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Weed Management Systems for Conventional and Glyphosate-Resistant Soybean Following Rice

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Weed Management Systems

for Conventional and Glyphosate-Resistant Soybean Following Rice

Abstract

Little information exists regarding weed management systems that maximize economic return from early-soybean-production-system (ESPS) plantings following rice in the midsouthern United States. A field study was conducted from 1999 through 2001 on Sharkey clay soil at Stoneville, Mississippi (33°26'N lat.). Objectives were to compare the agronomic performance of and economic return from irrigated conventional (CONV) and glyphosate-resistant (GR) soybean varieties grown in rotation with rice using two weed management systems. Weed management systems were (1) preemergent followed by postemergent (if needed) weed management with herbicides (PRE + POST) and (2) postemergent-only weed management with herbicides (POST). Lowest cost weed management resulted from using GR varieties with POST glyphosate, while the highest cost weed management (included technology fee) resulted from using GR varieties with PRE non-glyphosate herbicides + POST glyphosate. The use of PRE + POST weed management (that included a sulfonylurea herbicide) compared to POST-only weed management for soybean following rice resulted in shorter plants, lower yield, and less profit when both CONV and GR varieties were grown. When POST-only weed management was used, the best CONV and GR cultivars were similar in yield and net return. These results indicate that a total postemergent weed management system will result in higher yields and greater net returns when both GR and CONV soybean varieties are grown following rice under the conditions of this study.

Introduction

More than 2.5 million acres of rice are grown in the midsouthern states of Arkansas, Louisiana, Mississippi, Missouri, and Texas. Rice and soybean are rotated with each other in a biennial scheme on the majority of this acreage. There is little information regarding weed management in soybean rotated with rice in this region.

Soybean generally has provided low gross return with a small margin for profit in the midsouthern U.S. (Heatherly and Spurlock, 1999; Williams, 1999), especially when soybean prices are below $5 per bushel. A small profit margin dictates that all inputs associated with production must be evaluated with respect to increasing profit, and that yield losses due to controllable pests such as weeds must be prevented within economic constraints. A producer's objective is to control weeds adequately to maximize profits. However, inputs used for weed management in soybean represent a significant cost (Heatherly et al., 1994; Buhler et al., 1997; Johnson et al., 1997; Reddy and Whiting, 2000). In narrow-row (≤ 20 inches wide) soybean planted in a stale seedbed (untilled prior to planting [Heatherly, 1999b]), weed management programs almost exclusively involve herbicides (Oliver et al., 1993; Johnson et al., 1997; Johnson et al., 1998).

Many weed management systems provide similar levels of weed control, but cost differences can be substantial (Heatherly et al., 1993, 1994; Buhler et al., 1997; Webster et al., 1999; Reddy and Whiting, 2000; Reddy, 2001). Cost difference, coupled with yield differences among weed management systems, can result in significant differences in net return among weed control systems (Poston et al., 1992; Heatherly et al., 1993, 1994; Buhler et al., 1997; Johnson et al., 1997; Nelson and Renner, 1999; Webster et al., 1999; Reddy, 2001). Thus, effective weed management programs that are economical for a specific production system such as soybean following rice must be determined to maximize profits.

Traditionally, herbicides have been tailored largely for crops, rather than crops being tailored to tolerate a specific herbicide. During the past decade, however, advances in biotechnology coupled with plant breeding have resulted in the development of GR soybean varieties. The majority of the U.S. soybean acreage is now planted to GR soybean varieties.

Previous research indicates that non-glyphosate PRE herbicides used in traditional soybean production systems (May and later plantings) do not adversely affect GR soybean yield in a continuous soybean production system (Nelson and Renner, 1999; Roberts et al., 1999; Webster et al., 1999; Culpepper et al., 2000; Reddy, 2001), or in a soybean/corn rotation system (Gonzini et al., 1999; Corrigan and Harvey, 2000). This has led to the conclusion that residual herbicides can be used on GR varieties to prevent early-season weed competition in situations where a timely postemergent application of glyphosate is not possible (Corrigan and Harvey, 2000). Glyphosate applied to soybean at normal use rates has no negative effect on GR soybean (Nelson and Renner, 1999; Reddy et al., 2000; Elmore et al., 2001a). Glyphosate applied alone and in a timely manner to soybean needs no supplementation with non-glyphosate herbicides to achieve maximum weed control and yield (Gonzini et al., 1999; Webster et al., 1999; Corrigan and Harvey, 2000; Reddy and Whiting, 2000; Reddy, 2001; Heatherly et al., 2002). All of these results should translate to a reduction in management decisions for producers related to weed control in soybean when GR varieties are used with postemergent glyphosate.

