosulam and flumioxazin PRE improved control at two of the three locations. At Lewiston in 2000, common lambsquarters was controlled at least 96% with diclosulam or flumioxazin PRE. Since this level of control was so high, no further improvements in control were seen.

Prickly sida. There was a significant treatment by location interaction, therefore, data are presented by location. Dimethenamid PRE did not control prickly sida when compared to nontreated border areas (Table 3). However, prickly sida was controlled 100% with all other herbicide combinations at Lewiston 1999 and 2000. Prickly sida control was more variable at Rocky Mount in 1999. Dimethenamid PRE did not control prickly sida, however the addition of diclosulam or flumioxazin PRE increased control to 61 and 59%, respectively. Dimethenamid PRE plus paraquat EPOST fb acifluorfen plus bentazon POST controlled prickly sida 80% compared with at least 98% control when diclosulam or flumioxazin PRE was included in the aforementioned system. A similar trend was seen with dimethenamid PRE plus bentazon plus paraquat EPOST fb acifluorfen plus bentazon POST, which controlled prickly sida 79% compared to at least 96% control with diclosulam or flumioxazin PRE in this system. It is common for season-long control of prickly sida to require two postemergence treatments (Wilcut et al., 1994).

Pitted morningglory. There was a significant treatment by location interaction and no tillage effect for pitted morningglory control; thus data are presented by location. Dimethenamid PRE did not control pitted morningglory at any location while dimethenamid plus diclosulam or flumioxazin PRE controlled 59 to 89% of the pitted morningglory populations with no differences in treatments (Table 3). The additional use of either POST system to dimethenamid PRE alone increased pitted morningglory control 64 to 88 percentage points, depending on location. Pitted morningglory control with diclosulam and flumioxazin PRE systems was not consistently improved by additional use of POST treatments. Similar results have been seen with diclosulam PRE in conventional-tillage peanuts (Scott et al., 2001).

Entireleaf morningglory. Because there was a significant treatment by location for entireleaf morningglory control, data are presented separately by location. As noted with pitted morningglory, dimethenamid PRE did not control entireleaf morningglory while dimethenamid plus diclosulam or flumioxazin PRE controlled 80 to 90% of the populations with no significant differences in treatments (Table 4). The addition of either POST systems to dimethenamid PRE alone increased entireleaf morningglory control to at 69% at all locations. Additional use of POST systems to diclosulam PRE systems improved control at both locations while it only control for flumioxazin PRE systems at Rocky Mount in 1999.

Ivyleaf morningglory. There was a significant treatment by location interaction for ivyleaf morningglory control, therefore, data are presented by location. Many of the trends observed with the other two morningglory species were also noted with ivyleaf morningglory. Dimethenamid PRE did not control ivyleaf morningglory while the addition of diclosulam or flumioxazin PRE controlled 75 to 91% of the ivyleaf morningglory populations (Table 4). The additional use of either POST systems to dimethenamid PRE alone improved ivyleaf morningglory control to at least 70% at both locations. Ivyleaf morningglory control was improved with the addition of either POST herbicide system to diclosulam or flumioxazin PRE systems at Rocky Mount in 1999 but not at Lewiston. The level of control with diclosulam or flumioxazin PRE was so high (89 to 91%) that improvements were not noted.

Eclipta. There was a significant treatment by location interaction for eclipta control, therefore data are presented by location. Dimethenamid PRE alone did not control at any location while dimethenamid plus diclosulam or flumioxazin PRE controlled 86 to 98% of eclipta populations with no differences in treatments (Table 5). The additional use of either POST system to dimethenamid PRE alone increased eclipta control 84 to 100 percentage points, depending on location. Eclipta control with diclosulam and flumioxazin PRE systems was not consistently improved by additional use of POST treatments. Similar results were reported with diclosulam applied PRE (Bailey et al., 1999).

Peanut Yield.
There was a location by treatment interaction for peanut yield, thus data are presented by location. Dimethenamid PRE treated peanut yielded 1205 to 2580 lb ac^{-1} and these yields were always improved by additional inputs of diclosulam or flumioxazin PRE or by either POST herbicide systems (Table 6). These increased yields reflect the increased levels of weed control provided by the additional herbicide inputs (Tables 1 to 5).