The objective of this research was to compare yield and economic return from irrigated GR and CONV varieties grown in rotation with rice using preemergent followed by postemergent vs. postemergent-only weed management systems. Economic analysis was used to assess the profitability of the two weed management systems on clay soil. Seed yields and estimated costs and returns were used to generate budgets for economic comparisons.

MATERIALS AND METHODS

Field studies were conducted from 1999 through 2001 at the Delta Research and Extension Center at Stoneville, Mississippi (lat. 33°26'N) on Sharkey clay soil. Experiments in all 3 years involved soybean grown in a 1:1 rotation with rice. Soil tests determined that P and K levels were high and that soil pH ranged from 7.8 to 8.0. Experimental design was a randomized complete block with four replicates of each treatment each year. Treatments were variety and weed management system arranged factorially within each block. Treatments were randomly assigned to plots each year.

Planting dates and varieties used each year are shown in Table 1. Management inputs each year followed ESPS guidelines (Heatherly and Bowers, 1998; Heatherly, 1999a). Maturity Group IV varieties (CONV and GR) were chosen based on regional variety trial results and use patterns in the region. They were updated throughout the study period to ensure that recently released, relevant varieties that offered potentially improved performance were used. Sulfonylurea herbicide-tolerant DP 4748 S was included in 2000 and 2001. Seed were treated with mefenoxam fungicide prior to planting each year.

Plot size was eight 20-inch-wide rows that were 75 feet long. Planting rate was about 5 seed per foot of row, or 40 to 45 pounds per acre. All experiments were seeded into a stale seedbed (Heatherly and Elmore, 1983; Heatherly et al., 1993; Heatherly, 1999b) that had been shallow-tilled (≤ 4 inches) each preceding fall

Table 1. Planting dates, varieties and type, and seed cost ($/50 lb bag) associated with conventional (CONV) and glyphosate-resistant (GR) soybean varieties grown following rice in irrigated plantings at Stoneville, MS, 1999-2001.

Year	Planting date	Variety	Variety type	Seed cost
1999	April 23	DP 3478, AP 4880, D 478	CONV	17.50
		DP 4750, DK 4762, SG 468	GR	27.50
2000	April 21	DP 3478, AP 4882, DP 4748 S	CONV	17.00
		DP 4690, A 4702, P 9492	GR	26.00
2001	March 27	DP 3478, AP 4882, DP 4748 S	CONV	16.50
		DP 4690, A 4702, P 9492	GR	27.50/16.50 [1]

[1]First number is seed cost for DP 4690 and A 4702; second number is seed cost for P 9492.

Table 2. Preemergent (PRE) and postemergent (POST) herbicides applied to plantings of conventional (CONV) and glyphosate-resistant (GR) soybean varieties following rice under two weed management systems at Stoneville, MS, 1999-2001.

System[1]	Variety	Herbicide[2]
1999		
PRE + POST	CONV	PRE metribuzin + chlorimuron + metolachlor; no POST needed.
POST	CONV	Sethoxydim followed by (fb) bentazon + acifluorfen fb clethodim.
PRE + POST	GR	PRE metribuzin + chlorimuron + metolachlor; no POST needed.
POST	GR	Glyphosate fb glyphosate.
2000		
PRE + POST	CONV	PRE metribuzin + chlorimuron + metolachlor; POST sethoxydim (1/4).[3]
POST	CONV	Sethoxydim fb sethoxydim(1/4) fb bentazon + acifluorfen + clethodim.
PRE + POST	GR	PRE metribuzin + chlorimuron + metolachlor; no POST needed.
POST	GR	Glyphosate fb glyphosate.
2001		
PRE + POST	CONV	PRE metribuzin + chlorimuron + metolachlor; POST sethoxydim.
POST	CONV	Sethoxydim fb sethoxydim.
PRE + POST	GR	PRE metribuzin + chlorimuron + metolachlor; POST glyphosate.
POST	GR	Glyphosate fb glyphosate.