These data show that diclosulam or flumioxazin PRE offers more effective broad-spectrum control of yellow nutsedge, common lambsquarters, prickly sida, eclipta, and three *Ipomea* morningglory species than the commercial standard for North Carolina. In a majority of the comparisons, weed management systems utilizing diclosulam or flumioxazin applied PRE provided better and more consistent broadleaf weed control and higher peanut yields than weed management systems using standard POST herbicides. Peanut yields were indicative of the level of weed management provided by diclosulam- or flumioxazin-containing systems.

Economic Return.
There was a location by treatment interaction for economic net returns, thus data are presented by location. As with peanut yield, economic net returns from each herbicide system followed similar trends (Table 6). Systems that included dimethenamid PRE alone netted -$24 to $146 ac^{-1} while additional inputs of diclosulam and flumioxazin PRE or by either POST herbicide systems to dimethenamid PRE alone increased control. Diclosulam PRE added to dimethenamid PRE use resulted in net returns of $154 to $1178 ac^{-1} at all locations. Additions of flumioxazin PRE to dimethenamid PRE resulted in net returns of $85 to $1206 ac^{-1} at all locations. The additional use of POST herbicide systems to all PRE systems increased net returns.

Early POST and POST herbicides used in this study usually increased weed control when used with dimethenamid PRE but were not always needed with diclosulam or flumioxazin PRE. Our data indicates that diclosulam and flumioxazin PRE in strip- and conventional-tillage production systems controls common lambsquarters, eclipta, and prickly sida without additional herbicide inputs. However, control of yellow nutsedge and three *Ipomea* morningglory species frequently required additional POST herbicide treatments for season-long control. Annual grass control was inadequate and required clethodim for season-long control. The use of diclosulam or flumioxazin PRE can improve weed control, yield, and net returns over traditional systems of dimethenamid PRE herbicides in strip- and conventional-tillage peanut.

SOURCES OF MATERIALS

[1]Storm® contains 29% sodium salt of bentazon [sodium (3-isopropyl-1-*H*-2, 1, 3-benzothiadiazin-4(3*H*)-one-2, 2-dioxide)], 13% sodium salt of acifluorfen (sodium 5-[2-chloro-4-(trifluoromethyl) phenoxy]-2-nitrobenzoate, and 57% inert ingredients, manufactured by BASF Corporation, Agricultural Products Group, P.O. Box 13528, Research Triangle Park, NC 27709.
[2]Induce® nonionic low-foam wetter/spreader adjuvant contains 90% nonionic surfactant (alkylarylpolyoxyalkane ether and isopropanol), free fatty acids, and 10% water, manufactured by Helena Chemical Company, Suite 500, 6075 Poplar Avenue, Memphis, TN 38137.
[3]Agri-dex® contains 83% paraffin base petroleum oil and 17% surfactant blend, manufactured by Helena Chemical Company, Suite 500, 60755 Poplar Avenue, Memphis, TN 38137.

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Table 1. Effect of PRE and POST herbicide systems on peanut injury at three North Carolina locations.[a]

Herbicides			Early injury			Late injury		
			Lewiston 1999	Rocky Mount 1999	Lewiston 2000	Lewiston 1999	Rocky Mount 1999	Lewiston 2000
PRE[b]	EPOST[c]	POST[d]	%					
Dimethenamid	None	None	0 c	0 e	0 c	0 a	1 b	1 c
Dimethenamid + diclosulam	None	None	6 b	15 c	15 b	0 a	0 b	8 a
Dimethenamid + flumioxazin	None	None	7 ab	25 b	15 b	0 a	0 b	8 a
Dimethenamid	Paraquat	Acifluorfen + bentazon	0 c	3 d	0 c	0 a	2 ab	1 c
Dimethenamid + diclosulam	Paraquat	Acifluorfen + bentazon	7 ab	17 c	16 ab	0 a	0 b	7 a
Dimethenamid + flumioxazin	Paraquat	Acifluorfen + bentazon	7 ab	30 a	16 a	0 a	4 a	6 ab
Dimethenamid	Bentazon + paraquat	Acifluorfen + bentazon	0 c	2 d	0 c	0 a	1 b	2 bc
Dimethenamid + diclosulam	Bentazon + paraquat	Acifluorfen + bentazon	6 b	16 c	15 b	0 a	0 b	4 abc
Dimethenamid + flumioxazin	Bentazon + paraquat	Acifluorfen + bentazon	8 a	27 b	16 ab	0 a	0 b	8 a

[a]Values of injury within a column followed by the same letter are not significantly different at the 5% level as determined by Fisher's Protected LSD test.