[1]PRE + POST = preemergent followed by postemergent (if needed) weed management; POST = postemergent weed management.
[2]+ indicates a premix and/or a tank mix. Fb = followed by
[3]Fractions in parentheses indicate a partial application; i.e., only areas containing grass were sprayed (classified as "spot-sprayed").

with a disk harrow and spring-tooth field cultivator. Glyphosate at 0.75 pound of active ingredient per acre (lb a.i./A) in 10 gallons of water per acre was applied preplant to each experimental site each year to kill existing weeds.

Weed management systems were selected using the following premises. (1) The intent was to use proven weed management options that differ in cost. Using preemergent (based on expected weed infestations) plus postemergent (based on actual weed infestations) weed management – compared with using only postemergent weed management – is one method of achieving this. (2) Use of GR varieties offers an opportunity for using nonselective glyphosate in a postemergent weed management system. However, use of PRE herbicides with these varieties is often touted as a way of ensuring effective early-season weed control without sole dependence on the timeliness of glyphosate applied postemergent.

Based on these premises, weed management systems each year were (1) preemergent followed by postemergent (if needed) weed management with herbicides (PRE + POST) and (2) postemergent-only weed management with herbicides (POST). The purpose of both weed management systems was to minimize weed competition within the constraints of each individual treatment until the start of irrigation. Herbicides (Table 2) were broadcast applied each year at labeled rates with recommended adjuvants and in recommended tank mixes.

A premix of 0.4 lb a.i./A metribuzin and 0.067 lb a.i./A chlorimuron (sulfonylurea herbicide) tank-mixed with 2 lb a.i./A metolachlor was applied preemergent to both CONV and GR varieties in PRE + POST immediately after planting in all years. Rainfall of 0.5 inch or more occurred within 6 days of each PRE application in all years. Postemergent herbicides used in PRE + POST and POST for CONV varieties varied from year to year. They were selected and applied according to visual assessment of weed species and size of weeds that were present. Postemergent weed management was not needed in PRE + POST of the CONV varieties in 1999 or the GR varieties in 1999 and 2000 (Table 2). In 2000 and 2001, the PRE + POST of the CONV varieties received a postemergent application of 0.19 lb a.i./A sethoxydim for grass control. In 2001, the PRE + POST of GR varieties received one postemergent application of 0.75 lb a.i./A glyphosate. The POST for the CONV varieties consisted of applications of 0.19 lb a.i./A sethoxydim (one application in 1999 and two applications in 2000 and 2001), a premix of 0.5 lb a.i./A bentazon plus 0.25 lb a.i./A acifluorfen followed by 0.09 lb a.i./A clethodim (1999), and a premix of 0.5 lb a.i./A bentazon and 0.25 lb a.i./A acifluorfen tank-mixed with 0.125 lb a.i./A clethodim (2000). The POST for GR varieties consisted of two applications of 0.75 lb a.i./A

Table 3. Average daily maximum air temperatures (Max. T) and total rainfall amounts for indicated months from 1999-2001, and 30-year normals at Stoneville, MS.								
Month	1999		2000		2001		30-year normals [1]	
	Max. T	Rain	Max. T	Rain	Max. T	Rain	Max. T	Rain
	°F	*in*	*°F*	*in*	*°F*	*in*	*°F*	*in*
April	78	6.3	72	11.1	78	4.0	74	5.4
May	84	5.7	85	6.9	86	5.1	82	5.0
June	89	2.8	90	6.1	88	2.8	90	3.7
July	93	1.0	94	0.6	92	3.2	91	3.7
August	96	0.2	98	0.0	91	8.5	90	2.3
September	89	1.7	88	2.6	85	3.0	85	3.4

[1] 1964-1993, Boykin et al., 1995.

glyphosate applied sequentially in all 3 years, which is supported by results from previous research (Gonzini et al., 1999; Wait et al., 1999; Payne and Oliver, 2000; Swanton et al., 2000).

Preemergent and postemergent broadleaf herbicides were applied in 20 gallons of water per acre, whereas postemergent grass and glyphosate herbicides were applied in 10 gallons of water per acre. Herbicides were applied using a canopied sprayer (Ginn et al., 1998a) for over-the-top applications (to prevent drift to adjacent plots of different treatments) or a directed sprayer (Ginn et al., 1998b) for applications underneath the developing soybean canopy. In the years that the site was cropped to rice, weed management on the entire study area was done with combinations of thiobencarb, quinclorac, and propanil.

Irrigation water was applied by the furrow method through gated pipe whenever soil water potential at the 12-inch depth, as measured by tensiometers, decreased to between -50 and -70 cb during the beginning bloom to full seed period. Irrigation amounts and starting and ending dates each year were (1) 15.5 inches applied from June 15 to August 13, 1999; (2) 15.2 inches applied from June 14 to August 15, 2000; and (3) 9.5 inches applied from June 18 to July 26, 2001. Applied water traversed the area in furrows created by the tractor wheels during planting. Irrigation amounts were determined by the degree of cracking in this shrink-swell soil (cracks when dry, swells when wet), since water applied to it through surface irrigation flows downward to the depth of cracking and rises to the surface as the cracks fill (Mitchell and van Genuchten, 1993). Delta Research and Extension Center personnel collected the weather data approximately 0.5 mile from the experimental site (Table 3).

Percentage weed cover from all species present was estimated (Elmore and Heatherly, 1988) after soybean leaf senescence (just prior to harvest) in each plot to measure the season-long effect of the weed management systems. Total weed cover was calculated as the sum of visual estimates for each weed species from five randomly chosen 5-square-foot sample areas in each plot. Estimates of weed cover in 10% increments from 0−100% were made to estimate cover for each weed species. If a species was present in any of the samples of an individual plot, then its relative abundance was categorized as at least 0−10% (average of 5% cover) in that sample. This is similar to the process used by Yelverton and Coble (1991) to measure weed resurgence at the end of the growing season following early-season application of weed management systems intended to give 100% control.

Prior to harvest each year, mature soybean plant height (length from the soil surface to the tip of stem) was measured in all plots. Lodging ratings for each plot were recorded each year using a scale of 1–5 (1 = almost all plants erect; 5 = all plants down). A field combine modified for small plots was used to harvest the four center rows of each plot. Seed from all plots were cleaned by the harvesting machine; thus, correction for foreign matter content in seed of any treatment combination was not necessary in any year. Harvested seed were weighed and adjusted to 13% moisture.

Estimates of total costs and returns were developed for each annual cycle of each plot using the Mississippi State Budget Generator (Spurlock and Laughlin, 1992). Total specified expenses were calculated using actual inputs for each treatment in each year of the experiment. These expenses included all direct and fixed costs, but they excluded costs for land, management, and general farm overhead, which were assumed to be the same for all treatment combinations. Direct expenses included costs for seed and seed fungicide; herbicides; rollout vinyl pipe used in irrigation; labor, fuel, and repair and maintenance of machinery and irrigation system; hauling harvested seed; and interest on operating capital. Weed management costs after planting were calculated for each treatment, including charges for herbicides, surfactants, and application. All herbicide application costs included both variable and fixed expenses associated with tractors and sprayers. Weed management expenses for GR varieties shown in Table 4 include the additional cost for their seed (cost per 50-pound bag – $10.50 in 1999, $9 in 2000, and $10.50 in 2001).

Fixed expenses included ownership costs for tractors, self-propelled harvesters, implements, sprayers, and the irrigation system. Costs of variable inputs and machinery were based on prices paid by Mississippi farmers each year. Irrigation costs were based on a 160-acre furrow irrigation setup and included an annualized capital recovery cost per acre for the engine, well, pump, gearhead, generator, fuel tank and lines, and land leveling. Machinery ownership cost was estimated by computing the annual capital recovery charge for each machine and applying its per-acre rate to each field operation. Within each year's experiment, expenses other than those for weed management for both variety types (CONV and GR) within a weed management system and year were essentially the same.

Income from each plot was calculated using the U.S. Department of Agriculture loan price of $5.35 per bushel for Mississippi. This price was used because the Mississippi market-year average price was below the loan price each year. Net return above total specified expenses was determined for each experimental unit each year.