[b]The PRE herbicide rates were dimethenamid at 1.4 kg ai ha^{-1}, diclosulam at 0.027 kg ai ha^{-1}, and flumioxazin at 0.071 kg ai ha^{-1}.

[c]The EPOST herbicide rates were paraquat at 0.14 kg ai ha^{-1} and bentazon at 0.28 kg ai ha^{-1} and included NIS at 0.25% (v/v).

[d]The POST herbicide rates were acifluorfen at 0.28 kg ai ha^{-1} and bentazon at 0.56 kg ai ha^{-1} and included NIS at 0.25% (v/v).

Table 2. Effect of PRE and POST herbicide systems on yellow nutsedge and common lambsquarters control at three North Carolina locations.[a]

Herbicides			Yellow nutsedge			Common lambsquarters		
			Lewiston 1999	Rocky Mount 1999	Lewiston 2000	Lewiston 1999	Rocky Mount 1999	Lewiston 2000
PRE[b]	EPOST[c]	POST[d]	%					
Dimethenamid	None	None	17 d	54 b	65 b	0 d	58 c	59 c
Dimethenamid + diclosulam	None	None	91 a	87 a	84 a	78 c	93 b	99 a
Dimethenamid + flumioxazin	None	None	90 ab	75 a	86 a	84 bc	89 b	96 a
Dimethenamid	Paraquat	Acifluorfen + bentazon	44 c	55 b	65 b	84 bc	99 a	89 b
Dimethenamid + diclosulam	Paraquat	Acifluorfen + bentazon	87 ab	82 a	81 ab	91 ab	99 a	100 a
Dimethenamid + flumioxazin	Paraquat	Acifluorfen + bentazon	83 ab	76 a	81 ab	94 a	99 a	99 a
Dimethenamid	Bentazon + paraquat	Acifluorfen + bentazon	78 b	77 a	77 ab	88 ab	99 a	100 a
Dimethenamid + diclosulam	Bentazon + paraquat	Acifluorfen + bentazon	90 ab	85 a	92 a	91 ab	99 a	100 a
Dimethenamid + flumioxazin	Bentazon + paraquat	Acifluorfen + bentazon	88 ab	87 a	86 a	96 a	99 a	100 a

[a]Values of control within a column followed by the same letter are not significantly different at the 5% level as determined by Fisher's Protected LSD test.

[b]The PRE herbicide rates were dimethenamid at 1.4 kg ai ha^{-1}, diclosulam at 0.027 kg ai ha^{-1}, and flumioxazin at 0.071 kg ai ha^{-1}.

[c]The EPOST herbicide rates were paraquat at 0.14 kg ai ha^{-1} and bentazon at 0.28 kg ai ha^{-1} and included NIS at 0.25% (v/v).

[d]The POST herbicide rates were acifluorfen at 0.28 kg ai ha^{-1} and bentazon at 0.56 kg ai ha^{-1} and included NIS at 0.25% (v/v).

Table 3. Effect of PRE and POST herbicide systems on prickly sida and pitted morningglory control at three North Carolina locations.[a]