Analysis of variance (PROC MIXED [SAS Institute, 1996]) was used to evaluate the significance of treatment effects on weed cover, plant height, seed yield, and net returns within each year. Analyses across years included only 2000 and 2001 because varieties were common in those years. In the across-years analysis, year, weed management system, and variety were treated as fixed effects. Analyses for individual years treated variety and weed management system as fixed effects. Mean separation was achieved with an $LSD_{0.05}$.

Table 4. After-planting weed management (WEXP) and total (TEXP) expenses for conventional (CONV) and glyphosate-resistant (GR) soybean varieties grown following rice under two weed management systems at Stoneville, MS, 1999-2001.

Variety	PRE + POST[1]		POST[1]	
	WEXP	TEXP	WEXP	TEXP
	$/A	$/A	$/A	$/A
1999				
CONV	34	179-182	44	192-193
GR[2]	44	188-190	32	178-180
2000				
CONV	37	183-185	44	190-191
GR[2]	44	185-186	31	175-176
2001				
CONV	49	196-198	26	172-174
GR[2]	55	193-203	27	164-175
All years				
CONV avg.	40	186-188	38	185-186
GR avg.	48	189-193	30	172-177

[1]PRE + POST = preemergent followed by postemergent (if needed) weed management; POST = postemergent weed management.
[2]Extra seed cost shown in Table 1 for GR varieties added to their weed management expense.

Results and Discussion

Weather and soybean development. Thirty-year average monthly maximum air temperatures and total monthly rainfall (Boykin et al., 1995) for growing season months at Stoneville are presented in Table 3. In 1999, average monthly maximum temperatures during April through July were near normal, while August temperature was 6°F above normal. July and August rainfall amounts were well below normal. The beginning bloom through full seed period occurred from early July to mid-August. In 2000, average monthly maximum temperatures from April through June were near normal, while July and August temperatures were above normal. Rainfall in July and August of 2000 was only 0.6 inch. The beginning bloom through full seed period occurred from early July to mid-August. In 2001, average monthly maximum temperatures were near normal in all months of the growing season. August 2001 rainfall was above normal and a record for the month. The beginning bloom through full seed period occurred from mid-June through late July. The low rainfall amounts in July and August of 1999 and 2000 resulted in greater irrigation amounts being applied in those years than in 2001.

Weed management expense. Weed management expense for all replicates of the three CONV varieties was identical, as was the weed management expense for all replicates of the three GR varieties. Therefore, expense associated with each weed management system is shown only for CONV and GR variety categories (Table 4). Weed management costs for GR varieties were always less with POST than with PRE + POST. This agrees with findings of Webster et al. (1999), Reddy and Whiting (2000), Reddy (2001), and Heatherly et al. (2002). For CONV varieties, PRE + POST was cheaper in 1999 and 2000, while the opposite was true in 2001 because of less need for weed control in POST. The 3-year average cost for PRE + POST was $48 per acre for GR varieties and $40 per acre for CONV varieties. This difference is attributable to the higher cost for seed of GR varieties and is larger than that calculated by Webster et al. (1999). The 3-year average cost for POST was $30 per acre for GR varieties and $38 per acre for CONV varieties. This cheaper weed management with POST glyphosate vs. POST non-glyphosate herbicides over the course of this study agrees with results of Nelson and Renner (1999) and Heatherly et al. (2002). Over the 3 years of this study, POST for GR varieties cost the least ($30 per acre), and PRE + POST for GR varieties cost the most ($48 per acre). In a study where soybean followed soybean at the same location, weed management costs in PRE + POST for CONV varieties cost the most

Table 5. Percentage weed cover at maturity of conventional (CONV) and glyphosate-resistant (GR) soybean varieties grown following rice under two weed management systems at Stoneville, MS, 1999-2001.

Variety (V)		Weed management system (W)[1]		Avg.
		PRE + POST	POST	
		%	%	%
1999				
D 478 CONV		24	9	17 ab
DP 3478 CONV		26	10	18 ab
AP 4880 CONV		14	5	10 b
SG 468 GR		31	10	21 ab
DP 4750 GR		24	4	14 b
DK 4762 GR		34	19	26 a
	Avg.	26 a	10 b	
	$LSD_{0.05}$	V = 11; W = 6; V x W = NS[2]		
2000				
DP 3478 CONV		4 b	0 b	2
DP 4748 S CONV		1 b	0 b	1
AP 4882 CONV		4 b	1 b	3
DP 4690 GR		6 b	1 b	3
A 4702 GR		12 a	1 b	6
P 9492 GR		15 a	2 b	8
	Avg.	7	1	
	$LSD_{0.05}$	V = NA; W = NA; V x W = 5		
2001				
DP 3478 CONV		26	30	28 abc
DP 4748 S CONV		29	33	31 ab
AP 4882 CONV		14	21	18 c
DP 4690 GR		31	36	33 ab
A 4702 GR		28	48	38 a
P 9492 GR		23	30	27 bc
	Avg.	25 b	33 a	
	$LSD_{0.05}$	V = 10; W = 6; V x W = NS		