Herbicides			Prickly sida			Pitted morningglory		
			Lewiston 1999	Rocky Mount 1999	Lewiston 2000	Lewiston 1999	Rocky Mount 1999	Lewiston 2000
PRE[b]	EPOST[c]	POST[d]	%					
Dimethenamid	None	None	30 b	0 d	21 b	67 ab	0 d	0 d
Dimethenamid + diclosulam	None	None	100 a	61 c	100 a	75 ab	84 b	85 ab
Dimethenamid + flumioxazin	None	None	100 a	59 c	100 a	59 b	86 b	89 ab
Dimethenamid	Paraquat	Acifluorfen + bentazon	100 a	80 b	100 a	67 ab	74 c	64 c
Dimethenamid + diclosulam	Paraquat	Acifluorfen + bentazon	100 a	98 a	100 a	68 ab	100 a	90 ab
Dimethenamid + flumioxazin	Paraquat	Acifluorfen + bentazon	100 a	98 a	100 a	71 ab	100 a	92 ab
Dimethenamid	Bentazon + paraquat	Acifluorfen + bentazon	100 a	79 b	100 a	88 a	72 c	82 b
Dimethenamid + diclosulam	Bentazon + paraquat	Acifluorfen + bentazon	100 a	97 a	100 a	90 a	100 a	93 a
Dimethenamid + flumioxazin	Bentazon + paraquat	Acifluorfen + bentazon	100 a	96 a	100 a	91 a	100 a	91 ab

[a]Values of control within a column followed by the same letter are not significantly different at the 5% level as determined by Fisher's Protected LSD test.

[b]The PRE herbicide rates were dimethenamid at 1.4 kg ai ha^{-1}, diclosulam at 0.027 kg ai ha^{-1}, and flumioxazin at 0.071 kg ai ha^{-1}.

[c]The EPOST herbicide rates were paraquat at 0.14 kg ai ha^{-1} and bentazon at 0.28 kg ai ha^{-1} and included NIS at 0.25% (v/v).

[d]The POST herbicide rates were acifluorfen at 0.28 kg ai ha^{-1} and bentazon at 0.56 kg ai ha^{-1} and included NIS at 0.25% (v/v).

Table 4. Effect of PRE and POST herbicide systems on entireleaf morningglory and ivyleaf morningglory control at two North Carolina locations.[a]

Herbicides			Entireleaf morningglory		Ivyleaf morningglory	
			Rocky Mount 1999	Lewiston 2000	Rocky Mount 1999	Lewiston 2000
PRE[b]	EPOST[c]	POST[d]	%			
Dimethenamid	None	None	0 d	0 d	0 d	0 d
Dimethenamid + diclosulam	None	None	80 b	81 b	75 bc	89 a
Dimethenamid + flumioxazin	None	None	81 b	90 ab	80 b	91 a
Dimethenamid	Paraquat	Acifluorfen + bentazon	73 c	69 c	70 c	73 b
Dimethenamid + diclosulam	Paraquat	Acifluorfen + bentazon	100 a	93 a	100 a	90 a
Dimethenamid + flumioxazin	Paraquat	Acifluorfen + bentazon	100 a	91 ab	100 a	88 a
Dimethenamid	Bentazon + paraquat	Acifluorfen + bentazon	74 bc	85 ab	74 bc	88 a
Dimethenamid + diclosulam	Bentazon + paraquat	Acifluorfen + bentazon	100 a	95 a	100 a	94 a
Dimethenamid + flumioxazin	Bentazon + paraquat	Acifluorfen + bentazon	100 a	95 a	100 a	94 a

[a]Values of control within a column followed by the same letter are not significantly different at the 5% level as determined by Fisher's Protected LSD test.

[b]The PRE herbicide rates were dimethenamid at 1.4 kg ai ha^{-1}, diclosulam at 0.027 kg ai ha^{-1}, and flumioxazin at 0.071 kg ai ha^{-1}.

[c]The EPOST herbicide rates were paraquat at 0.14 kg ai ha^{-1} and bentazon at 0.28 kg ai ha^{-1} and included NIS at 0.25% (v/v).

[d]The POST herbicide rates were acifluorfen at 0.28 kg ai ha^{-1} and bentazon at 0.56 kg ai ha^{-1} and included NIS at 0.25% (v/v).