[1]PRE + POST = preemergent followed by postemergent (if needed) weed management; POST = postemergent weed management.
[2]V = LSD for variety mean separation. W = LSD for weed management system mean separation. NA for V and/or W indicates V x W LSD to be used for mean separation. V x W = LSD for variety x weed management system interaction. NS = no significant difference.

(Heatherly et al., 2002). Differences in total expenses (excluding charges for land, management, and general farm overhead) followed the same pattern as the differences in weed management expenses (Table 4).

Weed control and cover, soybean plant height, and lodging. Intended near-complete control of weeds in both weed management systems up to beginning of irrigation was accomplished in all years (data not shown). The effect of weed management system on weed cover at maturity was significant in all years (Table 5). In 1999, average weed cover was higher in PRE + POST (26%) than in POST (10%), and this was associated with shorter height of plants in PRE + POST (Table 6). Average weed cover values ranged from 10–26% among varieties (Table 5). The predominant weed species were barnyardgrass at 15% cover in PRE + POST and 5% cover in POST, and browntop millet at 10% cover in PRE + POST and 2% cover in POST. In 2000, weed cover in PRE + POST of the two shortest varieties in that treatment (A 4702, 12% cover and 22-inch height; P 9492, 15% cover and 22-inch height) was greater than weed cover in all other variety/weed management system combinations, which ranged from 0–6% cover (Table 5) and 26- to 35-inch height (Table 6). Predominant species in PRE + POST of A 4702 and P 9492 again were barnyardgrass and browntop millet. In 2001, average weed cover was greater in POST (33%) than in PRE + POST (25%). Average weed cover values ranged from 18–38% among varieties. The high overall weed cover in 2001 (Table 5) resulted from the shortness of varieties in both weed management systems (21–25 inches in PRE + POST and 23–26 inches in POST [Table 6]) in conjunction with the above-normal rainfall in August and early September (Table 3) when soybean was maturing and dropping leaves. Predominant species in PRE + POST and POST were spreading dayflower at 10% and 12%, respectively; barnyardgrass at 7% and 10%, respectively; and browntop millet at 8% and 7%, respectively.

Table 6. Plant height at maturity of conventional (CONV) and glyphosate-resistant (GR) soybean varieties grown following rice under two weed management systems at Stoneville, MS, 1999-2001.

Variety (V)		Weed management system (W)[1]		Avg.
		PRE + POST	POST	
		in	*in*	*in*
1999				
D 478 CONV		23	37	30 a
DP 3478 CONV		22	29	25 b
AP 4880 CONV		24	31	28 ab
DG 468 GR		26	32	29 ab
DP 4750 GR		24	35	30 a
DK 4762 GR		22	33	28 ab
	Avg.	24 b	33 a	
	$LSD_{0.05}$	V = 4; W = 2; V x W = NS[2]		
2000				
DP 3478 CONV		29 c	34 ab	32
DP 4748 S CONV		36 a	35 ab	36
AP 4882 CONV		29 c	33 b	31
DP 4690 GR		26 d	35 ab	31
A 4702 GR		22 e	33 ab	38
P 9492 GR		22 e	29 c	26
	Avg.	27	33	
	$LSD_{0.05}$	V= NA; W = NA; V x W = 3		
2001				
DP 3478 CONV		23	25	24 a
DP 4748 S CONV		24	23	23 a
AP 4882 CONV		25	25	25 a
DP 4690 GR		24	26	25 a
A 4702 GR		21	24	23 a
P 9492 GR		24	26	25 a
	Avg.	23 b	25 a	
	$LSD_{0.05}$	V = NS; W = 1; V x W = NS		

[1]PRE + POST = preemergent followed by postemergent (if needed) weed management; POST = postemergent weed management.
[2]V = LSD for variety mean separation. W = LSD for weed management system mean separation. NA for V and/or W indicates V x W LSD to be used for mean separation. V x W = LSD for variety x weed management system interaction. NS = no significant difference.