Table 5. Effect of PRE and POST herbicide systems on eclipta control at three North Carolina locations.[a]

Herbicides			Eclipta Lewiston 1999	Eclipta Rocky Mount 1999	Eclipta Lewiston 2000
PRE[b]	EPOST[c]	POST[d]	%	%	%
Dimethenamid	None	None	43 d	40 c	38 b
Dimethenamid + diclosulam	None	None	86 c	93 ab	98 a
Dimethenamid + flumioxazin	None	None	89 bc	97 a	97 a
Dimethenamid	Paraquat	Acifluorfen + bentazon	95 ab	85 b	95 a
Dimethenamid + diclosulam	Paraquat	Acifluorfen + bentazon	98 a	98 a	100 a
Dimethenamid + flumioxazin	Paraquat	Acifluorfen + bentazon	99 a	97 a	100 a
Dimethenamid	Bentazon + paraquat	Acifluorfen + bentazon	100 a	84 b	100 a
Dimethenamid + diclosulam	Bentazon + paraquat	Acifluorfen + bentazon	100 a	96 a	100 a
Dimethenamid + flumioxazin	Bentazon + paraquat	Acifluorfen + bentazon	100 a	97 a	100 a

[a]Values of control within a column followed by the same letter are not significantly different at the 5% level as determined by Fisher's Protected LSD test.

[b]The PRE herbicide rates were dimethenamid at 1.4 kg ai ha^{-1}, diclosulam at 0.027 kg ai ha^{-1}, and flumioxazin at 0.071 kg ai ha^{-1}.

[c]The EPOST herbicide rates were paraquat at 0.14 kg ai ha^{-1} and bentazon at 0.28 kg ai ha^{-1} and included NIS at 0.25% (v/v).

[d]The POST herbicide rates were acifluorfen at 0.28 kg ai ha^{-1} and bentazon at 0.56 kg ai ha^{-1} and included NIS at 0.25% (v/v).

Table 6. Effect of PRE and POST herbicide systems on yield, herbicide application cost, and economic return at three North Carolina locations.[a]

Herbicides			Peanut yield				Economic return		
			Lewiston 1999	Rocky Mount 1999	Lewiston 2000	Production cost	Lewiston 1999	Rocky Mount 1999	Lewiston 2000
PRE[b]	EPOST[c]	POST[d]	kg ha^{-1}			\$ ha^{-1}	\$ ha^{-1}		
Dimethenamid	None	None	2270 d	1350 d	2890 c	1560	-60 d	-670 d	360c
Dimethenamid + diclosulam	None	None	3010 bc	5900 abc	6780 ab	1615	380 bc	2320 abc	2910 ab
Dimethenamid + flumioxazin	None	None	2730 cd	5580 bc	6830 ab	1585	230 cd	2140 bc	2980 ab
Dimethenamid	Paraquat	Acifluorfen + bentazon	3150 bc	5750 abc	6440 b	1602	480 abc	2220 abc	2690 b
Dimethenamid + diclosulam	Paraquat	Acifluorfen + bentazon	3740 a	6130 ab	6870 ab	1657	820 a	2430 ab	2920 ab
Dimethenamid + flumioxazin	Paraquat	Acifluorfen + bentazon	3560 ab	6300 a	7150 a	1627	730 ab	2570 a	3140 a
Dimethenamid	Bentazon + paraquat	Acifluorfen + bentazon	2740 cd	5300 c	7080 ab	1613	220 cd	1930 c	3130 a
Dimethenamid + diclosulam	Bentazon + paraquat	Acifluorfen + bentazon	3800 a	5490 c	7140 a	1667	870 a	2010 c	3110 ab
Dimethenamid + flumioxazin	Bentazon + paraquat	Acifluorfen + bentazon	3440 ab	5750 abc	6940 ab	1637	660 ab	2210 abc	3010 ab

[a]Values of yield and economic return within a column followed by the same letter are not significantly different at the 5% level as determined by Fisher's Protected LSD test.

[b]The PRE herbicide rates were dimethenamid at 1.4 kg ai ha^{-1}, diclosulam at 0.027 kg ai ha^{-1}, and flumioxazin at 0.071 kg ai ha^{-1}.

[c]The EPOST herbicide rates were paraquat at 0.14 kg ai ha^{-1} and bentazon at 0.28 kg ai ha^{-1} and included NIS at 0.25% (v/v).

[d]The POST herbicide rates were acifluorfen at 0.28 kg ai ha^{-1} and bentazon at 0.56 kg ai ha^{-1} and included NIS at 0.25% (v/v).