Both weed management system and variety significantly interacted with year to affect plant height in the analysis across 2000 and 2001, the two years with the same varieties. Thus, results from individual year analyses are presented. In all years, weed management system significantly affected mature plant height of all varieties except DP 4748 S, the sulfonylurea herbicide-tolerant variety. Plants of varieties (excluding DP 4748 S in 2000 and 2001) in POST averaged 9, 7, and 2 inches taller than those in PRE + POST in 1999, 2000, and 2001, respectively. Shorter overall height of varieties in 2001 was related to the March 27 planting date vs. a late-April planting date in 1999 and 2000. However, the trend of shorter plants in the PRE + POST system was still evident, and the 2-inch average difference between the two weed management systems

Table 7. Seed yield and net returns for conventional (CONV) and glyphosate-resistant (GR) soybean varieties grown following rice under two weed management systems at Stoneville, MS, 1999-2001.

Variety (V)	Yield			Net return		
	Weed management system (W)[1]		Avg.	Weed management system (W)		Avg.
	PRE + POST	POST		PRE + POST	POST	
	bu/A	*bu/A*	*bu/A*	*$/A*	*$/A*	*$/A*
1999						
D 478 CONV	56.1 e	75.1 a	65.6	122 d	210 a	166
DP 3478 CONV	60.4 de	72.6 ab	66.5	142 cd	196 ab	169
AP 4880 CONV	68.4 bc	74.0 ab	71.2	184 ab	203 a	194
SG 468 GR	61.6 de	68.6 bc	65.1	139 cd	190 ab	165
DP 4750 GR	58.0 e	72.3 ab	65.2	120 d	207 a	164
DK 4762 GR	48.8 f	65.1 cd	56.9	73 e	170 bc	122
Avg.	58.9	71.3		130	196	
$LSD_{0.05}$	V = NA; W = NA; V x W = 6.0[2]			V = NA; W = NA; V x W = 31		
Greatest CONV	68.4	75.1		184	210	
Greatest GR	61.6	72.3		139	207	
2000						
DP 3478 CONV	64.2 d	72.4 b	68.3	161 d	198 bc	180
DP 4748 S CONV	80.1 a	80.2 a	80.1	244 a	238 a	241
AP 4882 CONV	65.6 cd	72.7 b	69.2	167 d	198 bc	183
DP 4690 GR	54.3 e	66.6 cd	60.4	104 e	182 cd	143
A 4702 GR	51.0 e	73.8 b	62.4	87 e	219 ab	153
P 9492 GR	50.4 e	69.5 bc	59.9	84 e	196 bc	140
Avg.	60.9 (57.1[3])	72.5		141 (121[3])	205	
$LSD_{0.05}$	V = NA; W = NA; V x W = 4.7			V = NA; W = NA; V x W = 24		
Greatest CONV	65.6[3]	80.2		167[3]	238	
Greatest GR	54.3	73.8		104	219	
2001						
DP 3478 CONV	36.8 c	47.0 a	41.9	-1	77	38 a
DP 4748 S CONV	35.8 c	38.4 bc	37.1	-5	34	14 b
AP 4882 CONV	39.7 bc	48.2 a	44.0	16	85	51 a
DP 4690 GR	38.9 bc	49.8 a	44.4	5	91	48 a
A 4702 GR	27.6 d	38.0 c	32.8	-52	31	-11 c
P 9492 GR	38.0 c	44.6 ab	41.3	11	74	42 a
Avg.	36.1 (36.2[3])	44.3		-4 b (-4[3]) b	65 a	
$LSD_{0.05}$	V = NA; W = NA; V x W = 6.4			V = 23; W = 13; V x W = NS		
Greatest CONV	39.7[3]	48.2		16[3]	85	
Greatest GR	38.9	49.8		11	91	

[1]PRE + POST = preemergent followed by postemergent (if needed) weed management; POST = postemergent weed management.
[2]V = LSD for variety mean separation. W = LSD for weed management system mean separation. NA for V and/or W indicates V x W LSD to be used for mean separation. V x W = LSD for variety x weed management system interaction. NS = no significant difference.
[3]Does not include DP 4748 S CONV.

was significant. Lodging was of no consequence in any year (data not shown), with all ratings being about 1.5 (a few plants leaning slightly).

Seed yield and net return. In 1999, the interaction of variety by weed management system significantly affected both seed yield and net return (Table 7). Variety AP 4880 produced statistically equal yield and net return from PRE + POST and POST, whereas the other five varieties produced greater yield and net return from POST. Within PRE + POST, the highest yielding CONV variety outyielded the highest yielding GR variety, and it resulted in a greater net return than the GR variety with the highest net return. Within POST, the highest yielding CONV and GR varieties were statistically equal and produced statistically equal net returns. The POST weed management system produced an average yield that was 12.4 bushels per acre greater and an average net return that was $66 per acre greater than average yield and net return from PRE + POST.

In the across-years analyses for 2000 and 2001, both variety and weed management system significantly interacted with year to affect both seed yield and net return. Thus, results from individual year analyses are presented (Table 7). In 2000, the interaction of variety by weed management system significantly affected both seed yield and net return. Variety DP 4748 S, the sulfonylurea-herbicide-tolerant variety, produced statistically equal yield and net return from PRE + POST and POST, whereas the other five varieties produced greater yield and net return from POST. Within PRE + POST, all CONV varieties outyielded GR varieties and provided greater net returns than did GR varieties. Within POST, the highest yielding CONV variety produced yield greater than that from the highest yielding GR variety, but net returns from the two were statistically equal. The PRE + POST weed management system used on all varieties that were not tolerant to the sulfonylurea herbicide produced average yield and average net return that were below the average yield and net return from POST.

Overall yields in 2001 were lower than those in 1999 and 2000 (Table 7) due to weather-induced *Phomopsis* seed decay that affected all varieties when seed were maturing (50% rainy days and 7.3 inches of rain in late August/early September). The interaction of variety by weed management system was significant for seed yield. As in 2000, the PRE + POST weed management system used on all varieties that were not tolerant to the sulfonylurea herbicide produced average yield that was below the average yield from POST. Using POST-only compared with PRE + POST weed management resulted in greater net returns with all varieties. In both weed management systems, the highest yielding CONV and GR varieties produced statistically equal yields and net returns.

SUMMARY AND CONCLUSIONS

Results from agronomic research rarely are devoid of effects of year or interactions between or among years and experimental variables. Thus, the following conclusions are based on results across years, since, in reality, producers must make decisions based on multiyear results regardless of the presence or absence of interactions.

During the 3 years of this study at this location, using a PRE + POST weed management system (that included a sulfonylurea herbicide) for soybean following rice resulted in shorter plants, lower yield, and lower profit when both CONV and GR varieties that were not tolerant to sulfonylurea herbicide were grown. The use of the sulfonylurea-tolerant variety DP 4748 S overcame this effect. Thus, a POST-only vs. a PRE + POST weed management system will result in higher yields and greater net returns when non-sulfonyl-tolerant soybean varieties are grown following rice under the conditions of this study. The PRE + POST vs. POST finding is different from that of Gonzini et al. (1999), Nelson and Renner (1999), Roberts et al. (1999), Webster et al. (1999), Corrigan and Harvey (2000), Culpepper et al. (2000), Payne and Oliver (2000), Reddy (2001), and Heatherly et al. (2002) where soybean followed soybean or corn. In those studies, the effect of PRE was either neutral or erratically reduced yield and profits.

Use of CONV vs. GR varieties grown in an irrigated or high-yield environment (such as the conditions present when following rice in this study) resulted in greater profit when PRE + POST was used. This finding agrees with results from irrigated Arkansas studies (Webster et al., 1999), Nebraska studies (Elmore et al., 2001b), and Mississippi studies (Heatherly et al., 2002). Conversely, when POST-only weed management was used, the best CONV and GR cultivars were similar in yield and net return. These results indicate that GR varieties, when combined with POST glyphosate for weed management as intended, will perform similarly to CONV cultivars. Thus, there is no apparent yield or profit penalty for using GR cultivars in combination with the recommended POST-only weed management with glyphosate.

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